UNIVERSITI TEKNOLOGI MARA

ELUCIDATION OF FUTURE DESIGNERS INTERPRET THE IDENTITY OF FUSION IN ECODESIGN

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AUTHOR'S DECLARATION

I declare that the work in this thesis was carried out in accordance with the regulations of Universiti Teknologi MARA. It is original and is the results of my own work, unless otherwise indicated or acknowledged as referenced work. This thesis has not been submitted to any other academic institution or non-academic institution for any degree or qualification.

I, hereby, acknowledge that I have been supplied with the Academic Rules and Regulations for Post Graduate, Universiti Teknologi MARA, regulating the conduct of my study and research.

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ABSTRACT

This research addresses the challenges of establishing an ecological design (ecodesign) identity, focusing on the difficulties Malaysian product designers face in creating aesthetically appealing sustainable designs. It highlights that manufacturers often lack semantic design thinking in intangible product forms, resulting in a limited perception of beauty within the ecodesign context. Consequently, young designers struggle to interpret ecological forms, affecting the development of a strong sustainable product identity. This study explores ecodesign concept theories and beliefs, emphasizing the importance of semantic design thinking among young product designers through two approaches: the support model and the evaluation model. Adopting the Design Research Methodology (DRM) framework, this study integrates a systematic approach through the Verbal Protocol Analysis (VPA) method. A mixed-method sampling (MMS) strategy involved 61 participants from three industrial design disciplines - art and design, design and architecture, and engineering design - across Malaysian public universities. Initially, 16 participants engaged in preliminary VPA probing within a portable laboratory, supported by a small focus group discussion to deepen qualitative insights, while 45 participants explored metaphorical processes through online distance learning. Using an inverted thinking model of VPA Capsule triangulation within design methodologies, non-parametric statistical testing was conducted to assess perceptions of ecodesign identity. Findings were validated through methodological triangulation. The results, addressing six research questions, highlight that the drawing process is stimulated by design mimicry, whereby young designers derive inspiration from visual elements (VE) through a zoomorphism approach. Subsequently, semantic representation enables versatile adoption through "think-aloud" methods across multiple continuums. Moreover, recycling methodologies and material choices drive a fusion design approach. Therefore, classifying design themes is crucial, as ecodesign identity emerges through metaphor visualization and bipolar digitization, supported by tacit knowledge. Definitely, the "Fusion Design Scheme" synthesizes this identity via bubble model impacts. Future research suggests that semantic representation of design patterns is vital for adapting to sustainability competencies aligned with the Sustainable Development Goals (SDGs) through designerly methods. Overall, the findings contribute to enhancing the aesthetic value and marketability of ecodesign, supporting the development of a cyber-physical system for sustainable product design

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LIST OF SYMBOLS

Symbols

α	Coefficient Alpha
k	Cohen's kappa Coefficient
γ	Gamma Coefficient
μ	Mean
r	Pearson Coefficient
N	Population
n	Sample Size
σ / s.d	Standard Deviation
P_s	Spearman's Population Correlation Coefficient
r_s	Spearman Rho Coefficient

LIST OF ABBREVIATIONS

Abbreviations

ED	Engineering Design
EoF	Evolution of Form
DRM	Design Research Methodology
DV	Dependent Variables
ID	Industrial Design
IM	Industrial Marketing
IV	Independent Variables
IoT	Internet of Things
MT	Manufacturing Technology
MV	Moderating Variables
NPD	New Product Development
3R's	Reduce, Reuse, and Recycle
SfPD	Sustainable for Product Design
SPSS	Statistical Package for the Social Science
TD	Transdisciplinary Design
TID	Traditional Interdisciplinary Design
VE	Visual Element
VPA	Verbal Protocol Analysis

CHAPTER 1
INTRODUCTION

1.1 Research Background

Environmentally-friendly product design, or an ecodesign product, is commonly designed by industrial designers in specific manufacturing fields (OTA, 1992). By applying a design concept, design methodology and holistic approach, industrial designers can begin preliminary works in planning the input, organising activities and delivering outputs until there is an outcome of finished goods, where the product design objective of ecodesign concept is to address the environmental solution's needs, especially in minimising environmental impacts. Following the minimisation of environmental impacts, product design creation will use green marketing or green design programmes to follow the specific requirements in many environmental standards and certain national standard programmes. This means the sustainable supply chain has been developed alongside the creation of ecodesign products (OTA, 1992). Next, the function of green marketing is to introduce, sell and seek a marketability of ecodesign products, which possibly allows consumer participation into beneficial waste resource and recovery management (Baker, 2003). Obviously, this cradle to grave concept called the ecodesign product can only be made and designed under the sustainable for product design (SfPD) development programme (Lee, 2005).

According to the above scenarios, from the researcher's previous studies in Master's Degree, the researcher had successfully observed and addressed a new ecodesign concept model formulation under an ecological form's theoretical framework for a SfPD solution needs in formgiving context. Using a specific subject, such as the local manufacturer practicing designers, the previous study had established a clear conception design research following the descriptive study I (DS-1) in a systematic design research methodology (DRM) framework (Chumiran, 2016). The exploration of the Malaysian manufacturers had exposed an actual green manufacturing operation and situation realistically, which was behind the research and development (R&D) group challenges to produce SfPD concept within intangible ecological form of ecodesign context throughout the years. This new, intangible ecological form approaches an element of green technology for the SfPD mechanism within its green movement

development. Because of the new design era, green technology allows for the expansion of internal and external national economic growth, suitable with sustainable development as a national fundamental and concurrent concept. Hence, manufacturer practicing designers, who have been newly-exposed to sustainable development and begun to evaluate the form of ecodesign products, will be able to beneficially apply their understanding in designs of consumer products and practice the reduce, reuse, and recycle (3Rs) methodology as descriptivism of the person's behaviour response and design thinking (Chumiran, 2016). Through the intangible ecological form of ecodesign knowledge, this new finding approach makes ecodesign practices stand in a realistically-structured manner, whereby the ecodesign concept methodology is elaborated in a systematic way to produce "the ecodesign product identity" under the SfPD family concept. However, further research study in the form of PhD dissertation is required to investigate the exploratory method of the designer's human emotion (subject), specifically in SfPD creation. The believing way of design thinking was identifying the semantic of intangible product form that it comes out from ecological form of ecodesign implicitly. By the fundamental of human emotion understanding, the scope of the designed thinking in the education of industrial design perspective must be explored. Moreover, this will represent the study of the ecodesign product identity following the area of design thinking. Besides that, the impact of DS-1 stage research findings indicated a reflective design thinking, as well as hermeneutic phenomenology. Therefore, an emphasis on the study of design reflective practice is needed to explain the method of intangible ecological form theory, which would reveal the existence ecological design identity in a formgiving concept creation. The significance of design reflective practice has beneficially facilitated the understanding of the ecodesign product identity consistently.

Nevertheless, this study is focused on "the method of product form identity concept" to recognise the intangible ecological form of ecodesign theory within its fundamental step practices (basic research of industrial design entity). It can be reached via the industrial cycle roadmap using the conceptual of SfPD as well. Through the establishment of DS-1 stage conception in theoretical framework (DS-1 stage: refer to Appendix 1), an earlier design's formulation is supposed to be structured in the fundamental form of an entire ecodesign identity that establishes the validation and availability of intangible ecological form model itself. Therefore, the previous theory establishment will be empirically sampled the Malaysian public university setting,

where its many novices or young designers would learn about the ecodesign product in certain and/or different design mainstream of the industrial design orientation. For qualitative induction reasoning, the prescriptive study (PS) stage will be interpreted to seek the design phenomena through designer's human emotion based on the study of the ecodesign product identity via an artifact in product form. Meanwhile, the descriptive study II (DS-2) stage will gauge and describe the meaning of the product form identity within its methodology and approaches so that it represents the quantitative of deduction reasoning. Hence, the sequence of the research methodology appears with an ecodesign product identity → product identity. Provisionally, this research study will impact, promote, and deliver an ecodesign supply chain in order to generate resource recovery and waste management for the industrial design field accordingly.

1.2 Problem Statement

Product form or formgiving is the artistic quality of the overall visual appearance in which it represents the fashion of a designed object to meet or express behavioural needs, emotions, ergonomics, and design functions (Abidin, 2012). Karjalainen (2004) clarified that the designed object's form creation significantly emerges from the design quality; using the semantics transformation approach in an object's form, purposely for brand identity. In other design perspectives, the researcher has found that the semantics design is a fashioning approach on the transformation of artistic quality in product form performances. This semantics design could be easily way of design thinking that it enables to tell the abstraction of product form quality naturally. Meanwhile, for the meaning of the word "form", Abidin (2012) has coined the following statement, "Form in design means to shape or mould a particular model into a certain state or shape" (p. 365).

In identifying and emphasising the problem statement, the researcher has found a major concern that the Chief Designer, Ben Teo; (Benithem Sdn. Bhd.; an office furniture manufacturer) has stated about the difficulty to create or produce a beautiful design in the Malaysian ecodesign product market (Gomes, 2012; Chumiran et al., 2020). This realistic concern occurs when the Malaysian design manufacturer was involved in presenting their output product during the Malaysian International Furniture Fair 2012 (MIFF 2012) Kuala Lumpur a few years ago phenomenally. For the detail

statement, the Chief Designer, Ben Teo, explicitly expressed and described the enquiry statement, which is interviewed and translated by Gomes (2012), as follows, "The local market is still into elaborate designs that draw attention at first glance. But Westerners prefer designs that are clean, streamlined, functional, ergonomics, use materials that are sustainable. Those designs have a lasting kind of beauty. But they are actually harder to make" (p.03).

According to the above citation, the researcher was intrigued by the last points of the two sentences, which is, "Those designs have a lasting kind of beauty. But they are actually harder to make." Here, the researcher found that the novices or young designers were unable to define the semantics design thinking within an intangible product form in the SfPD development, where it is common for practicing designers to not be able to conceive or interpret ecodesign research within their role and responsibility (Chumiran et al., 2020). Due to the lack of understanding on the meaning of "beauty" in an aesthetic interpretation context, the novices or young designers are supposed to reinforce and enhance their creation of design communication in mind (Karjalainen, 2004; Storer, Lawson & Page, 2007; Karjalainen & Snelders, 2009; Chumiran et al., 2020). Then, the design communication can achieve their exact aesthetic interpretation following the intangible ecological form of design concept requirement, especially the identity of ecodesign concept. According to the evolution of Design for Sustainability (DfS), this situation occurred via the limitation of ecodesign approach in the product innovation level. Experts, Ceschin and Gaziulusoy (2016), had strongly exposed and elaborated the two specific impacts of pinpoints for the limitations of ecodesign approach in the reasoning of manufacturing sectors, which were cited as:

a) Lacks complexity, focuses only on environmental problems, and disregards problems which cannot be accounted for in life-cycle assessments (Ceschin & Gaziulusoy, 2016); and
b) Associated efficiency gains did not resolve the impact due to ever increasing consumption, has a technical perspective with a limited attention to the human related aspects (e.g., user behaviour in the use phase) (Ceschin & Gaziulusoy, 2016).

Besides that, the meaning of "beauty" was found in Abidin's Philosophiae Doctor (PhD) dissertation. Abidin (2012) began with the term "aesthetics" from Merriam-Webster (2006) to describe the meaning of "beauty." He intentionally quoted, "Aesthetics is a branch of philosophy that deals with the nature of beauty, art, and taste, and the creation and appreciation of beauty." Consequently, the researcher is required to elaborate three underpinned keywords relating to the earlier statement given accordingly.

Firstly, in the "Definition of aesthetic development and styling" subtopic, Abidin (2012) elaborated the word "beauty" links with the "styling approach" (Pahl & Beitz, 1996), which is an ideal set of choices made according to the stylist's criteria (design process), which reveals the semiotics of language (visual semantics: form development) under the engineering design platform. Using the quality object or perception strategies, this significantly caused a complementary of two major designing components between styling design (design process) and aesthetics treatment (development of form) through design communication, which had correlated together by embodying the process of developing engineering design, commonly enhanced and performed by the stylist (Abidin, 2012: Pahl & Beitz, 1996). For example, the opinion's decision is to select the product styling, whether it is "beautiful" or "ugly" as bipolar adjectives. Hence, to simplify the fundamental understanding of beauty, it means the nature of aesthetics is for implying a visual appearance or product's form, with differences in the styling approach that it scientifically branches to the emotion of human psychology (Abidin, 2012; Crilly, 2005). However, form interpretation is required to use the fundamental of morphing or semantics transformation for tangible explicit form study – which is identified as root "causes" contribution. In the product's form interpretation process, Karjalainen (2004) had empirically tested and measured the product form using the semantics transformation approach to define a product brand of visual communication. He elaborated the effects and factors of stylish attribution using the Volvo car styling and Nokia mobile phone designs to project the fashion of product brand identities. Hence, tangible product form can be obviously interpreted. Instead, it is very difficult for the designer to compare, "what is *intangible semantics form* exactly? How significant is the intangible semantics form?" Therefore, the researcher revealed the intangible form due to previous the problem statement by Toe (Gomes, 2012) that this "intangible semantics form" is positioned implicitly under environmental design heuristically.

Secondly, for the methodology of intangible ecological form, the researcher has found the "effects" on sustainable design practice, which is the ecodesign methodology that manufacturers generally use along the industry practices. The example has shown, Garcia and Filho (2008) successfully displayed different ecodesign information from the researched manufacturer practices. Both of them coined in ecodesign method elaboration topic that the preferable of different methodological approaches by different authors drove a confrontation with the environmental parameters in earlier ecodesign strategies upon a new product development. For the methodology implication into the product form of ecodesign thinking, the researched manufacturer had carried out a self-elaboration way of ecodesign approach, used observably. Hence, there was an inaccurate specific source from many novices or young industrial designers, delivered in various forms of product ecodesign entity (ecodesign product identity) that it is commonly based on quantitative goal setting (Garcia & Filho, 2008). Definitely, this sustainable design practice refers to the word "sustainable," as cited earlier in the statement, "…But Westerners prefer designs that are clean, streamlined, functional, ergonomics, use materials that are sustainable" (Gomes, 2012). Hence, an evidence of an example within the specific subject (the young designer) presented the consistently problematic supply chain and its problem tree characteristic. However, the researcher recommends the study platform to approach the recycling methodology, which is the reduce, reuse, and recycle (3Rs) method to suit and practice in the manufacturing field. For details, this recommendation will be emphasised clearly in the further chapter of the Literature Review.

In the problem identification, the "elaborate" word interpretation commonly referred to as the industrial cycle platform in green manufacturing activities (Scallan, 2003; Kalpakjian & Schmid, 2010). The new model era of ecodesign formulation has been transmitted with, "Form is to form a formgiving to form an ecological form of ecodesign" in the previous Descriptive Study 1 (DS-1) research conclusion for the sustainable design approach (Chumiran, 2016). Historically and as inspired by the Dutch designer, Mart Stam, who created the cantilever chair design, Mácel (1990) agreed that due to the design concept and material used, form follows function, as explicitly shown in the product form's characteristics. This is suitable with the kind of manufacturing process selection, and accordingly, enables the performance of a degree of manufacturing innovation in the design process and machinery's technology. Again, the metal tube material influenced the form of the cantilever chair design, as well as the

"power of form" (Mácel, 1990). For the industrial life cycle, The Office of Technology Assessment – OTA (1992), a non-profit research body entity, recognised and emphasised, "the common design practices" in an example given, "... the designers rarely think about how their products will be managed as wastes after their useful life is over and waste management providers tend to accept the composition of waste streams as a given (p. 39)". Obviously, it illustrates very poor understanding in the ecodesign product process together with the industrial cycle interpretation, when the designers lack knowledge on raw materials (physical materials) and waste management, The ecodesign product process demonstrates a very poor understanding, particularly when referring to closed-loop methodology practices. This complicates the ability to clearly encode and decode the semantics of design communication, especially within SfPD development, making effective collaboration and interpretation more challenging. which is actually be delivered in future ecodesign objectives settings.

For the problematic validation, the researcher approached the elaboration of *hierarchy evidence*[1] in the use of three paragraphs above mentioned. In the building of the hierarchy knowledge, this study uses the *Maslow's hierarchy of needs*[2] to visualise the structure and flow of hierarchy pyramid communication. Since the content statements were consistently aligned with the hierarchical structure, all three categories such as (1) causes, (2) effects and (3) problem identification, were systematically developed through Problem Tree Analysis[3] in as Appendix 2. Due to the phenomena-driven enquiries, the synthesising of problem statement should be managed and sorted according to each category of Problem Tree Structure respectively. According to the branches of taxonomy categories, the tree pattern will be assigned the point's attribution that it is allowed to deliver the (1) justification and (2) identification into the specific group category. These two complementary will be defined an exact framing of knowledge domain/area that to support the essential of philosophical assumption

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[1] Hierarchy evidence describes the scope of evaluation that the literatures came across from the broader knowledge sources or large study area vitally (Evans, 2002).

[2] Five levels of Maslow describes three categories, such as: (1) basic needs –physiological needs and safety needs; (2) psychological needs – love needs and esteem needs; and (3) self-fulfillment needs – self-actualization (Maslow, 1943).

[3] The Problem Tree Analysis is the visual aid (pictograph) for the investigation of three problem stages that it identifies the branches of attribution networking (Snowdon, Schultz & Swinburn, 2008).

(Creswell, 2003; Guba 2005). In order to define the synthesis of the problem statement from the phenomena heuristically following, an appropriate problem statement could be employed,

> *"Designers have a very inadequate understanding of how to encode and decode data using the ecodesign product process. It made reference to the closed-loop methodological practice, which makes it challenging to establish the semantics of design communication in the ecodesign identity of SfPD."*

Using the observation, the researcher attempted to test the problem validation using two hypotheses statement exercises. The puzzles of problem statement must be clear that it can be derived to develop the research question accordingly (Creswell, 2003; Hart, 2005). Hence, both hypothesis statements will be created some justification whether the existence of problem occurred or instead. The two hypotheses are as follows:

a) Null hypothesis:

> *"**If** the ecodesign identity in product form is absent, **then** the intangible ecological semantics cannot be effectively interpreted through an aesthetic product form."*

b) Alternative hypothesis:

> *"**If** the ecodesign identity in product form is present, **then** the intangible ecological semantics can be effectively conveyed through an aesthetic product form solution."*

As a result, the researcher found the existence of semantics product form study from literature reviews is that it can be examined by the simple heuristic evaluation under the "the method of product form identity concept" in an earlier background section. Therefore, the researcher rejected a "null hypothesis" statement, because the new model era of ecodesign formulation could possibly be delivered by the ecological form into the family of sustainable for product design (SfPD) concept. Hence, the researcher will use the "alternative hypotheses" statement to approach the DRM framework model accordingly, which is to begin from the impact; Prescriptive Study

(PS) stage and evaluation; Descriptive Study II (DS-2) stages for answering the problem statements using the further research questions provided. This exploratory of designer's human emotion refers to the young designer level that their actual method in intangible ecological form of design activities towards fundamental research is needed. The self-evaluation of hypotheses statements testing is made, and this is very significant due to the study has gone through a broad of design knowledge claimed and/or perspective. Therefore, the researcher have felt an existence the phenomena of design belief and theory that it could be interpreted as the validation of problem statement revealed by a fundamental of design thinking obviously.

1.2.1 The Knowledge Gap

To understand the knowledge gap, the researcher used the mapping concept from the interpretation of product form meaning context. This product mapping is called product semantics. Abidin (2012) agreed to coin the product semantics research by Wolberg (1998), is vitally important to the industrial designer since their roles and responsible deals with the image morphing algorithm (digital mode) in the product form and/or formgiving orientation. This product form image is beneficially developed in the interpretive sense of design knowledge (a logical mechanism in design belief) that the increased understanding of an intangible ecological form characterises the ecodesign identity through the human emotion of the designer.

In product semantics, two photographics (bipolar) between adjective and antitheses in product semantics are required – there could be built a design space in the middle. Besides, the blend-shape representation will be fitted-in and delivered the morphing algorithm attribution accordingly. Further, the expectation of middle photographic will be emerge a linear interpolation and/or extrapolation where the scaling or number of photographic (algorithm attribution) can be determined depending on quality review (Abidin, 2012; Chumiran et al., 2018). In the transformation of photographic quality, the middle space will be displayed the image of blend-shape representation following the form of product semantics patterns. Using by the semantics study intuition, the product form creation is divided in two categories; (1) the tangible form creation and (2) intangible form creation. The tangible form is referred to as the *explicit* semantics development from the product form's foundation by "direct" visual and/or mass of production physically and the intangible form represented the *implicit*

semantics development from the product form's fusion by "indirect" ecological system of artifact timeline environmentally (Abidin, 2012; Chumiran et al., 2018). Therefore, these two types of semantics product form had adapted with the fluid form transformation, which is called the morphing concept (Abidin, 2012).

A fusion design notion inside the feature of product semantics development has been uncovered and identified as the notable knowledge gap in the struggles to integrate beauty into product form. This bridge of knowledge gap occurred when two domain knowledges are triangulated between "visual elements study" and "principle solution study" concurrently (Chumiran et al., 2018). The visual element study represents the industrial design thing, such as the visualisation of morphing metaphor in quality of form (Akner-Koler, 2000). In the other hand, the engineering design thing refers the principal solutions study, such as algorithm morphing of digitisation in form integration (Muller, 2001). Due to ecodesign identity implicitly looks on the product form, there has been signed the fusion design concept in the morphing concept. Four characteristics of product semantics have been defined and addressed, such as: (1) 3Rs elements; (2) photographic based; (3) beam equation principle; and (4) beam structural elements in this fusion design concept (Abidin, 2012; Chumiran et al., 2018). The researcher is purposefully interested in observing an ecological form of ecodesign since it represents a contextual of environmental communication for the clues to ecodesign market trends, and it goes beyond scales of image extension in the ecodesign identity.

After familiarity with the context and meaning of earlier morphing concept, the researcher began to assess the existing knowledge gap in the problem identification. In the result of research conception segment, the sources of product semantics interpretation had been triangulated by two different design knowledges and/or areas involving: (1) a recycling methodology (Design for Recycling, DfR), which was screened by using the 3Rs method cognition that represented the system thinking from the engineer discipline; and (2) an evolution of form (artifact's quality review) from the designer practices, where it can emerge the understanding of form following the function within its ecodesign conception (heuristic approach) as representing the design thinking. Thus, the meeting point of fusion design concept (as ecological form identity theory and/or belief) is visually portrayed in the middle of two circles in the Venn diagram. For instance, some differentiations of thinking patterns (system thinking and design thinking) influence both of them in design theories believed or working atmosphere within the specific field background (OTA, 1992, p. 36).

However, the meeting point of subtract areas in Venn diagram concept are, "compulsorily needed to be studied and/or understood" around the domain of product form research study in the scientific literature review approach provisionally. The connection between two different domains preferably uses the bridge of knowledge as reference to the change for environmental communication (refer to Appendix 1) as the sign of ecodesign market, which refers to the bridge heuristic method and design experience triangulation (Chumiran et al., 2020). Also, a clear thought process about the fusion design concept mentioned is vital for the ecodesign identity to answer all the research questions. Therefore, the methodological continuum between qualitative and quantitative of data collections was the only way to solve, describe, gauge, and convince them on what the appropriate fusion design concepts are. Hence, they are supposed to bridge the knowledge gap holistically between the two design fields. There may also be articulated data used simultaneously in which the researcher will intentionally apply the mixed methods for the research methodology.

1.3 Research Objectives

According to the existing research segment of the DRM framework, the researcher intuitively placed another three research objectives concurrently, which are:

a) To frame the ecodesign identity method of distinguishing intangible ecological form through the human emotion of the designer in the SfPD concept;
b) To envisage the design scheme work model of fusions' ecodesign identity in ecological form knowledge as ecodesign information, in order to elucidate "an ecological form formulation" into the future NPD system that could be enhanced the development of ecodesign identity using the product form understanding; and
c) To transact the visualisation of bubble modelling that it delivers the DRM roadmap completion according three stages in DRM framework provisionally: descriptive study I (DS-1), prescriptive study (PS) stage, and descriptive study II (DS-2) stage.

Through the use of a Knowledge Domain Hierarchy for Research Objectives Mapping, this study aims to consciously develop a young designer's understanding of ecodesign, especially from the standpoint of semantic context, and to introduce them to a variety of industrial design (ID) orientations as practiced across Malaysian public universities.

In Appendix 3, verbs from the Taxonomy Circle that corresponded to particular cognitive levels were used to generate the initial study questions (RQ1, RQ2, and RQ3) (see Bloom's Revised Taxonomy or a comparable cognitive framework). These verbs were chosen with care to represent the breadth and depth of comprehension needed in the Subject (Knowledge) Domain.

The study guarantees that the research questions and the desired learning outcomes are in line with each other thanks to this methodical methodology, which also serves as a basis for the dissertation's methodical development. An in-depth examination of the ecodesign knowledge transmission in the framework of industrial design education at Malaysian public universities is supported by the mapping method, which also helps to clarify the study direction.

While staying consistent with the Knowledge Domain Hierarchy and the related prototypical verbs of the Taxonomy Circle, the following chapters of this dissertation will go into greater depth about each research question, including the methodological framework and analytical tools used.

1.4 Research Aim

The aim of this research is to seek and investigate "the ecodesign concept theory and/or belief" using the support and evaluation models on how an ecological form of ecodesign model can be formulated into the SfPD development to reveal the ecodesign identity in product form context. The function of the investigation is to recognise the exploratory of designer human emotion via a think aloud from the design manuscript.

In the output of DS-1 research, the researcher found the cantilever design principle from the empirical of descriptive statistics evidence, which is the primary dataset, that it synthesised with the form follows function representation. Based on the DS-1 stage enquiries, all attributions will be conveyed into literature review stage under the pyramid hierarchy (Maslow, 1943; Evans, 2002; Lee, 2005; Ceschin & Gaziulusoy, 2016) and emphasised with the DRM methodologies used with relevant data collection

according to the evolution of Design for Sustainable (DfS) (Ceschin & Gaziulusoy, 2016). Thus, three different categories of ID backgrounds or orientations in selected Malaysian public universities will be tested via the ecodesign concept theory and/or belief and its practice model implementation into the further PS and DS-2 stages simultaneously. The undergraduate students of the industrial design department are intentionally sampled on the respondents and/or participants, as well as sampling design's essential. An exact sampling will be provided and represent the approximation of the designer's human emotion, which meant that the method of intangible ecological form is important for any design field orientation.

Referring to research subject, the researcher begins from the selection of three departments of faculty backgrounds or orientations, such as: (1) art and design; (2) design and architectural; and (3) engineering design school establishments in Malaysian public universities. This study will be conducted to reach the sampling objective and its representativeness setting to describe how the subject findings achieve the ecodesign concept theory and/or belief (ecodesign concept existence) that would always refer to the intangible ecological form of ecodesign context.

Due to Malaysian public universities' learning approach being equivalent and/or in equilibrium with other global universities, this allows and delivers the supply chains of industrial design field/domain, where the Malaysian undergraduate programme offered has represented the body of knowledge in the world of industrial design research contribution.

1.5 Research Questions

The research questions (RQ) are developed from the belief of intangible ecological form modelling (bubble model, see Chapter 3) through the emergent theorising of fundamental and/or basic research that it significantly sourced by descriptive study I (DS-1) findings. The belief of intangible ecological form modelling implicitly underlies the interpretation of the designer's human emotion beyond the formulation. Therefore, the RQs' DRM framework of ecodesign research work phases should be divided by two segmented respectively. The researcher plans to apply the sequence specific questions following two different methodologies:

1.5.1 Prescriptive Study (PS) Stage

i) What stimulate of drawing process for the concept of ecodesign identity in the design manuscript?
ii) How do young designers inspire an ecological form of ecodesign identity by comparing design theme and pattern instinctively?
iii) Why choose the design pattern of semantic representative for the ecodesign identity?

1.5.2 Descriptive Study II (DS-2) Stage

iv) What is the drawing of the product semantics scaled in the concept of ecodesign identity?
v) Why classify the design theme for the fusion design in an ecological form of form identity?
vi) How to collate the semantic representative of ecodesign identity through the recycling methodology?

The function of RQs' DRM framework is to increase the measurable criterion performance in network of influencing factors modelled (Chapter 3) that both criterions of elements bubbled, such as form follows function (morphing metaphor as visual elements study) and 3Rs method and technology (3Rs method cognition as principle solution study) expectedly produces the ecodesign identity. Thus, it might be achieved an objective of the ecodesign concept theory and/or belief. In other term, this network of influencing factors modelled also familiarly known with bubbling model as well. Due to the further selection of qualitative and quantitative methodologies scheduled in Appendix 4.

Both phases of RQs' DRM framework will be executed with the sequential mode which is the process flow of the methodology have to be started with the belief of design phenomena into the theory of design perception (Creswell, 2003; Blessing & Chakrabarti, 2009). At the same time, the elucidation of knowledge domain for the research objectives and research questions by proto-verbs is required to display the mapping of the cognitive levelling and verbs related together with the contextual of

constructive alignment (CoCAP). These will be tabulated in further sub-topic of the thesis structure.

1.6 Definition of Terms

The multiple designs of cross-disciplinary research have created many definitions in the terminology key point, which clearly describe some scientific research. For the researcher, wide-ranging knowledge and/or fields of research are widely used. The development of common definitions develops in the middle of the research study period. The study will, therefore, coincide with the definition of terminologies for the duration of completion and compiles the aforementioned definitions accordingly.

1.6.1 Design for Sustainability (DfS)

In product design, sustainability means taking into account a product's environmental, social, and economic implications throughout its entire lifecycle, from raw material extraction to disposal. By the design thought process, a conscious design thinking within the 360 closed-loop philosophy concept applied to professional practitioners based on the principle of an ecological cycle system for a better environment, health and well-being to systematically avoid the harmful product (Lee, 2005; Ceschin & Gaziulusoy, 2016). Thus, the behaviour of human activities emerges environmental interactions through the use of design communication possibly delivered the messages for the environmental communication of sustainable product development concurrently.

1.6.2 Ecodesign Communication

Information on the creation of ecodesign principles (EDPs) for the reduction of environmental impacts via a sustainable design system promoting specific eco-labelling international standard: Environmental labels and/or credibility requirements (Bratt, 2011; ECOSIGN, 2018; Maccioni et al., 2020). For instance, ECOSIGN (2018) elaborates on the types of eco-labelling standards (Type I, II, and III) and their significance in conveying environmental information to consumers. Bratt (2011)

emphasizes the importance of the credibility of these labels in influencing environmentally conscious consumer behavior. Maccioni et al. (2020) discuss how eco-labelling is linked to product innovation and differentiation in sustainable markets. ECOSIGN (2018) explained the types of eco-labelling international standards related with market dynamic as follows:

i) ISO 14020:2000. Environmental labels and declarations. General principles;
ii) ISO 14024:1999. Environmental labels and declarations. Type I environmental labelling. Principles and procedures;
iii) ISO 14021:2016. Environmental labels and declarations. Self-declared environmental claims (Type II environmental labelling); and
iv) ISO 14025:2006 Environmental labels and declarations. Type III environmental declarations. Principles and procedures.

1.6.3 Fusion Design

The combination of two different elements, knowledge principles or critical thinking, reveals the design appearance from the shape of an innovative design entity that it represents the natural sources, energies and environmental needs. For example, the use of ecodesign identity for the automotive and/or car styling in the application of hybrid design (hybrid electric vehicle, HEV) that two source energies have combined between fuel energy (combustion engine) and electric energy (drive motor) to generate the mechanical powertrain for rotating the wheels to improve fuel economy and reduce emissions (Chumiran et al., 2020: Denton, 2004). Hence, the significant of car styling must be addressed and translated the product form of ecodesign identity which is the car styling of HEV appearance should be met with car styling concept as semiotic sign of product form quality. The example given is based on the theoretical knowledge of engineering design that it could engaged with the product form as formally used and practiced by industrial design field. Using the design concept method, the product form will take account on the articulated data from the engineering design field that the combination of the fusion design enables to embody the quality product form. Hence, there have a significant designing approach to the industrial design practitioners for designedly way of fusion design development.

1.6.4 Intangible Ecological Form

The conception of intangible ecological form developed from many years of decades. It reveals to encode the product form quality for conveying the intangible form creation using the extrapolative strategy which is the sustainable product development in the product form creation. The emergence of extrapolative strategy is based on the beyond continuum, as well as 'non-linear' and/or an 'indirect' ecological system of an artifact's timeline environmentally (Chumiran et al., 2018). In the observation of the design study, the description of beyond continuum is explained by bipolar photographic with the American Electric-Curtis & Crocker, electric fan – an early 1880 (invention) into the Dyson Multiplier AM06, a 12-inch bladeless fan that was introduced in the year 2009 (innovation). To demonstrate the evolution of an intangible ecological form, the study counts the years between 1880 and 2009, which is a period of 129 years. The total number of years is divided by ten: 129/10 = 12.9, and rounded off to the nearest whole number to get 12. Therefore, from 1880 to 2009, there are 12 entire decades. For the lessoning, understanding the long voyage of invention serves as valuable historical context for grasping the evolution of ideas and technology over time. Many inventions draw on the work of earlier generations, and tracking this genealogy can reveal information about the interdependence of innovation.

1.6.5 New Product Development (NPD)

A process system for producing a new product innovation for the new marketplace that engages with the various business strategies in a more realistic phase of market opportunities. It will involve expectations of consumer needs based on technology and competition for human capital. The fundamental goal of new product design is to create creative products that suit consumer wants, fill market gaps, or provide novel features or functionalities. The emphasis is on developing something new and potentially disruptive in the marketplace. Creativeness, innovation, and differentiation are typically focused on the new product design principles. As a result, in order to stand out in the market, factors, such as aesthetics, performance, or technological innovation may be prioritised.

1.6.6 Semantics Products Form

Semantics product form refers to items, designs, patterns, mediums, and artifacts used to identify product quality insight. In the beginning, the sign of product design for the increment patterns and designing performance that it psychologically encoded the design meaning for the product designer and/or user communication. Articulated data is expressed clearly or precisely in its context. There may imply data coding that is well-organised, arranged, or presented in a clear and meaningful manner. Basically, the product form or formgiving is the artistic quality of the overall visual appearance, in which it represents the fashion of a designed object to meet or express behavioural needs, emotions, ergonomics and design functions (Abidin, 2018). In product design, the shape or look of a product can elicit perceptions and affect design decisions. For example, the visual design of a website or the physical appearance of a product might elicit specific thoughts or connections in users or customers. These perceptions can influence how users interact with the product (a design representative to the product designers), as well as their overall pleasure or things acceptance.

1.6.7 Sustainable for Product Design (SfPD)

Sustainable for product design or environmentally friendly product design approaching the environmental methodological framework to prevent and minimise the environmental impacts of all three major pillars through social, economic and environmental considerations. The innovative product design combined with the environmental discipline and designing aspects to provide ecodesign communication using the life cycle of the quality product (OTA, 1992; Lee, 2005; Ceschin & Gaziulusoy, 2016). In other words, the outcome of dangerous and harmful environments results from human activities that deplete and damage the earth's natural resources as a substance in the environment. Therefore, the basic goal of sustainable product design is to minimise environmental impact and resource depletion across the product's entire lifecycle. The emphasis is on developing products that are ecologically friendly, socially equitable, and economically viable. Sustainable product design promotes environmental stewardship, resource efficiency, and social responsibility through ecologically sensitive practices. It seeks to reduce negative environmental and societal consequences while increasing beneficial outcomes.

1.6.8 Tangible Ecological Form

The term "tangible ecological form" in product design refers to the physical expression or embodiment of ecological principles in a product's design. It comprises a variety of design elements that emphasise sustainability, environmental responsibility, and ecological consciousness. It derives the explicit semantics designs evolve from the product form's base by "direct" visual and/or mass of production physically, as well as interpolative strategy (Chumiran et al., 2018). For example, designing products with modular or adaptable components to increase their lifespan and lessen the need for replacement. The modular components programme promotes the use of materials with low environmental impact, such as recycled or biodegradable materials, while avoiding those that harm the environment. Hence, the tangible ecological form in product design involves incorporating ecological considerations into every stage of the design process, from concept generation to manufacturing and distribution, in order to create goods that are both environmentally friendly and useful.

1.7 Scope and Limitations of The Study

The scope of this study includes the network of influencing factors which are addressing products form of ecodesign identity and it new intangible ecological form modelling to reach an objective of the ecodesign concept theory and/or belief through the designer's human emotion. There will be used the specific methodology selection, is based on the approximately relevant conception from the previous descriptive study (DS-1) as primary data. In this scope parameter study, the participants of young industrial designers will have to test and use the enquiries of research theory building (DS-1 Stage: conception segment) due to the convergence of the DRM paradigm research context.

Inspired by formgiving design knowledge as the state-of-the-art and design, elaboration of two DRM stages will be conducted by two different qualitative and quantitative methodologies using the sequential stage processes. By these scenarios, the researcher had found the limitation of the study that the qualitative approach orientation is predominantly influenced and controlled by exploratory methodology based on the fundamental research orientation.

Based on ecological design principles, the real-world design environment demonstrates an iterative, practice-led research methodology. Prescriptive studies (PS) are used to build intangible ecological forms, and then descriptive studies (DS-2) are used to evaluate them in real user scenarios. This is similar to professional design practice, which prioritises conceptual design over user testing, simulating and prototyping. Engaging sampled respondent groups (sampling) allows the research to gather useful information that guides the development of theories. This strategy ultimately seeks to match academic research with the realities and expectations of professional ecodesign practices, adding to the "body of knowledge" in sustainable design education and methodology.

Essentially, this PhD dissertation aims to complete the design theory building of conception research design from the primary dataset of DS-1 stage intentionally. This occurs due to the basic[4] relationship with applied[5] research platform has established an earlier basic empirical scientific inquiry consciously (Roozenburg & Eekels, 1995; Medin, 2012; Bently, Gulbrandsen & Kyvik, 2015; Chumiran at el., 2018).

Hence, in the ecodesign for ID, the complex knowledge area of intangible ecological form can fruitfully enhance a new SfPD programme into a DfS development eventually from the many ID disciplines; to facilitate the ecodesign embodiment in reaching a holistic design studies and/or design research. This intangible ecological form of knowledge is a phenomenal new distinction design. In the real world of ID eyesight, the evolution of the NPD into the SfPD is about standard compliance in the real environment, situation and requirements in many countries' national agenda worldwide.

1.8 Significance of The Study

The significance of the study is to recognise the ecodesign concept theory and/or belief that the latest intangible ecological form modelling, where it is beneficially useful

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[4] "Basic research is experimental or theoretical work undertaken primarily to acquire new knowledge of the underlying foundations of phenomena and observable facts, without any particular application or use in view" (OECD, 2001).

[5] "Applied research is original investigation undertaken in order to acquire new knowledge. It is, however, directed primarily towards a specific practical aim or objective" (OECD, 2001).

to the novices or young industrial designers in creating ecodesign products form as known with environmentally-friendly product designs. This is especially since the basic understanding of the semantics design thinking process emerges before, during and after the design cognition (the designer's human emotion), and the designers respond a certain designing behaviour during the development phases of ecodesign information. The elaboration on the designing method of ecological form model of these three points is as follows:

i) Initially, to set out the 3Rs elements/system strategy (recycling methodology context) with its own ecological form that it uniquely uses in SfPD development as design mechanism to break of the complexity creation of ecodesign identity. Thus, the effectiveness of producing the environmentally-friendly product reveal the ecological form by the heuristic approach consistently.
ii) A new modelling ecological form formulation exposure via formal ID education synchronises with the designer's competency in the professional levels and put a same par degrees of engineering design expertise. For example, fewer numbers of industrial designers in academia and an organisation will lead R&D working groups or teams or departments into the structure of NPD practiced-based.
iii) Lastly, the DfS growth systematically performs and delivers the closed-loop phenomena that the basic environmental data sheet might be contributed into the resource recovery and waste management. Therefore, the possibilities of new modelling ecological form will facilitate the fundamental of recycling methodology and system, as well as bring the awareness to the ecodesign identity holistically.

1.9 Philosophical Assumptions

The philosophical assumptions is called paradigm or worldview is essentially explained the scientific investigation which is the suitable kind of research methodology use (Guba, 1990; Cresswell, 2003). In this study, a key approach to the investigation and definition of the research paradigm is based on the human emotion of the designer as the belief. Using design and environmental communication in ecodesign, the researcher attempts to interpret the observational method that it could be addressed the intangible ecological form of ecodesign process phenomenologically (Schön: Abidin,

2012). This design communication called semantic design thinking that contains the transformation of the product form using morphological thought for the pictographic digitisation. The pattern of design metaphor in this study is based on the pictographic digitisation. For environmental design communication, it represents the ecological design information system that represents a commitment between human activities (recycling methodology) by ID context and environmental interaction context (sustainable design-three pillar components) through global warming and/or climate change emitted alongside greater global industrialism (Chumiran, 2016). However, this research scope specifically focuses on environmental design communication. This focus reasoning is structured by the bubble modelling of DRM roadmap completion according three stages in DRM framework intentionally. To connect with the human emotion of the designer as the belief, the expert Schön (1983: 1992) having been used the basic research to represent the fundamental of design thinking concept. He introduced the environmental design communication model, and the use of the theory is to solve the uncertain design communication as an attribution of the problem statement. Thus, the researcher must describe the puzzling philosophical assumption in this research topic with regard to the product form using morphological for the pictographic digitisation, as well as on the environmental design communication.

In an earlier stage of PhD research paradigm, the researcher is initiatively investigated, explore and define the attribution of inquiry that it may lead the teleological continuum of research roadmap sequentially. According to Burk (1988), the teleological continuum understanding possibly provides a logical mechanism for the consequences of philosophy starting from three puzzles of the doctrines of the ancients (attribution) which is it navigates the cause and effect to reach the notion of a goal. He described the ancient's doctrines with (1) "…the Form of *The Good* directly influences and *in-forms* things and events"; (2) "…a related theory, Aristotle's doctrine that *final causes* are needed to explain purposive growth"; and (3) " I puzzled long and hard over the Neo-Platonic Great Chain of Being, as used, for example, by Descartes in his *Meditations"*(p. 336). After the puzzling phases, Burk (1998) defined technically that he found a finite man journey, "An idea of an infinitely perfect God, that God must exist" to reach the paradigm outcome. Subsequently, all three components of the ancient doctrines will generate three other standard arguments, which are as follows:

a) "*The cosmological or first-cause argument*: everything that exists must have a cause, and ultimately a self-caused cause, which is the one infinite God" (Burk, 1988; p. 337);
b) "*The ontological argument*: since perfection is correlated with existence, if God is defined to be infinitely perfect, God must exist" (Burk, 1988; p. 337); and
c) "*The argument from design*: every entity was designed by a designer which has at least as much design-power as the entity designed, hence, nature must have a designer, namely, God" (Burk, 1988; p. 337).

For the belief and truth lesson, the researcher coincided with Burk (1988) to accept the standard arguments in this further philosophical assumption study in order to realise the paradigm or worldview. Burk (1988) stated that all these contemporary teleological issues are going to shift underlying an ancient and medieval philosophy to the assumption of ontological realism. By the "final causal" of the primarily research concept, the research study found that a firm qualitative structure, as well as basic research event can be shaped on the basis of the design thinking elaboration. Therefore, this lesson of teleological assumption is to clearly increase the believer's distinction that the teleological doctrines derive the philosophy hierarchy and it final-causal principle which has puzzled us all have to do with the role of values, goals, and purposes in creation, growth, development, causation, and action in the most general sense (Burk, 1988). Moreover, this lesson was consistently patterned with the same interpretation in mind that it was aligned with Friedman's design knowledge research (2000), as well as evidently coincided with the formalising outline of expert Fuller (1969:319) on the previous stated (refer to item 1.2). The fact was given with an earlier process of design, the formalisation of the notion had sequentially started the teleology research study into intuitive stage.

The term "final causal" referring to the ID teleology context of research is very important that the use of teleological explanation findings will be subsequently transformed a methodology traits philosophical assumption. However, in this research study, the researcher has found the emergence of "disclosure philosophy"[6] (DP)

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[6] "A definition of disclosure philosophy: The world is the most comprehensive being-complex (and thus meaning -complex) of all: it is the ultimate totalising horizon, more sensed than comprehended,

dominant. This design causation conveys a clear design inquiry and phenomena data sources (Burk, 1988) that how: (1) the ontological paradigm ("what is the nature of reality?") appeared; and let (2) the epistemological ("what is the nature of the relationship between the knower (the inquirer) and the known (or knowable)?"); while the (3) methodological ("how should the inquirer go about finding out knowledge?") shifting into the continuum transformation consistently (Guba, 1990; Guba & Lincoln, 1994). For instance, artifact digitisation of imaging disturbs the complexity and/or challenges in specifying the identity of the ecodesign as an intangible ecological form of ecodesign. This causal effect of design results from the environmental impact issues that the harmful product design will deploy our ecological system's instability. It means the solution of design and/or program is compulsory. Further, the design thinking (ID realm) and system thinking (ED realm) had successfully merged due to differentiated two design domains respectively to synchronise a design communication result. It has allowed the imaging visualisation of the aesthetic-product form study to be projected in the digitisation concept. Hence, an artificial intelligent (AI) knowledge has been revealed at the same time that the case example of an ecodesign identity is intuitively evoked by scientific DRM modelling to the human emotion of the designer. According to the latest movement of the era, namely, cyber-physical system (CPS), the knowledge of AI patterned specifically in artifact digitisation is originally oriented to screen the formulation of ecodesign modelling, as well as an intangible ecological form of ecodesign (Brandt et al., 2016; Chumiran et al., 2018).

Fundamentally, Garret (1975) introduced earlier DP phenomena by demonstrating the disclosure pattern example by using two domain components, such as: (1) economic environment (marketplace regulation) and (2) job opportunity disclosures (business systems) to enhance the understanding of financial security analysts for the domestic economic plan programme. The issued were raised from the National Economic Program – American Securities and Exchange Committee that the country faced the depression of market value phenomena (environmental) within the

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whose limits determine the nature and scope of what-is. "World," then, in the first sense, is a formal or transcendental notion in that it refers to the structure of any possible experience of being-in-a-world." Source: Philosophy and Phenomenological Research, Heidegger and the Modes of World –Disclosure (Bartky, 2012).

security system of business enterprise communities (employment opportunity disclosures), is bank investors and corporate group during the massive securities market (Garret, 1975). Due to a poor economic situation, Garret (1975) coincided with some solution, namely, the economic model of Roosevelt's leadership approach to pragmatism in business at the same time a "breathing spell" that all of these preferred from the economic expert Professor Herbert Stein (former Chairman of the President's Council of Economic Advisers). Unfortunately, the differences of opinion between the Commission and the securities industry have been challenged to a large extent. Therefore, the emergence of DP has been established and some approach to solve a depressing period is needed – *"There is no doubt that a major underlying premise of the federal securities laws is that full and prompt disclosure will best serve the purpose of both investors and corporate issuers. Not with standing some recent questioning of this philosophy, we are persuaded that the original assumption – that full disclosure permits investors to make informed and intelligent choices; discourages hanky-panky on the part of corporate management; and operates to reduce suspicion and generate confidence – are valid today as they were forty years ago" and "...unless Congress acts effectively to adopt a comprehensive and effective economics program, such as the one outlined by the President Ford..."* (Garret, 1975).

Similarly, the researcher has inspired the narrative reported by Garret (1975) into the sub-topic paradigm explanation study. From this lesson of DP concept within the paradigm pattern, the researcher found two tendencies of values in the DP, namely, (1) paradigm shift and (2) paradigm of design pedagogy; both were phenomenally exposed to the value reasoning that could be screened and revealed a complexity of current paradigm movement provisionally. The paradigm shift theme represents the SfPD timeline's history in many decades ago that it phenomenally develops the intangible ecological form of ecodesign by designing diversity (basic continuum in EoF theory) – using the artifacts digitisation in the CPS of fourth industrial revolution (Industry 4.0 era movement). While, in defining the ecodesign identity, the attribution of environmental communication arose between the designers and the engineers in green manufacturers' R&D categorises the topic of design pedagogy; Under the pragmatism platform – the ecodesign concept version among manufacturers may have been reflected in the ecodesign concept product form.

Nevertheless, this research paradigm showed that the artifacts of design are based on photographic digitisation (Abidin, 2012), which is to the designer interprets

the intangible ecological form of ecodesign identity virtually. However, Creswell (2003) had noticed to the researcher that this attribution happens due to a nature of paradigm's inquiry that each and/or every research topic have different design philosophical assumptions. He has coined the knowledge claim position (inquiries) that he determined four types of knowledge claim position, such as: (1) postpositivism; (2) constructivism; (3) advocacy or participatory; and (4) pragmatism. For this research paradigm lesson, the study identifies the processes of framework movement into the positivism (ontology) → postpositivism (epistemology) → pragmatic (methodology). Thus, the researcher defines this knowledge claim position is merely exposing the research paradigm attribution. Guba and Lincoln (1990) has, in some philosophical ways - ontological, epistemological and methodological - coincided and explained the basic inquiry paradigm with the fundamental questions and certain characteristics. In the alternative paradigm dialogue, he had categorised (1) positivism; (2) postpositivism; (3) critical theory; and (4) constructivism with four elements of a basic set of beliefs. Hence, the further stage is to identify the nature of research topic to generate the reality and the nature characteristics of research concept. Using the design phenomena, this research paradigm identification obviously contained some nature characteristics and/or criterion including (1) a pragmatic; (2) coherent (3) spatial profiling; and (4) disclosure approach.

For realisation, the philosophical assumptions and/or research paradigm study is actually to address a new degree method distinction of product's form quality that the emergence an intangible ecological form of ecodesign can be visualised and believed by the designing theory model, as well as the conceptual of bubbling model. This may appear a "reality" question memorising to the significant of design topic and research paradigm concurrently, such as "what is the exact problem to agree and/or accept this intangible ecological form of ecodesign identity?", "what is the contribution of design knowledge that it can be used for the academician?" and "how to approach the logical methodology on the heuristic method in the study of pragmatic design-based research? Therefore, the lessoning study of research paradigm must begin from the positivism of ontological paradigm that there should formally explained on what is *reality* that has happened (Guba, 1990; Guba & Lincoln, 1994).

1.9.1 Ontological

The ontology explanation describes and realises the morphological photographic digitisation occupied in this artificial intelligent knowledge (design information system) in the world context of the ID field. Using the design artifact, the intangible ecological form of ecodesign identity is phenomenally emerging where it implicitly explains and networks the evolution of the NPD. Besides, the identification of the design artifact is very important that the extraction of the data set could be projected, and the design typological phenomena could be categorised to represent the nature inquiry of articulation data needs (Abidin, 2012; Chumiran at el., 2018). This design phenomenon occurred when the design process was non - linear, it was slightly difficult to trace and screen until the heuristic evaluation intuitively triggered the design element and/or principle (Lockwood, 2010; Abidin, 2012). At the same time, the AI knowledge correlated semantics and semiotics pattern languages that the human emotion of the designer approaches the communication of design to realistically engage the artifact of design for the nature of teleology (Burk, 1988; Friedman, 2000).

Regarding to the above scenario, the researcher realised that in this research study the positivism beliefs had occurred. The ontological paradigm refers to the kind of critical realist that is, but "can never be fully apprehended" (Guba, 1990). There have been navigated under the laws of nature where it "can only be understood incompletely". Some reality of design beliefs facts have been found in this ontological study, namely, (1) the element of design; (2) the principle of design; (3) design Gestalt laws; and (4) design timelines. Plausibly, in the design thinking process, the young designers can naturally think of the design beliefs as well. This design cognition thinking, as non-linear of the iterative process, will simulate design beliefs for designers to demonstrate their design concept accordingly. Thus, a design concept objective is to fit the form follows function that it can obviously deliver an aesthetic value and the valuable product system.

For evidence, the case study of designer Mart Stam might be described four components of ontological study according to the design artifact; (1) cantilever chair design; (2) 3Rs method; (3) semantics; and (4) sustainable product design. It demonstrated an ecodesign concept through the visual elements in the designer's thinking as design communication (Abidin, 2012; Chumiran at. el., 2018). The reduction of materials had approached heuristically and allowed the recycling

methodology to understand the ecological form of ecodesign identity (Chumiran, 2016; Chumiran at. el., 2018). Besides, on the green manufacturing sector, an increase in the understanding of semantic knowledge was developed using the broader design information system that the design practitioner tried to engage the 3R elements with the ecodesign identity (Chumiran, et al., 2014). This ecodesign identity called intangible ecological form has truly inspired environmental impact issues to derive new SfPD distinction as well - known as environmentally friendly product. The manufacturers of Malaysia had been statistically sampled using cluster sampling and had triangulated with other purposeful sampling to systematically demonstrate accurate results of design phenomena (Chumiran, 2016). It interpreted scientifically in a few testing methods by the statistical thumb rules. This positivist source from the "worldview" is to explore phenomenally the WHAT real situation of the perspective or belief of the designers; following FIRST major component of building consistency, namely, WHAT is the logic improvement? Evidently, the findings shown from the sample studied consistently used and accepted to bear the design belief realistically.

The case study above was based on the critical realism. It had stated "a "real" reality but only imperfectly and probabilistically apprehendable" (Guba & Lincoln, 1994). Instead, the epistemology underlying this ontological paradigm was assumed that the world of design activity phenomena used the "re-thinking approach" to solve environmental issues. It has been shown symbiotically shifting the 3R elements to create the design concept of the SfPD (ecodesign product) in ID formalisation. But there will be some question like why the creation of the SfPD did not follow the previous and/or existing scientific research under the concept of life-cycle assessment (LCA) methodology? This situation was described clearly by Guba (1990) that this "reality exist but can never be fully apprehended. It is driven by natural laws that can be only incompletely understood". In the other word, what things came out of the box from a real world and where they arose intentionally from a kind of natural causes – in the central concept, designers (human being) will define an essence to perceive their prediction, realisation, sensory intuition and intellectual mechanism (Cook & Campbell, 1979: Guba, 1990). A further discussion therefore describes what is the theory formulation of the ecodesign model to create ecodesign identity? and how can we know the method of theoretical knowledge practices in the ecodesign identity?, that it could be explained realistically in the epistemological paradigm. Thus, in this research study, the design phenomena eyesight must be realised by using the ID area.

1.9.2 Epistemological

In this epistemology, the researcher found that the EoF theory study had validated the identity of ecodesign using a two - pole design continuum between geometric form and organic foam (Akner - Koler, 2007; Abidin, 2012). By the design continuum theory of EoF, it visualises the type of development of multiple shapes during the morphing design process and allows the semantics thinking process to study accordingly. In other words, it defined how practitioners apprehend the very basis of semantic design knowledge within which confidence refers to "something that we should understand". Form here, two epistemological relationship have been traced that (1) "the knower – inquirer" focuses to practitioners belief, such as industrial designers, engineers, product developers, project managers and managers of production where they work together or individually in the roles position of the manufacturer organisation (R&D team members) and (2) "known - knowable" is described as human approach, behaviour, activity or productivity to existing or certain systems (3Rs methodology and design principle) in the common manufacturing environment that relate to business operations. These two relationships deal with the nature of the inquiry paradigm being generated significantly (Guba, 1990; Guba & Lincoln, 1994).

First, the researcher tries to describe the context of the knower as mentioned above. This explanation is based on the inquirer's interaction and is investigated in the philosophical assumption's postpositivism (Guba, 1990) - postpositivism is supplied and/or sourced from a realistically ontology. For example, the creation of the EoF theory possibly approaches a new distinction between design formulation and 3R element of the design practices that allows the understanding of WHAT the practitioners to achieve a sustainable design goal. Through artifact digitisation, this EoF theory had demonstrated that the elementary of the internet of things (IoT) was approached in order to simultaneously develop design and environmental communication. These data sets can be displayed under the domain of AI knowledge using semantic design thinking, which is the morphological product form that develops imagery of a design belief and/or perspective into the human emotion of the designer (Burk, 1988). The combination of both design evolution qualitative and morphing algorithm quantitative could facilitate heuristically the interpretation of ecodesign identity. The subject of the R&D team members thus makes it possible to communicate the type of environmentally friendly product using the 3Rs methodology, which is the conceptual formulation of bubbling

model, is suitable for interpreting the quality of VE practice. It is necessary to clearly define the 3Rs element of design practices that the quantitative approach inquiry has emerged and allow morphologically inspects the emergence of VE in the principle of cantilever design. Usually, the 3Rs principle is representative of the algorithm studying semantics in the natural language. According to Abidin (2012), the perception of semantics is required to measure and/or gage the design needs purposely explain the answers with the scientific rigorous. From here, as knower, the notion of design communication between two design cognitions, such as design thinking (designers) and system thinking (engineers) has remained and navigated simultaneously under the NPD design program and particularly SfPD philosophy. Therefore, in the second epistemological connection, further dissertation will explain the hermeneutic stuff on HOW the designing knowledge arose and previous one could be interpreted consequently.

Second, the researcher identifies the implicit and/or explicit data set that the practitioner believes to use the recycling methodology and design principle in the NPD roadmap together. The implicit and/or explicit components were derived from the nature of the paradigm investigation. By the known–knowable, the particular objectivism epistemology can hermeneutically describe the essence of the phenomenology being practiced during the procedures of design, as well as human activities. The design formalisation (explicit) logically inspired the manufacturing operation to create the ecodesign identity form within the SfPD program. It's displayed a goal that could implicitly be accepted by all practitioners to engage the design concept form (cantilever design principle – form follows function). This example of case study started with Heskett's (2002) design formalisation. The notion that this characteristic allowed the researcher to evoke the epistemological assumption accordingly was very grammatically language. For validation, acceptance of design processes along an intuitive design process can be measured statistically using the quantitative method. About a known, on what kind of sampling perception among practitioners, a theory building will be generated to test the structure of quantitative analysis, which means that some variables are compulsorily inspected in the form of the theoretical framework methodology. It was the deduction reasoning strategy and in setting for appropriate or multiple test techniques the design sampling could be used to objectively achieve the responses of study issues sensation. Once the investigation is completed, the findings will be presented and shown the rigorous scientific answers that uncertain and/or certain

knowable acknowledge the design concept (output) of the research study: thing as the truth of design theory - so their beliefs are actually anchored. On the other hand, in the formalisation of design, WHAT really is reality happens to produce the form of ecodesign identity.

Therefore, the epistemology study from this research lesson is about two folds of hermeneutic things, such as: (1) the notion of design communication-two design cognitions: design thinking (designers) and system thinking (engineers) and (2) the design conception occurred in evidence of reality. These two epistemological findings strongly reflect an altered objectivity. The inquirer's interaction was shown and investigated together, allowing "to strive to be as natural as possible" (Guba, 1990; Guba & Lincoln, 1994). Hence, the observation of postpositivist stance are clearly occurred when the investigation of the values' underlying and predictability to a real social world through the epistemological findings (Ryan, 2006). However, this previous study used the DRM which is the empirically explanatory of design sciences that is related to design interaction or/ and design object/artifact orientation (Blessing & Chakrabarti, 2009). The results of the DS-1 stage findings (primary dataset) will be used in additional assumption of methodology. The thick description pattern (inconsistency and superficial essence coding: unknown specific 3Rs activities) provisionally satisfied the inquirer data set, which meant that the qualitative reasoning will be addressed and that the design knowledge will be sought in accordance with the basic research (Chumiran, 2016). Therefore, the essence of design events can be depended on to the critical tradition in order to empirically test the design theory construction from the source of industrialism setting for the relevant - following SECOND major component of building consistency, namely, WHY the coherent of ecological form identity? Furthermore, there will be more questionnaires from this research study to perceive that HOW will the modified experimental/manipulation emphasise the postpositivism imbalances in the methodology stage?

1.9.3 Methodological

A main reason for the methodological assumption opinion has been assigned by the research inquiries is to explain a new method distinction of distinguishing intangible ecological form of ecodesign using digitisation pictographic based. It had been phenomenally believed and precepted when an artifact design object has vitally

"articulated" with their design approach in every product form case study (Friedman, 2000; Abidin, 2012). According to Creswell (2013), the artifact study is under the pragmatism of methodological assumption.

The source of new method distinction introduction had emerged from the conception of design research segment as DS-1 stage (methodological triangulation: positivism and interpretivism epistemologies) previously. It developed an intangible ecological form of ecodesign formalisation which means the ecodesign process modelling notion addresses the ecodesign identity as well - following THIRD major component of building consistency, namely, WHAT a designing methodological traits? In ID psychology context, the designers must be essentially creative and innovative of design practise as state-of-the-art ecodesign. A biological diversity of design concept derives the designer to create the new product development. When the fashion of design concept arose from the environmentally friendly product design (environmental impacts) along the green manufacturing era, a designing world fashion has immediately shifted an ID field perspective into the sustainable for product design (SfPD) development, namely, a fusion design (Chumiran, 2016). Here, two folds of methodological assumption reveals from an earlier stated scenario that the designer's human emotion will be emphasised a design process area particularly in this enquiry of philosophical reasoning with (1) perception; numerical method study and (2) belief; non-numerical method study.

First, the numerical method study normally measures the perception of human design experience in order to address a certain value and/or number of scientific testing methods and has an impact on the research study. This fieldwork activity gathers the generalise of probability sampling from a certain referred setting location within the sampling population. The sampling size has usually been taken from the number of competent practitioner designers where the population and/or demographic of the subject could be described statistically as a real-world perception underlying the truth human activity of phenomena design. The variables interpretation of the value is based on mathematical thumb rules. Using the quantitative method and design approach, an iteration of the design process will empirically aim a design roadmap objective that it tends a comprehensive structure of the intangible ecological form of ecodesign theory. Comprehensively, a quantitative structure nature allows and represents the six design iteration perspectives – convergence thinking perspective model (Friedman, 2000; Wynn, Eckert & Clarkson, 2007; Abidin, 2012; Chumiran, 2016). This quantitative

reasoning, such as system thinking will therefore facilitate the complexity designing method for navigating a design thinking research. It could describe and anchor the distinctive intangible ecological form of ecodesign (a goal) by effectively solving the descriptive exploratory of statistic design method. There are a few common practices in the mathematical approach for the numerical characteristics, including theoretical framework, statistical computing, deduction strategies, semantics algorithms, frequency variables, hypotheses, countable languages and theoretical building. Instead, it is logical that the understanding of descriptive study will not explain the human emotion of the practitioner that HOW does the competent designer can realistically demonstrate the designing method itself (Blessing & Chakrabarti, 2009; Abidin, 2012). Eventually, there was some interviewed session (qualitative approach) from the outcome of methodological triangulation – due to the thick pattern of description (inconsistency and superficial essence coding: unknown specific 3R activities) specifically influenced the additional inquirer data set in methodological reasoning (Knox, 2004; McIntyre, 2004; Pathirage et. al, 2008). This qualitative approach operates in describing and supporting the DS-1 result interpretation of the value generally. It therefore intended intentionally for the obvious interpretation of value under the coding of the first cycle (Saldana, 2009).

Second, the non-numerical method study explains the human emotion of the designer that an exact belief interpretation of the conceptual basic research study is addressed by the quality of the designing method experience. The grounded method is usually required to explore the purposive sampling (sampling frame) from the representative and/or element geographical population of the essential subject with a specific focus group study, as well as non-probability sampling study. The text manuscript will be evaluated by verbal protocol analysis (VPA) to search for the element of prescriptive attribution using the coding content analysis phenomenally. The attribution is intuitively important because the implementation of the induction strategy could bring the enrichment within the design belief itself on the designing method experience. A rigorous heuristic evaluation usually defines non-numeric characteristics, such as conceptual framework, coding of themes or categories, induction strategies, coherent design research, branch taxonomies, morphing artifacts, design evolution, and languages of quality for the interpretation of the industrial design meaning context. Due to the development of artifact design, the researcher uses the context of industrial design reasoning under the needs of the engineering design platform. Hence, the researcher

realised by the logical justification that the identity of the ecodesign was screened by the exploratory of methodological assumption according to semantics thinking orientation under the qualitative reasoning and its designing practise method: a clinical method is required to hermeneutically describe a semiotic, metaphor pattern, grammatical formalising and pictographic - based.

Consequently, this study used the DRM which is the empirically explanatory of design sciences that is related to design interaction or/ and design object/artifact orientation (Blessing & Chakrabarti, 2009; Abidin, 2012). The DRM aims to explain and cause problem solving the complexity of design research activities from the assumption of phenomenology systematically. According to Blessing and Chakrabarti (2009), there were four stages of DRM framework, such as: (1) research clarification – RC stage; (2) descriptive study I – DS-1 stage; (3) prescriptive study – PS stage; and (4) descriptive study II – DS-2 stage. To relate in this research topic, the purpose of methodology used is to increase the understanding of ecodesign complexity phenomenally that it moved surrounding the design research parameter between conceptual framework and the formulation of bubbling model. By right, this DRM initiative emphasises the analysis of the premise of methodology that it is to conceive of the above situations, followed by Guba (1990); Guba and Lincoln (1994) in this research study. In the fundamental views of postpositivism, Guba (1990) outlined a methodological explanation - the Paradigm Dialog book - that the methodological was divided by two categories of responses, namely, (1) critical multiplicity as referring to critical realism and modified objectivity; and (2) objective investigation as achieving realism within four components of imbalances with; (2a) "the imbalance between rigor and relevance"; (2b) "the imbalance between precision and richness"; (2c) "the imbalance between elegance and applicability" and (2d) "the imbalance between discovery and verification".

Hence, the researcher identifies the specific redress imbalances of methodology as "the imbalance between precision and richness" due to method of research design approach within the roadmap of DRM framework accordingly. Based on the fundamental or basic research orientation, this methodological reasoning emerged from the PS stage study sequentially shifts into the DS-2 stage study. The clinical method is required to engage and pivot the roadmap of DRM framework so that a proper term qualitative method will be performed during the research design activities and/or processes (Guba,1990; Guba & Lincoln, 1994; Kurby & Zacks, 2008). In order to

address the quality of the design method experience in qualitative data collection, this clinical method is suitable for experimental VPA (grounded theory). For sampling method, this study will use the non-probability sampling for the numbers of participant which is the characteristic and/or element of sample size (purposive sampling) is to be required in our public university's representatives setting. By the level of method-terms suggested by the experts, the researcher realised to apply the grounded study as a qualitative design research platform. However, the paradigm-term level, as well as the paradigm shift did not reflect this level of method-terms. The main goal study that meant between precision (quantitative approach) and richness (qualitative approach) has just been defined as a complementary logic for achieving scientific research design in pragmatic paradigm. Due to the priority of pragmatic paradigm refers to a philosophy known – What works in a worldview?, as pragmatism places an emphasis on problem-solving and inquiry while promoting the growth of understanding by experience and in-depth knowledge through reflection and thought (i.e., critical thinking). Moreover, no naturalistic paradigm changes have been made to these two (precision and richness) categories of redress imbalances because the application is specifically based on the last basic postpositivism beliefs system, which is the modified experimental/manipulative, an emphasis on critical multiplism. Redress imbalances by doing inquiry in more natural setting, using more qualitative methods, depending more on grounded theory, and reintroducing discovery into the inquiry process" (Guba,1990; Guba & Lincoln, 1994).

1.10 Ethical Consideration

Ethical concerns are critical in PhD dissertation research to preserve the integrity of the research process and to protect the rights and well-being of participants and/or respondents, if appropriate. The research study prompts the Ethics and Publication Unit's (EPU) evaluation of ethics documents in Appendix 6. The unit's responsibilities include improving the performance of in-house UiTM journals and the UiTM Research Ethics Committee (REC) Secretariat, which manages ethics application submissions, organises REC meetings, maintains REC documentation, prepares for audit, organises REC Member trainings, and provides other secretarial support.

The ethics research duration must include data collection following an ethics sanction that occurs within 12 months of the validity period, which runs from 21 October 2020 to 31 August 2021. The purpose of this study is to investigate the

ecodesign identity method of distinguishing intangible ecological form through the human emotions of young industrial designers in the SfPD identity concept, as well as different ID orientations in ecodesign communication among various three Malaysian public institutions. As a consequence of the two components indicated above, it should avoid and safeguard something from harm, hazards, and any consequences for the participating subject. In instance, a proper ethical case study technique might be simulated and used to the conduct approach design strategy. Some ethical considerations for the PhD dissertation research could include:

a) *Informed consent* - Making certain that participants and/or respondents consent to participate freely and without being forced to do so, and that they are fully informed about the goals, methods, risks, and rewards of the research.
b) *Confidentiality* - preserving the privacy and confidentiality of the personal data and information of the participants and/or respondents, including their answers, names, and any other sensitive information gathered for the study.
c) *Respect for participants and/or respondents* - recognising the contributions of study participants and/or respondents and treating them with decency, respect, and compassion at all times during the research process.
d) *Minimisation of harm* - reducing any possible risks or harm to participants -both psychologically and physically - and offering help or referrals in the event that negative consequences occur.
e) *Cultural sensitivity* - Acknowledging and honouring participant diversity and cultural variations, as well as modifying research techniques and protocols to make sure they are respectful of and appropriate for various cultural contexts.
f) *Compliance with regulations* - respecting the applicable institutional policies, rules, and ethical guidelines governing research involving human subjects, animals, or sensitive data.
g) *Conflict of interest* - disclosing any possible financial or other conflicts of interest that might affect the findings of the research or jeopardise the study's objectivity.

These are a handful of instances of ethical factors that scholars ought to meticulously examine and incorporate into their doctoral dissertation investigations.

Following moral guidelines maintains the ethical norms and obligations of researchers toward participants and the larger community in addition to guaranteeing the validity and reliability of the research findings. The upcoming Chapters 3 and 4 will provide an explanation and description of the specifics of ethics practice. Therefore, the research topic technique must fully comply with the DRM framework and the flow of research activities.

1.11 Thesis Structure

The previous DS-1 stage of DRM framework had accomplished from the Malaysian industry players as called the organisational who are represented the office furniture manufacturing via R&D department communities. There are completely tested by the initial theoretical framework to measure the variables following the reference and/or impact model (bubbling modelling), probability sampling and descriptive statistical analysis of testing methods. The study of DS-1 stage aims to the professional industrial designers to shift their knowledge and working experience of design discipline through the conception of knowledge transfers in industrial design field. For the result, the findings are based on the expectation of research outcomes that refer to which type of ecodesign practice actually enables the addressing and achievement of the best ecodesign practicing for the Malaysian public institutions and/or design school thought; this puts a focus on the formgiving concept. The following is the research finding from the abstraction of DS-1 stage phase:

> *Finally, the "cantilever principle" and "3Rs loop cycle" are the two major findings that answered the research questions in formulation of ecodesign. However, this design theory interpretation must be focused and scaled under the ecodesign concept. Therefore, this basic qualitative structure output has matched the researcher's hypothesis statement that "3Rs method succeeded to address an ecological form of ecodesign within it industrial cycle or ecological cycle methodology; by cantilever design concept, it transmitted formgiving concept at wider sustainable designs knowledge, methodology lesson and processes holistically." Hence, the research outcome delivered and exposed the potential improvement of resource recovery and material waste management to save our planet's ecological systems (Chumiran, 2016).*

In the PhD dissertation study, the creation of thesis structure naturally oriented by the qualitative methodology that the investigation of the explanatory method of the designer's human emotion (subjects' participant) in ecodesign identity creation specifically. Using the understanding of psychomotor from the designedly way of design thinking, the significant research study is purposely screening the pattern of think aloud. Then, it was synonymly emerged the method of design research called the prescriptive study that it came from the distinction of second stage under the DRM framework. To relate with the nature of the study, which is revert to qualitative methodology, the researcher identifies some of the participant of study (young designers) are being influence of the research topic and/or title into the design experience via think aloud. Through the scenario, the researcher has inspired the knowledge disciplines of human insight to shape this thesis structure. It was started from the pattern of fundamental and/or basic research tradition. Thus, the thesis structure characteristic is formed through on design thinking holistically. The unknown and mysterious of form imagery by the young designers makes a logical of think-aloud, in which the exploration of design experience must be interpreted by the qualitative methodology.

Abidin, Christoforidou and Liem (2009) and Abidin (2012) preferred to use the VPA method, is to utilise an exact figure of design representation (media-based or AI material sources) into a meaning of the tacit knowledge (one's idea of product form) following the development of morphing concept. According to the previous experts' suggestions, there are some analogical and funnel thinking that would allow the emergence of the key design questions. There have been obviously developed and circulated thesis structure along the research theme or topic on: (1) how it works; (2) how can the method be approached; (3) how to validate the method; and (4) how to use the feasibility method. However, balancing the visible and invisible components of the knowledge domain necessitates a complete approach that considers both explicit and tacit knowledge. Organisations that effectively manage these components can use their knowledge resources for innovation, problem-solving, and continual improvement.

In Chapter 1, an earlier research study sourced from the literature review had mapped in the deduction of DS-1 phase to enable the framing of the PhD dissertation following an impact of inductive dissertation of PS phase under one programme of the DRM framework phases. In the literature review mapping, the variables of data set sources had interacted and inspired the pattern of the theme, as well as qualitative

grounded theory naturally. By heuristic study, the thin description bridges to engage the synthesising of literature review which is the decoding and/or encoding identification is essentially required. Thus, the pattern of thin description navigated the development of problem statement, is revealed from the knowledge of system thinking that it is hidden in the knowledge of design thinking as opponent process of mind perspective. Typically, this chapter introduces the research topic, offers background information, outlines the research questions or objectives, discusses the significance of the study, and previews the thesis framework. However, the research proposal requires a formal document that specifies what you intend to explore under your research topic. Therefore, the content has approached the contextual aspect of constructive alignment implies that the alignment should consider the specific context of the researcher/learners, the subject matter, and the educational environment. Alignment in this study is contextually grounded by customising research and educational approaches to satisfy the complex requirements of Malaysian industrial design institutions and students, rather than only being theoretical. As a strategic tool for mapping the Knowledge Domain Hierarchy according to levels of Low-to-High Order Thinking Skills (LOTS to HOTS), a Matrix Schedule is presented in order to operationalize this framework in Appendix 5. Apart from this dissertation scenario, an elucidation of knowledge domain hierarchy for the research objectives and research questions by proto-verbs will be mapped together to clearly demonstrate the structure of organisational in research design study for the dissertation of literature review, as shown in Table 1.1.

In Chapter 2, the dissertation literature review chapter provides a complete review of relevant literature, and theoretical frameworks linked to the research issue. It synthesises previous research, finds gaps or controversies in the literature, and provides the theoretical framework for the study. Using the knowledge of sustainable design principal orientation, the researcher employs practiced-based design thinking to screen the certain and uncertain complexity of ecological form literally. With regard to the current research issue, the study chooses a suitable time to perform a critical literature review (CLR), which should involve a thorough evaluation and analysis of the body of existing literature (a grounded theory, heuristically), often with a particular theoretical or methodological focus. It is recommended to use the keywords' articles for three thematic analyses (3Ts) Coding Scheme for LRS, such as: (1) thematic cycle coding: categorisation of keywords; (2) thematic co-occurrence analysis: abstraction of key

groups; and (3) thematic cluster: conclusion of key findings, in accordance with the research study's scenario. A literature review strategy (LRS) is required. Thus, the 3Ts Coding Scheme Strategy study focuses on keyword wording accessibility aspects during the coding scheme stages, which imply the causal statement and pattern explanation as significant statements for the field or domain representation in the qualitative technique.

For Chapter 3, the dissertation methodology chapter explains the research methods and procedures used to acquire and analyse data. This section covers information on the (1) research design; (2) sampling strategies; (3) data gathering methods (such as think aloud observations and clinical surveys); and (4) data analysis approaches. Actually, the chapter presents the concept of design insight, the designer's human cognition, and the reasoning of research technique in the context of an intangible ecological form of ecodesign. The study's goal is to recognise the ecodesign identity phenomena utilising a systematic technique known as design research methodology (DRM), which is suitable for young industrial designers who comprehend design iterative evidence. However, the conventional Heskett model derived from the old form of the master model into an innovation of ecodesign circular process, namely, "form is to form a formgiving to form an ecological form of ecodesign" as the ecodesign identity information (the change in environmental communication) is grammatically recognised as a noun-verb-noun-transitive verb. This was motivated by the creative design thought of rethinking waste. This study issue uses the DRM to support the design belief (goal setting) using a knowledge of the empirical design testing method because of the nature of design studies. Currently, the bubbling model's key component is its explicit display of the study area and niche through its criteria and elements. In research methodology, the development of an operational flowchart for the bubbling model is crucial. It is recommended that the holistic analytical approach be used when utilising specific empirical and/or experience methods to obtain solid evidence (validation), particularly for new design theories that are developed in accordance with research design flowcharts.

In Chapter 4, the dissertation's data acquisition chapter explains and investigates the pattern of data collection utilising certain approach methods to collect the dataset that would meet the direction of procedural steps according to the methodology model. Based on the appropriate design sampling, a proper procedural step can be applied to a special focus group of non-probability sampling, meaning participants who have seen

qualitative technique, which is the VPA method. While the same group of participants can be switched into cluster sampling of probability sampling, as with respondents in the designing clinical survey (DCS) at the fieldwork study. These two complements of topic terminology can be found realistically during data collection design, which is commonly known as sequential mixed methods (MM) sampling. Thus, the goal of data collection is to identify, divide, and present two dataset patterns: (1) metaphor visualisation as a visual elements (VE) study that represented design thinking knowledge in the industrial design field; and (2) bipolar digitisation as a principle solution study from system thinking in the field of engineering design. The methodological reflections chapter focuses on the researcher's experiences and obstacles encountered during the research process, as well as any ethical considerations or methodological restrictions.

Chapter 5 in the dissertation reveals the results and data analyses, this chapter displays the research findings, which are often organised according to the research questions or objectives in the fundamental and/or basic research as qualitative approach. It comprises data analysis and interpretation, as well as tables, figures, or other visual aids to highlight critical findings. The research study uses inversion thinking to reduce the steps beyond a VPA capsule strategy. The inversion thinking method can motivate research to come up with unique ideas that are not immediately evident by rephrasing challenges and encouraging them to think creatively and beyond the box. The use of the inversion thinking model in VPA capsule can significantly increase data analysis depth, quality, stimulating creative solutions, ensuring systematic analysis, and enhancing think aloud of verbal protocols. This strategic approach leads to a more in-depth and nuanced understanding of the research data. As an outcome, an explanation of datasets will be structured to produce unique responses, allowing it to answer research questions within the scope of its goals in the fundamental prescriptive of qualitative methodology. The study assigned the VPA method consisting with the product clinical adoption (PCA) strategy holistically, which meant the grounded theory testing method conducted and handled by the task directional together with the environmental needs, in order to engage the observational interviewing method as related to the verbal think aloud. On the other hand, the evaluation of DS-2 stage for quantitative methodology is required when reliability test measurements are truly examined in an accurate manner using the Statistical Package for Social Sciences (SPSS) software in a survey of other types of testing method practice especially the non-parametric test.

In Chapter 6 of the dissertation of findings discussion, the research study interprets the results in light of the research questions, theoretical frameworks, and relevant literature. It explains the findings' ramifications, investigates any unexpected results or study shortcomings, and makes recommendations for future research. As a result, the elucidation of the research topic will focus on a specific knowledge domain's subject for an intangible ecological form of ecodesign identity that is covered by the visual aid representation with bubbling model of source requirements containing (1) design theory: an ecological form of ecodesign identity theory; (2) design model: Heskett model to the circular of product form model; and (3) design scheme: designing works scheme. As a consequence, the study's implications, such as: (1) interpolation for explicit information; and (2) extrapolation for implicit knowledge, must be determined concurrently using the bubbling model approach. However, the visual elements (VE) is composed of four basic qualities: point, line, plane, and volume. These properties act as a catalyst to create the naturally occurring organic and geometric patterns in the design source. Design and system thinking that represent the two pattern sources as two-dimensional (2D) and three-dimensional (3D) concepts are, therefore, triangulated. A dimensional direction of fusion morphing metaphor, namely, a fusions' ecodesign identity, comes from the conjunction of the triangulating metaphor visualisation for the ID field and the bipolar digitisation reflecting the algorithm digitisation in the ED field. In other words, it is synonymous with new product development.

Chapter 7 concludes the research on "fusion ecodesign identity" by emphasizing its contributions to sustainable product design, particularly through design communication and pedagogy. The study affirms that fusion ecodesign is an integration of cultural diversity and technological innovation—strengthens product identity and enhances design thinking. A key finding involves using "think aloud" methods and the Monö model to trace the transition from product form imagery to verbalization, design thinking, and product attractiveness. This process is framed through thick and thin descriptions and refined into a simplified three-stage Waterfall Model to support young designers and industrial practitioners. The research highlights the alignment of fusion ecodesign with the quadruple helix model (academia, industry, government, and civil society), using educational initiatives like The Ship Campus and Malaysia's teaching factory models – public universities. Design pedagogy integrates problem-based learning (PBL) and emphasizes biomimicry, system thinking, and knowledge domains

(cognitive, psychomotor, affective, and knowledge). For practitioners, the human-centered design (HCD) approach is crucial for iterative, user-focused development, and R&D activities are mapped against knowledge-based competencies. Finally, the chapter recommends further integration of explicit and tacit knowledge on fusion ecodesign into Malaysian design communities. It suggests adapting design strategies based on manufacturing contexts -OEM, ODM, and OBM - to align with various Sustainable Development Goals (SDGs). The study positions designers as strategic agents in shaping ecologically responsible product identities and systemic innovation.

Table 1.1
Elucidation of Knowledge Domain Hierarchy for The Research Objectives and Research Questions by Proto-Verbs (Adapted: Atkinson, 2013)

No.	Research Objectives	Knowledge Domain (Hierarchy Level)/Proto-verbs	Research Questions' Mapping of Design Research Methodology (DRM) Framework		
			Research Questions	**Cognitive Levelling and Verbs Related**	**Contextual of Constructive Alignment (CoCA)**
1.	To frame the ecodesign identity method of distinguishing intangible ecological form through the human emotion of the designer in the concept of ecodesign identity.	Contextualise (K2 Level) Proto-verb: Frame	i- Prescriptive Study (PS) Stage; What is stimulated of drawing process for the concept of ecodesign identity in the design manuscript?	Low Order Thinking i – Stimulate	Domains: Proto-verbs (Hierarchy Level) Cognitive: Apply (C2) Affective: Respond (A2) Psychomotor: Manipulate (P2)
			ii- Descriptive Study II (DS-2) Stage; What is constructing of the product semantics scaled in the concept of ecodesign identity?	Low Order Thinking ii - Construct	
2.	To envisage the design scheme work model of fusions' ecodesign identity in ecological form knowledge as ecodesign information, in order to elucidate *"an ecological form formulation"* into the future development of ecodesign identity using the product form platform.	Conceptualise (K3 Level) Proto-verb: Envisage	i- Prescriptive Study (PS) Stage; How do young designers inspire an ecological form of ecodesign identity by comparing design theme and pattern instinctively?	Higher Order Thinking i- Compare	Domains: Proto-verbs (Hierarchy Level) Cognitive: Analyse (C3) Affective: Value (A3) Psychomotor: Perfect (P3)
			ii- Descriptive Study II (DS-2) Stage; Why is classifying of the design theme for the fusion design in ecological form of ecodesign identity?	Higher Order Thinking ii - Classify	
3.	To transact the visualisation of bubble model that it delivers the DRM roadmap completion according three stages in DRM framework provisionally; descriptive study I (DS-1), prescriptive study (PS) stage and descriptive study II (DS-2) stage.	Process (K4 Level) Proto-verb: Transact	i- Prescriptive Study (PS) Stage; Why choose the design pattern of semantic representative for the ecodesign identity?	Higher Order Thinking i – Choose	Domains: Proto-verbs (Hierarchy Level) Cognitive: Evaluate (C4) Affective: Organise (A4) Psychomotor: Articulate (P4)
			ii- Descriptive Study II (DS-2) Stage; How to collate the semantic representative of ecodesign identity through the recycling methodology?	Higher Order Thinking ii - Collate	

Source: Adapted from Atkinson (2013)

CHAPTER 2
LITERATURE REVIEW

2.1 Introduction

This chapter describes the ideation of design insight, designer's human cognition and argumentation of conceptual design area in intangible ecological form of ecodesign. The aim of the study is to seek an emergence of ecodesign identity phenomena that the industrial designers create and develops the product form by the specific conceptualization of sustainable for product design (SfPD) using the artificial intelligent (AI) knowledge platform. The SfPD has come from the new product development (NPD) domain which meant the branches and / or components of design and/ or product innovation family in engineering design (ED). Using the knowledge of sustainable design principle orientation, the researcher uses the practiced based design thinking to screen the certain and uncertain complexity of ecological form literally. At this moment, by the elaboration of thematic content analysis, this technique refers a qualitative research methodology that it can be digested the conceptual design area in order to interpret the imagery and / or visual of design thinking following the industrial design (ID) realm or mainstream (Creswell, 2003; Abidin, 2012).



Plate 2.1 Iceberg Model of Biophysical Sosioeconomics

Source: Change Oracle: Matthews (2023)

Consequently, the identification of external and / or internal sources is the main component in this study. It can be explained and discovered by the domain parameter along the study of ID knowledge. For a literature goal setting, the researcher approaches the philosophical assumption continuum namely ontology, epistemology and methodology having occurred realistically as Plate 2.1 (Guba, 1990; Guba & Lincoln, 1994; Change Oracle: Matthews, 2023). In the evolving landscape of industrial innovation, NPD is increasingly shaped by the dual pressures of environmental sustainability and socio-economic accountability. The Iceberg Model of Biophysical Socioeconomics offers a conceptual lens through which product development processes can be critically examined, moving beyond surface-level outcomes to uncover the deeper systemic and cognitive dimensions that influence design. When coupled with an ecodesign identity, this model becomes a valuable framework for embedding sustainability into the core of innovation strategies. The iceberg model, adapted from systems thinking, illustrates how observable events in product development such as the launch of a new eco-friendly product, are only the visible tip of a much larger system. Beneath the surface lie patterns and trends, systemic structures, and mental models, each of which plays a crucial role in shaping product outcomes. These layers help identify not just what is happening in NPD, but why it is happening and how it can be improved through sustainable practices.

At the surface level, ecodesign identity manifests in tangible product features such as biodegradable materials, energy efficiency, or minimalist packaging. These features represent the event level of the iceberg, where sustainability is visible to consumers and regulators. However, relying solely on surface-level changes risks greenwashing and fails to address the root causes of environmental degradation (Niinimäki, 2020). Deeper within the iceberg, patterns and trends reveal a growing societal shift toward environmental consciousness and ethical consumption. In this layer, ecodesign identity aligns with consumer behavior, environmental legislation, and global supply chain trends, guiding companies toward more consistent integration of sustainability in product lines. This includes the adoption of life cycle assessment (LCA) tools, circular design principles, and product stewardship models (Geissdoerfer et al., 2017). Moving further down, systemic structures, including corporate policies, R&D practices, and industry standards - either facilitate or constrain the integration of ecodesign. At this level, ecodesign identity becomes institutionalized, embedded in the design protocols, material sourcing policies, and innovation incentives that shape how

products are conceived and produced. Collaborative approaches that bridge industrial design with environmental science and engineering disciplines are essential at this stage (Bocken et al., 2016).

At the base of the iceberg, mental models represent the values, assumptions, and worldviews that drive product development decisions. A shift from anthropocentric to ecocentric mental models is fundamental for embedding ecodesign identity at this level. Designers and decision-makers who internalize ecological ethics and systems thinking are more likely to champion regenerative and inclusive design practices, recognizing that products exist within interconnected socio-environmental systems (Kim et al., 2020). Hence, this typical continuum could be synchronized with the initial Chapter 1 where there will be anchored the research objective, research questions and clearly defines the research framing within its problem identification.

However, to define the SfPD knowledge, the fundamental of NPD is required to track the branches of product innovation heuristically. This fundamental refers to the basic research actually. According to Bradbury (1989), the notion of innovation process is initially known with the "technology push model" (introduced by Gardiner and Rothwell, 1985) oriented by science discover, technology products and company markets. In second complimentary of entrepreneurship innovation, Bradbury (1989) coincided the explanation of "market pull model" from the experts Gardiner and Rothwell (1985) had similarly and / or same pattern model as traditional view of innovation obviously. There were used three components behind the traditional innovation model namely need pulls, technology makes and company markets.

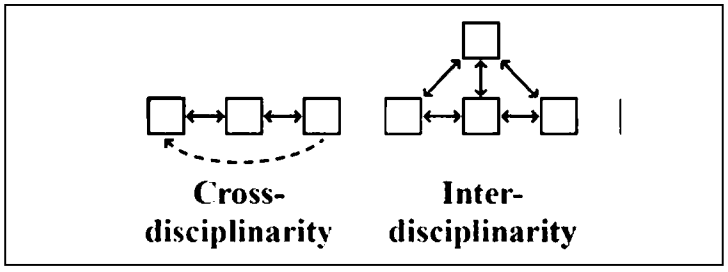


Figure 2.1 Traditional Interdisciplinary

Referring to Figure 2.1, a pioneer Jantsch (1970) have successfully categorized the three boxes (components/ traditional innovation) demonstration by pattern of study area (niche) which is to address the logical disciplinaries of networking process from

the cross-disciplinary shifting to the inter-disciplinary. Three components' examples will be navigated the right attribution of components innovation representatives a hypothetical form as design belief (need pulls) ↔ ecodesign (technology makes) ↔ product marketing (company markets). Thus, this research study having synchronized with the essential research design that an intangible ecological form of ecodesign has to be formed with prescriptive reasoning (grounded - verbal protocol analysis) initially and then will be gauged with the descriptive reasoning (correlation and association - statistical testing methods) for the design belief towards the product marketing within theory building itself (Blessing & Chakrabarti, 2009; Abidin, 2012).

Relating on the knowledge reflection, the study required to extract the content of literature review study, the research will be applied the research strategy of three major components following (1) chronological order (CO), (2) evolution of design (EoD) and (3) thematic analysis method (TA). The CO of literature review focuses on the product form following the narrative sequence of events / years of the product produced / design era movement, from earliest to last. Meanwhile, the EoD of the literature review discussing recycling knowledge – design for recycling (DfR) were derived from the evolution of cycle in accordance with design for X (DfX) globally. Lastly, the approach applied in this study is TA method content, which emerges from the research model of prescriptive study (PS) stage in the design research methodology (DRM) – referring to the bubbling model. By the categorization of design phenomena, the theme of study indicates the primary source information that could emphasize the grounded theory within an orientation of basic/fundamental research.

Therefore, this literature review study is possibly made the new structure of design thinking which meant the intangible ecological form of ecodesign context in the conception of SfPD entirely. The DRM framework will approach to reach a goal setting that bubbling modelling should be followed to support the designing theory in this research study simultaneously. It facilitates the researcher to get the research roadmap where there could possibly framing the systematic methodology used to answer the research questions within the design belief itself.

2.2 The Conceptual of Intangible Ecological Form in Industrial Design Field

This research study describes AI of ecodesign identity (product form context) using the combination of design thinking and system thinking where it had embodied

from three components of transdisciplinary design (TD) as known with syntactic, pragmatic and semantics in form giving development (Jantsch, 1970; Abidin, 2012; Jeder, 2014) through intangible ecological form context (Chumiran et. al, 2018). Suitable with the current industrial revolution era known as industry 4.0, the research study focuses on the digitization of pictograph imaging that the kind of ecodesign identity interprets an actual product form referring the internet of things (IoT) sources. The industrial designers must be aware and perceived on the benefits of IoT networks that it can expedite the product design development and its timeframe especially regarding the conception of design identity and its application of design technology used. Since the material's sources of designing tools have been transformed by the conception of design identity along the AI element, the ecodesign information creatively has formed a superimpose SfPD information similarly. Thus, the IoT network became a significant channel for a design material, design sampling and data collection towards digitization of pictograph imaging in an intangible ecological form of ecodesign. For the transdisciplinary learning, it will be explored and determined some uncertain and / or certain an aesthetic value of the ecodesign identity which means under the digitization of pictograph imaging following three components of TD mentioned earlier.

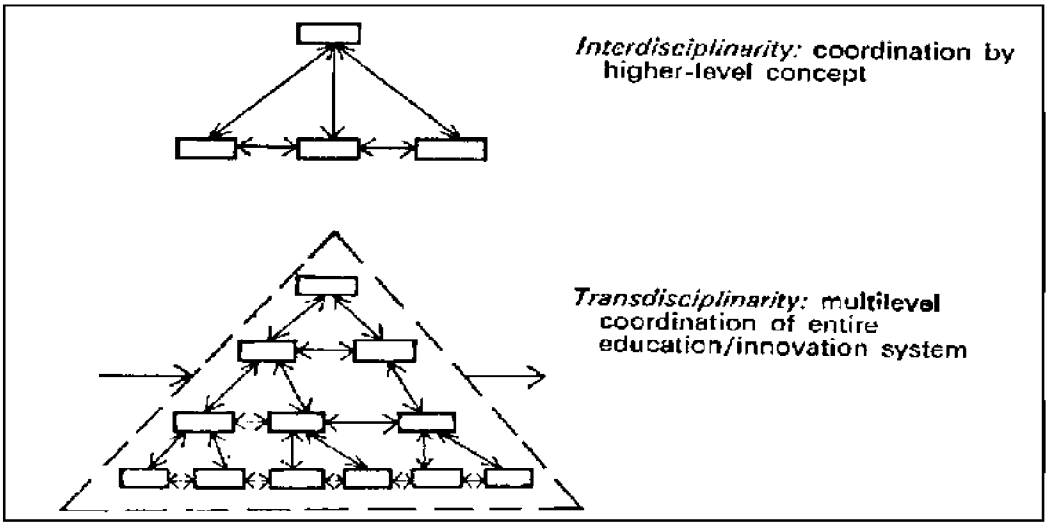


Figure 2.2 Traditional Interdisciplinary Design (TID) Becomes Transdisciplinary Design (TD)

Next, to elaborate the design study regards an intangible ecological form of ecodesign, the researcher initiatively describes TD; three design disciplines explain short meanings under the aesthetic values (Schwarzfischer, 2010; Schwarzfischer,

2011). The researcher coincides to the expert Schwarzfischer (2011) that the value of aesthetic keyword is nearest with the gestalt theory according to the shape of products. In terms of the aesthetic of product design, Schwarzfischer (2011) categorized an object (product) and meaning (communication) in the observing system that the Gestalt experience enabled the product designers interfaces the semiotic signs, terms, sense and emotion: an aesthetic experience creation on the understanding and simulating design called Gestalt Intergration (GI).

Thus, to demonstrate and formulate the formation meaning of syntactic, pragmatic and semantic that all those three were began from the traditional interdisciplinary design (TID) structured initially as Figure 2.2 (Jantsch, 1970; Jeder, 2014). However, the interpretation of TD only can be shown and used upon and / or when that three components had integrating, networking and linking together (Jantsch, 1970; Schwarzfischer, 2017). This TID structural unit having connected and it allow the emergence form of structural TD systematically. Therefore, the researcher began to describe the essential of ecodesign identity (an intangible ecological form) using the traditional TID following;

a) *Syntactic* - "...composition of parts within a whole" (Schwarzfischer, 2011). The fundamental of gestalt law is crucial for the designer's human cognition that the product designer would synonymously figure and employ completely the principle or element of art and design. (Abidin, 2012; Chumiran, Abidin & Sirat, 2014). Using the visual element (VE), the gestalt theory heuristically projected the whole of design principle on the imaging design artifact and / or object. In order to screen the VE, some pattern of picthographic design artifact using the front view and third-quarter front view is required morphologically.
b) *Pragmatic* - "...the genesis processes of desired values (preferred options) into design analysis, the resulting transdisciplinary design theory is capable of covering all kinds of Gestalt phenomena of a life form" (Schwarzfischer, 2011). For instance realistically, a stimuli of design cognition on the design thinking (designer – industrial design, ID) triangulates with the system thinking (engineer – engineering design, ED) together in a SfPD methodology and / or program (Abidin, 2012; Chumiran, Abidin & Sirat, 2016). This is to analyze and create the design bridge that it can achieve a design roadmap during the product form

development. Then, this design studies are to identify what is a specific design concept (subject matter/ object/ artifact) in ecodesign information (SfPD: NPD context) synonymously. By the comparison of two different values characteristic, the both desired values components merging with the same theme and / or group category which meant the integration of design similarity following the Gestalt theory within it capable, characteristic and criteria (3C's) needs. Thus, the combination of both design processes will be emerged "the fusion design" as well as an intangible ecological form of ecodesign. However, for the fusion design meaning, it will depend on the design study theme and / or categorizing design concept in ID knowledge field specifically. At this time, the disclosure approach (dual methodology) strategy allowing the industrial designers interprets and demonstrates the whole composition of design artifact and / or object. Therefore, the design phenomena will be frequently visualized to transcribe a goal desire ecologically.

c) *Semantic* - "…as different codes used by different observers" (Schwarzfischer, 2011). Essentially, coding is a method of defining a passage in the text or other information objects (photograph, picture), looking for and defining ideas, and discovering relationships (Gibb, 2007; Saldana, 2009). This code wording is to refer the quality of product form (object / design artifact) morphing the design experience and / or form evolution observationally (Abidin, 2012). The design artefact can be represented by a numerical scale and / or algorithm element as well. It normally oriented with the certain physical of product form by the photographic imagering pattern. For an example, bipolar images using the extrapolative strategy of pictographic design artefacts had demonstrated the continuum of visualization according to the levels respectively (Chumiran, Abidin & Sirat, 2016; Chumiran et al., 2018). With regards, the research design inspired from the expert Akner-Koler following the evolution of form (Eof) theory, it displayed the reliability and validity of dataset which is geometric shape shifted into an organic shape to allow the emergence of ecodesign identity (Chumiran et al., 2018). During the evolution of design artifact, the basic form giving context is ecologically visualized two categories namely (1) tangible form explicitly used the interpolative strategy and (2) intangible form implicitly used the extrapolative strategy. As a result, these two techniques were heuristically mapped and recognized using the reduce, reuse, and recycle (3R's)

methodology (Mobius loop - industrial cycle), in which semantics design thinking is intuitively applied to approach the VE pattern comprehension of product form imagery.

After the explanation of three components of TD clearly, the researcher has found the network of multilevel coordination based on TID composition (Jantsch, 1970; Jeder, 2014). The pyramid pattern levelling (hierarchical system) has been structured and networked the values to reveal the degree of TD's units' level sequentially. The coordination occurred to axiomatically connect with several group of design disciplines (every sublevelling) where the notion of TID connecting have reaching the higher design values (peak level) gradually. However, this discussion of TD creation will be emphasized in further Chapter Three - Research Methodology under the subtopic Research Design. Due to the thematic content analysis, this study of literature review is required to define and identify themes within certain and / or uncertain interpretation to relate with AI of ecodesign identity in formgiving development along the SfPD parameter of ID field. Therefore, the AI of ecodesign identity referring to the orientation of history and it design modelling are significantly important that it can be developed and constructed the digitization of pictograph imaging following three components of TD before. Further subtopic will elaborate two pinpointed components which is the fundamental of designing activities have conceptually influenced the emergence of product form identity generally using the chronological approach of content analysis. Thus, this study will comprehend and utilize the understanding of design thinking to pursue the beyond an intangible ecological form of ecodesign identity provisionally.

2.2.1 Industrial Design Orientation

Between the early 1900s and 1934, industrial design began to emerge as a distinct discipline, influenced heavily by the Industrial Revolution and the Werkbund movement. The rapid growth of mass production technologies demanded new approaches to product aesthetics, functionality, and efficiency. In 1907, the German Werkbund was founded, uniting artists, architects, and industrialists to improve the quality of industrial products. This movement promoted the fusion of art and industry, laying the groundwork for design standards and functional aesthetics. By separating from architecture and interior design, industrial design gained recognition as a vital field

focused on consumer goods, usability, and manufacturing. This evolution was further solidified by institutions like the Bauhaus (1919–1933), which emphasized interdisciplinary design education (Banham, 1960; Dormer, 1990; Aynsley, 2009).

The ID orientation began and developed from the age of Bauhaus era started 1919 until 1933. Around fourteen years of Bauhaus history, it was literally called with Bauhaus movement (Hauffe, 1996). Synonymously, Bauhaus has derived the centre of modernism and functionalism that it being classified a design knowledge to emerge the ID orientation under the design school or college or institution as axiomatically branched a different field of study type and / or category. Using the chronological approach, the Bauhaus movement has revealed with three design ages period along the establishment which was conducted by three directorships namely (1) Walter Gropius (1919 – 1928): art and craft for aesthetics – father of industrial design Raymond Loewy, (2) Hannes Mayer and Raymond Loewy (1928 – 1930): art and technology for mass production - emerged in the United State of America, (3) Ludwig Mies van Der Rohe (1930 – 1933): architecture for socio economic development and (4) Harley Earl (1930 – 1938): The first Styling Studio from General Motor. By these history track records, each Bauhaus director having differed aims an educational goal as their roadmap in institution even they were same design education background and profession: arose from architecture field – master architect as well. Besides, between the early 1900s and 1934, industrial design began to emerge as a distinct discipline, influenced heavily by the Industrial Revolution and the Werkbund movement. The rapid growth of mass production technologies demanded new approaches to product aesthetics, functionality, and efficiency. In 1907, the German Werkbund was founded, uniting artists, architects, and industrialists to improve the quality of industrial products. This movement promoted the fusion of art and industry, laying the groundwork for design standards and functional aesthetics. By separating from architecture and interior design, industrial design gained recognition as a vital field focused on consumer goods, usability, and manufacturing. This evolution was further solidified by institutions like the Bauhaus (1919–1933), which emphasized interdisciplinary design education (Ren, 2017; Loewy, 2022; Whoppah, 2023).

However, this study will be exposed and elaborated the diversity of ID field context which is the Bauhaus movement era have patterned the foundation of domain TD accordingly. Therefore, the elaboration of Bauhaus movement will be led the design phenomena using the field of study following the chronological approach accordingly.

Firstly, the Bauhaus has established in 1919 - a city of Weimar and the founder formally known director Walter Gropius. In the beginning of ID curriculum, the Bauhaus school and / or fundamental was formed a reimagination of radical concept that to rethink the combination of art's materials where it had creatively merged with the other knowledge namely handcraft design disciplinary (Heskett, 1991; Hauffe, 1996; Winton, 2000). The Bauhaus student called apprentice, they (apprenticeship of Bauhaus) were offered and approached the "art through craft" - workshop courses to emphasize the basic experiment at six types of workshops education included (1) metalworking, (2) cabinetmaking or carpentry, (3) weaving, (4) pottery or glasswork, (5) typography or photography and (6) wall painting or commercial art. The combination of art and design made the Bauhaus fundamental produced the artisans (artistic) and designers (handicraftsmen) together in a time: to produce an aesthetic design and / or object for improving the people quality of life systematically. Obviously, all courses provided had not representing the education of architecture program specifically at all. Initially, this education of Bauhaus practices being driven and implemented through by the manifesto and / or goal concept instead than curriculum. For instance, the researcher found a pinpointed by the expert Jaeggi (2019) from Bauhaus-Archiv / Museum für Gestaltung clarifies the statement following;

> *"This woodcut by Lyonel Feininger was included by Walter Gropius in the Bauhaus's founding manifesto and programme in 1919. It shows a cathedral with a tower whose tip is surrounded by three stars – standing for the three arts of painting, sculpture and architecture – with the rays from them interlaced symbolically. All of the crafts and arts had already worked together on an equal basis even in the stonemasons' lodges of medieval cathedrals. At the Bauhaus, the cathedral now stood for the total work of art that was to combine architecture, craft and art into an ideal unity. (Jaeggi, 2019)"*

To relate, the researcher intuitively define the design curriculum that it's to identify the education of Bauhaus practices. Hauffe (1996) coined and stated with the "expressionism" word refers a goal concept as to reach the level of form master and / or master of applied arts. Which meant, the goal creation on the arts combination had led the equilibrium of skills between artistic and handcraft using the free experimentation - medieval cathedrals: Merged all three arts field of study symbolically

(Hauffe, 1996; Jaeggi (2019). After a few years later, Gropius had ideally changed his mind that the education of Bauhaus basic curriculum is needed for the modernism of avant-garde as Figure 2.3, when an institute faced the confrontation of design phenomena from an architect Theo van Doesburg during the Dutch De Stijl movement concurrently.

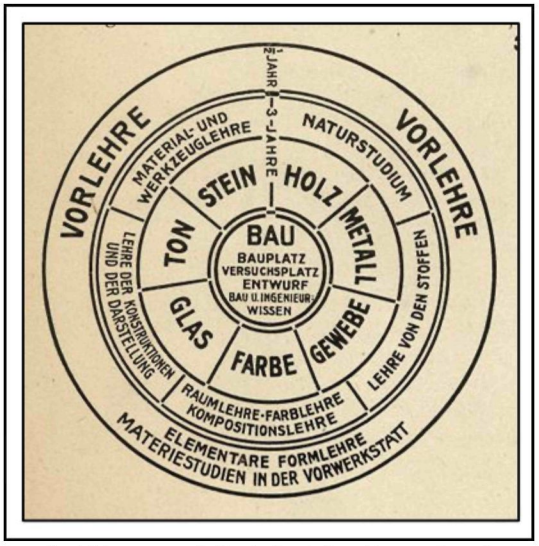


Figure 2.3 Schematic Diagram Model - The Introduction of Bauhaus Basic Curriculum in 1922.

Source: Hauffe (1996)

At the time, the architect Van Doesburg clearly disagreed with the Bauhaus apprentice Itten, claiming that he had demonstrated a radical artisan direction, along with the subject matter, rather than the constructivist form and pattern concept of the De Stijl movement (Hauffe, 1996; Jaeggi, 2019). Thus, the director Walter Gropius is initiatively introduced the schematic diagram model called Bauhaus basic curriculum in 1922. Bauhaus architect Marcel Breuer was inspired by Reitveld's elementaries artwork, which motivated him to create the TI 1A armchair in 1923 (see Plate 2.2). The designer Mercel Breuer was not the only one affected by Reitveld's elementaries style. The other Bauhaus architect auxiliary, Mart Stam, has also impressed. He created a novel chair design idea that stressed the use of steel tubes, as well as construction research employing 10 pieces of gas pipes and ten elbow jointings. In 1926, the Dutch architect Mart Stam was introduced a 3D frame of steel tubing chair familiarly known with a S33 cantilever chair design. According to Plate 2.3, this chair design is unique due to no back legs at behind which meant a new design concept has demonstrating the

"free swinger" and / or "element of cantilever principle" obviously. Later, he exhibited and published the first prototyping of cantilever chair S33 used the canvas striped seat and back rest assembled with the iron frame at Werkburd Exhibition in 1927 (Macel, 1990; Hauffe, 1996; Chumiran, Abidin & Sirat, 2014; Chumiran, Abidin & Sirat, 2016).



Plate 2.2 The Reduction of Material is Vitally Used for The De Stijl Elementaries in Design Approach.

Source: Hauffe (1996) and Sotheby's Magazine (2019)

Above comparison study shown the imagery of visual element evidently influenced the product form pattern concurrently. It's proven to the workshop experiment by Bauhaus designer Breuer that he applied the elementaries and / or constructivist form in an earlier purpose of mass production methodology; (a) Red and Blue Chair by Gerrit Rietveld (1917) and (b) TI 1A Armchair by Marcel Breuer (1923).

Meanwhile, the Werkbund (1907) and Bauhaus (1919–1933) movements in Germany emphasized the integration of form and function, separating design from traditional architecture. During this period, Raymond Loewy emerged in the United State of America. as a key figure. Active from 1929 to 1980, he brought aesthetic refinement and branding to mass-produced products, making industrial design more consumer-oriented. Known as the "father of industrial design," Loewy revolutionized product styling with streamlined forms, influencing everything from locomotives to household appliances. While Bauhaus promoted minimalism and function, Loewy added emotional appeal and marketability, bridging European modernism and American commercial design (Ren, 2017; Loewy, 2022; Whoppah, 2023).

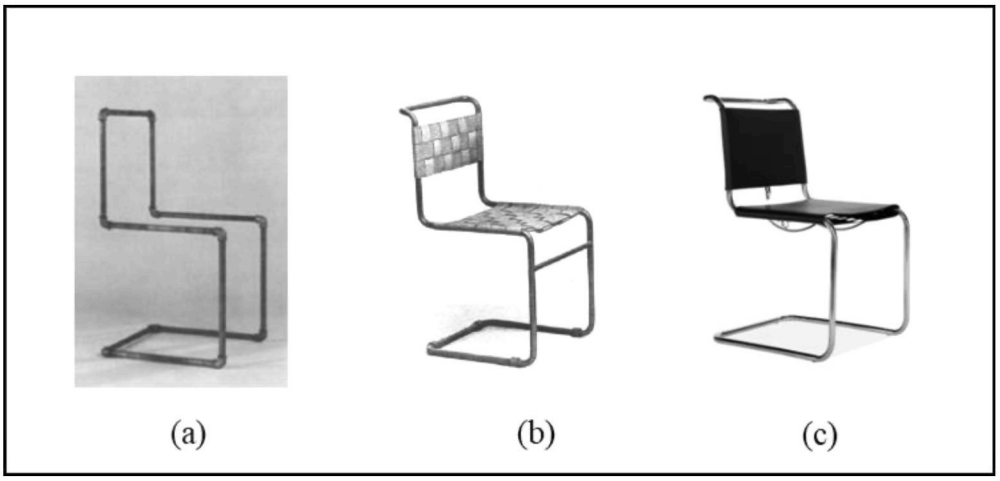


Plate 2.3 The Elementaries and / or Constructivist Form of Cantilever Chair Invented by Dutch Designer Mart Stam;

Source: Macel (1990) and Thonet (2024)

(a) the reconstruction version made by gas pipes and its elbows in 1926; (b) and (c) the first prototype of cantilever chair exhibited by iron frame at Werkburd exhibition, Schorndorf in 1927.

Secondly, Bauhaus moved to Dessau upon the completion of new hallmarks building and the facilities designed by Gropius in 1925. Meanwhile, the conservative government had pressured and urged the directorship Bauhaus Gropius that the school is compulsorily shifted the institution from Weimar city to Dessau in the same year. Due to two major attributions called the financial difficulties and disagreement of school direction, there had causally stressed the Bauhaus to address the problematic situation accordingly (Heskett, 1991; Hauffe, 1996; Winton, 2000). At this moment, Gropius stepped down from his position and let a new directorship Hannes Mayer driven the Bauhaus school entirely in 1928. Since the authority was mandated, he had restructured two major areas of internal management such as (1) organizational and (2) the content of Bauhaus visionary consequently. He strictly assigned the standardization of product design which is the new curriculum direction must be surely incorporated with the functionalism philosophy as known with mass production. The slogan "art to industry" was used in the transformation of Bauhaus curriculum (Heskett, 1991; Hauffe, 1996; Winton, 2000). This new distinction of design curriculum had impacted the Bauhaus experiment study that the materials study and the construction of design process had delivered towards basic needs of the population. The both combination of the experiment actually referred to the beginning design curriculum into the

technological conception. For instance, Hauffe (1996) clarified the Bauhaus curriculum direction has changed entirely according;

> *"Meyer was a disciple of collective thinking and rejected what he thought of as the artistic-romantic approach. He strove to make Bauhaus instruction more scientific and introduced new subjects such as psychology, sociology and economics. Under Meyer, thus, in the weaving department, student begun to experiment with weaves and synthetic fibres. (Hauffe, 1996)"*

According to Heskett (1991), one of the foundational elements introduced in Bauhaus education was the concept of "essential laboratories," which embodied the principle of Bauhaus production. This approach emphasized the transformation of design objects or artifacts into product prototypes before they entered mass production. Meanwhile, in Germany, Hannes Meyer, who became the second director of the Bauhaus from 1928 to 1930, stressed the importance of socially responsible design that met the functional needs of the wider public. As a result, under his leadership, the Bauhaus shifted further toward collective production, technical rationalism, and a strong focus on user-oriented design, thus aligning more closely with the demands of industrial processes and mass manufacturing.

At the same time in the United States, Raymond Loewy began laying the foundations of what would become a revolutionary design career. Known today as the "Father of Industrial Design," Loewy introduced a new vision: combining modern aesthetics with market appeal. In 1929, he designed the exterior of the Gestetner duplicating machine, followed by work for Westinghouse and Sears. His designs were sleek, user-friendly, and commercially viable that directly reflecting the Bauhaus principle of uniting form and function, but reinterpreted through a capitalist, mass-market lens. Loewy's breakthrough came in aligning design with brand identity and emotional appeal, concepts less emphasized by European modernists like Meyer. While Bauhaus under Meyer focused on egalitarian and functional design, Loewy's approach introduced styling—the deliberate shaping of products to attract consumers and promote sales. This period marked a pivotal divergence: Europe sought to rationalize design for the common good, while the U.S., through figures like Loewy, industrialized beauty for consumer culture. Loewy's influence set the stage for the American design identity, defining how aesthetics, innovation, and business would intersect in the 20th century.

Hence, the researcher discovered an earlier scientific study for product design that showed the Bauhaus core education timeline, which effectively exhibited and emerged the history of mass production. Also, experimentation of workshop laboratories is actually represented the application of design technology, basic design pedagogy and ED practises into the design artefact and / or product design development as well. This workshop's experiment practise had working until the hand-covered period to Bauhaus third directorship consequently.

Third, directorship Hannes Meyer resigned from the Bauhaus in 1930 after being connected with and participating in political activities of the Communist Party (Hauffe, 1996; Winton, 2000). Meyer difficulty faced with the complexity of issues from the political government. With the membership status reasoning, it brought some huge impact for him into the contribution of Bauhaus institution and / or academic especially regarding the financial constraint, public or student's connection and a tensional stress of politician state environment with the Germany right-wing municipal government. In the same year, once again, the Bauhaus design curriculum has changed by third directorship Ludwig Mies van Der Rohe. Specifically, the new programme interior design has been made and the program was conducted by the private commissions Lilly Reich in master architecture field (Winton, 2000). Under the Mies van Der Rohe, the new content and academic structure emphasizes the architecture department and it design disciplines. The alteration of design curriculum made the Bauhaus student disconnected with the social and political interest physically which is the Mies van Der Rohe was imposed the new leadership approach in an every education program activity. However, because of depolarization, the Nazi regime closed the Bauhaus institution in 1933. This causal came from unstoppable pressured situation until the political ground; the previous perception based on the tradition of Meyer – Bauhaus students were still supported and members of the Communist Party. Thus, all the master architect and designers decided to move and they immigrated to the United State of America.

Fourth, during the Bauhaus era (1919–1933), a global transformation in design was unfolding. In Europe, the Bauhaus movement emphasized the unification of art, craft, and industry through functional minimalism. Meanwhile, in the United States, a different but complementary development took place: on June 23, 1927, General Motors (GM) established the first in-house corporate design department—the Art and Colour Section—under the leadership of Harley Earl. This milestone marked the birth of

industrial design in the American automotive industry and set the stage for design's integration into mass consumer culture. Harley Earl, trained in custom coachbuilding and inspired by emerging trends in modernism, pioneered the concept of "styling" in product development. Unlike the Bauhaus approach that focused on pure function, Earl introduced the idea that emotional appeal, aesthetics, and brand identity could drive consumer choice. He implemented the practice of annual model changes and launched the first concept car - the 1938 Buick Y-Job which showcased futuristic design elements and market-testing innovation. While Bauhaus promoted "form follows function," Earl expanded the equation: "form follows fantasy and function." His work bridged the divide between European functionalism and American consumerism, reflecting a cultural shift toward aspirational design. The establishment of GM's Styling Studio was not just a corporate strategy but a landmark moment in the history of industrial design, influencing generations of designers and corporations worldwide (Lamm, 1976; Banham, 1980; Car Body Design, 2012; Sparke, 2004).

Together, these developments in Germany and the United States show how the 1920s and 1930s were foundational decades for shaping industrial design as a distinct and influential discipline.

2.2.1.1 History of Industrial Design in Malaysia

The history of industrial design in Malaysia is a relatively recent that it's rapidly evolving field into the two sectors concurrently. There have ground based-roots in the internal Malaysian country's following the industrialization and economic development, which gained momentum of movement from the beginning 1950s to the 2020s until present as known with the mid-20th century. The essential of the history overview will be led the earlier establishment of Malaysian industrial design movement (Hirschman, 1989; Iqbal, Hussin & Seman, 2014). Also, there will have an appropriate figure about the Malaysian industrial design era as similarly noticed with the global industrialization history following,

i) *Early Establishment of Malayan Economics Development (1950s)* - The establishment of Malayan economics development began during the end of the 1950s. An earlier pioneer investor business creates the economic field that it

refers to the investment business and / or activities, is led by Japan country since the end of World War II (Hirschman, 1989; Iqbal, Hussin & Seman, 2014). During the period, the investment business approach the establishment production of various industries, including food, textile and pottery industries, which contributed to the increment of several essential sectors for product, services and innovation oriented by the acquisition of raw materials and trade. The recognition of economics investments specifically derived the importance of Malayan economics development and it enabling to gain and support the industrialization process depended on the multi-national foreign investors especially Japanese investor initiatives.

ii) *Industrialization Changes (1960s-1970s)* – The industrialism movement process started after the historic announcement of Malaya Independent Day (Merdeka - National Day) by the Federal of Malaya in 31 August 1957, until the industrialization changes of Malaysia during the earlier 1960s. Evidence on the beginning of Malaya economic studied by Hirschman (1989) describes with the statement as "…For an excellent study of industrialization in the early 1960s, see E.L. Wheel- wright, Industrialization in Malaysia (Melbourne: Melbourne University Press, 1965)" that the major contribution of races is weighting nearest to non-Malay race. The Malaysian government moves to take an initiative with the proactive proposal that the announcement of the New Economics Policy (NEP) – Dasar Ekonomi Baharu (DEB) in earlier 1970; the modern Malaya economics emergence to ethnic riot in Klang Valley. This period saw the establishment of various manufacturing industries, including electronics, textiles, and furniture, which created a demand for product design and innovation. The government recognized the importance of design in industrial development and started to support design education and initiatives. Besides, in the reflection of DEB, the formation of UiTM's Industrial Design program in 1972, the introduction of design into school subjects in the 1980s and 1990s, the diversification of design degrees across institutions like UNIMAS, USM, and APU, and the emergence of platforms like MIMOS, TANGGAM, and FITEC (Abd. Rahman, 2023; Rahman, 2023).

iii) *Formation of Institutions (1980s-1990s)* - In the 1980s and 1990s, Malaysia saw the establishment of institutions and organizations dedicated to design education and promotion. One notable institution is the Malaysian Institute of Art (MIA),

which began offering design courses and played a significant role in nurturing local design talents. The government also launched initiatives to promote design, including exhibitions and competitions.

iv) *Development of Nation-Building Vision 2020 in Design (1990s–2000s)* - In the 1980s and 1990s, Malaysia began laying a strong foundation for design as a strategic component of national development. This era saw the establishment of key institutions and organizations dedicated to design education and promotion. To nurture early design thinking, the national school curriculum introduced subjects like Kemahiran Hidup (1989) and later Rekacipta (1996), promoting creativity and problem-solving among students. In line with the aspirations of Vision 2020, the government also supported numerous design-related initiatives such as exhibitions, competitions, and innovation awards. Importantly, this period marked the emergence of industrial design as an academic discipline, with universities offering specialized programs across the country. Significant milestones include the launch of UiTM's Industrial Design degree in 1972, MIA's program in 1991, UNIMAS in 1993, LUCT in 1994, and UTM in 1997, followed by a growing number of diploma and degree offerings through USM, IIUM, UNIKL, and others in the 2000s. Despite the economic recession in 1998, Malaysia's commitment to design education persisted, ensuring a steady pipeline of local design talent that would contribute meaningfully to national development. These academic advancements laid the groundwork for professional organizations and initiatives in the following decade.

v) *Emergence of Local Design Talent (2000s-Present)* - The 21st century witnessed a dynamic expansion in the field of industrial design in Malaysia, marked by the rise of local design talent and the proliferation of design-focused firms. Public universities and institutions began offering specialized programs in industrial design to meet the increasing demand for skilled professionals, fostering a new generation of Malaysian designers. This momentum led to Malaysian talent gaining international recognition at global design competitions and exhibitions, highlighting their creativity and innovation on a broader stage. A pivotal milestone during this period was the establishment of PEREKA Malaysia in 2012, a professional body dedicated to promoting industrial design excellence and advancing the role of designers within the national development agenda. PEREKA not only supports professional standards but also champions

interdisciplinary collaboration, sustainability, and innovation as central pillars of design practice. Its emergence reinforced the identity of industrial designers as key contributors to nation-building, transforming them into systems thinkers and solution providers for both social and industrial challenges. For government initiatives and support, the Malaysian government has been actively promoting industrial design as part of its efforts to transform Malaysia into a high-income nation. Initiatives such as the National Design Policy (NDP) and the Malaysia Design Council (MRM) were launched to support and develop the design industry. Various grants, competitions, and exhibitions are organized to encourage innovation and entrepreneurship in design.

In the observation of design study, the history of industrial design in Malaysia is marked by a steady evolution from its early days as an emerging field to its current status as a growing and vibrant industry. However, the government's support, the emergence of local talent, and international exposure have all contributed to the development and recognition of Malaysian industrial design on both the national and global stages. Hence, the Certified Industrial Designer (CiDe) designation, as established by the MRM, represents a national benchmark for excellence, professionalism, and accountability within the industrial design profession. Its significance goes far beyond individual recognition - it plays a vital role in advancing Malaysia's design capacity, fostering nation-building, and aligning with the government's broader development agendas.

As Malaysia moves towards a knowledge and innovation-based economy, CiDe certification helps formalize and professionalize the role of industrial designers, ensuring they possess not only high-level technical expertise but also broader competencies such as research acumen, communication, digital literacy, cultural awareness, and ethical practice. These capabilities are critical in addressing increasingly complex social and industrial challenges, and in positioning Malaysian designers as strategic assets in both public and private sectors.

Government support for design-led development is reflected in national policies such as Vision 2020, the National Entrepreneurship Policy 2030, and the Creative Industry Policy, which prioritize innovation, sustainable development, and global competitiveness. By aligning with the CiDe framework, the government ensures that its design talent pipeline meets international standards and is prepared to contribute

meaningfully to national progress. This also strengthens Malaysia's reputation globally as a design-forward nation, capable of producing high-value products and solutions.

Moreover, the emergence of local talent is accelerated through the CiDe system. By establishing measurable, competency-based criteria, MRM empowers Malaysian designers - especially emerging professionals and graduates - to benchmark their abilities, receive structured guidance, and access professional growth opportunities. This system nurtures homegrown talent, promotes design entrepreneurship, and reduces dependence on foreign expertise.

CiDe-certified designers become ambassadors of professional design practice, reinforcing national identity through culturally relevant and context-sensitive design while embracing innovation and sustainability. Their roles are critical in sectors such as healthcare, education, mobility, smart cities, and industry 4.0 - where Malaysia seeks to build future-ready infrastructure and services.

2.2.1.2 The Role of PEREKA Malaysia in Advancing Industrial Design

The Persatuan Pereka Perindustrian Malaysia (PEREKA), established in 2012 under the Societies Act 1966, has become a cornerstone in the advancement and professionalization of industrial design in Malaysia. As the national association representing industrial designers, PEREKA plays a critical role in supporting the country's transition to a knowledge-based and innovation-driven economy. Its work encompasses advocacy, certification, cultural promotion, education, and the creation of professional networks that strengthen the national design ecosystem (PEREKA Malaysia, 2023).

A key role of PEREKA is to serve as an advocacy body, emphasizing the strategic relevance of industrial design in Malaysia's socio-economic development. As the country works toward post-industrial growth under frameworks such as Vision 2020 and Industry 4.0, design has been increasingly recognized as a vital element in value creation, innovation, and competitiveness. PEREKA supports this transformation by participating in policy discussions, advising governmental bodies, and ensuring that industrial design is integrated into national development agendas (Omar, 2019). Second, another critical function of PEREKA lies in its educational and developmental initiatives. In collaboration with higher education institutions, the association helps shape curricula that align with current industry demands. PEREKA also organizes

public exhibitions, forums, and competitions to raise awareness and appreciation of industrial design. Such programs serve both to cultivate public interest and to enhance the technical and creative competencies of local designers. Third, in line with efforts to professionalize the field, PEREKA partnered with SIRIM and the Malaysian Design Council (MRM) to launch the Certified Industrial Designer (CiDe) program in 2020. This certification acts as a quality assurance mechanism, ensuring that practitioners meet nationally recognized standards of competence and ethics (PEREKA Malaysia, 2023). By introducing formal recognition, PEREKA not only fosters trust among clients and manufacturers but also enhances the global mobility of Malaysian designers. Fourth, equally significant is PEREKA's role in preserving and promoting cultural identity through design. Malaysia's rich multicultural heritage provides a unique context for design innovation. PEREKA encourages the integration of traditional motifs, narratives, and local materials into product and industrial design, aligning creativity with cultural sustainability. Exhibitions like Reka Malaysiaku, held in collaboration with the National Art Gallery, illustrate this initiative by featuring work from Malaysian designers that reflects local identity and craftsmanship (The Malaysian Reserve, 2019). Six, PEREKA serves as a networking and collaborative platform. It connects designers with industry leaders, manufacturers, government agencies, and international design organizations. These partnerships enable knowledge sharing, commercial collaboration, and exposure to global best practices. PEREKA's active engagement with international bodies also helps elevate Malaysia's presence in the global design community.

Appendix 7 presents a conceptually rich visual illustration accompanied by an enhanced articulation of the original narrative, emphasizing PEREKA's role in shaping Malaysia's industrial design landscape chronologically. The goal is to reflect PEREKA's multifaceted role in nation-building and industrial design evolution in Malaysia while referencing historical development milestones following to the scene composition (Abd. Rahman, 2023; Rahman, 2023):

i) *Centerpiece* - A stylized tree whose roots are embedded in traditional Malaysian crafts (batik, songket, woodcarving), referencing the 1973 establishment of Lembaga Kraftangan Malaysia.
ii) *Trunk* - Formed by a timeline ribbon that weaves through major milestones (e.g.,

1972 UiTM's Industrial Design degree, 1993 UNIMAS, 2004 USM, 2012 PEREKA's founding). This trunk is a timeline ribbon, visually textured with key milestones from the 1966 establishment of SIRIM, 1972 UiTM's Industrial Design program, through to the 2012 founding of PEREKA, and extending toward the future with design-led innovation policies and digital transformation efforts.

iii) *Branches* - Extending into future-facing themes like sustainability, digital innovation, design education, and interdisciplinary collaboration, with keywords like "Circular Economy", "System Design", and "Smart Manufacturing".

Beyond professional and cultural functions, PEREKA contributes meaningfully to nation-building by championing design thinking as a strategic response to Malaysia's evolving industrial and societal challenges. Since its founding in 2012, PEREKA has emerged during a period rich with design-related educational expansion and industrial policy innovation, as reflected in Malaysia's broader trajectory—from early institutions like UiTM's 1972 industrial design program to newer design initiatives like MOBILI (2013), TANGGAM – MTIB (2016) and The Kuala Lumpur Design Festival (KLDF) 2023 (PEREKA Malaysia, 2023). Industrial designers today are no longer confined to traditional product development roles. They are systems thinkers, sustainability advocates, and agents of transformation, actively shaping Malaysia's creative economy, digital service sectors, and innovation ecosystems—aligned with national efforts such as the New Economic Model 2010 (MEM, 2010) and National Entrepreneurship Policy 2030 (MECD, 2030). PEREKA supports this expanded role by fostering an environment where Malaysian designers are encouraged to take interdisciplinary and future-oriented approaches. In doing so, it amplifies the intent behind initiatives like IDEATION Sdn. Bhd. and educational reforms such as the Reka Bentuk & Teknologi curriculum (2017).

Overall, PEREKA plays a multifaceted role in advancing industrial design not just as a profession, but as a cultural and strategic asset. By bridging tradition and innovation, education and industry, PEREKA ensures Malaysian design remains globally competitive and locally meaningful - a critical force in shaping Malaysia's national identity and economic resilience.

2.2.2 Designing Model

The accumulation of knowledge is essential, as is the formulation of a distinct ecological vision and goal that directs the entire design process. Since these principles will support the product's intangible form, they should be cantered on sustainability, environmental stewardship, and responsible consumption. Examine how the product can embodies ecological symbolism and cultural relevance. This could entail using symbols that speak to ecological issues or natural forms found in cultural history. A key component of the industrial design field's developing model for intangible ecological form is the incorporation of non-physical, sustainability-driven components into the design process. This approach guarantees that products are not just practical and aesthetically beautiful but also deeply resonate with consumers that prioritize environmental responsibility by emphasizing emotional connection, cultural importance, ethical behaviours, and user experience. In addition to adding value and promoting a more sustainable future, the final products have a distinct ecological character that transcends their material composition (Romford, 2022).

However, the strategy of literature review is required that it is possibly be managed the whole dissertation of literature review displayed by knowledge domain. The studies have chosen the knowledge domain to facilitate the dissertation of literature review as well. In the earlier background of the knowledge domain, the research study coincides an expert anthropologist Edward T. Hall, expands on the iceberg image of culture that he first introduced in 1976. Analogical thinking uses a society's culture as an iceberg model. Then, there are certain apparent elements that are typically observed above the water, such as a greater amount hidden beneath the ice block surfaces.

In Plate 2.4, an idea suggests to use the knowledge domain, is developed from Anderson and Krathwohl (2001) that the knowledge dimension must approaches the contextual of constructive alignment (CoCA) which is to mapping three type of taxonomies blooms namely (1) cognitive domain, (2) affective domain and (3) psychomotor domain – (CAP) concurrently. Constructive alignment is an educational paradigm that emphasises the necessity of aligning different components of the educational process in order to improve learning results. He described the functional of knowledge domain under the “knowledge and understanding - the subject domain”. Applying constructive alignment concepts to educational research processes improves clarity, engagement, and coherence. It guarantees that learning experiences are

purposeful, relevant, and consistent with the desired results, resulting in more effective teaching and improved journey dissertation of learning. The phrase is frequently used to emphasise that there is a great deal more to learn or understand than what is initially obvious. Salleh et al. (2015) describes with "…shows the iceberg competency model which is one of the competency models which is based on three main aspects namely knowledge, attitude and skills. It is also one of the models that is frequently adapted and modified at organisations for establishing competency model". The iceberg competency model helps me understand that what we see in someone's performance - like skills and knowledge is only a small part of who they are. Underneath, there are deeper qualities such as attitude, motivation, and values that also affect how a person works. This makes me think about my own development and how I should not just focus on improving my skills, but also on understanding and improving my mindset and behaviour. It also reminds me to look deeper when working with others, as the real reasons behind actions are often not immediately visible.

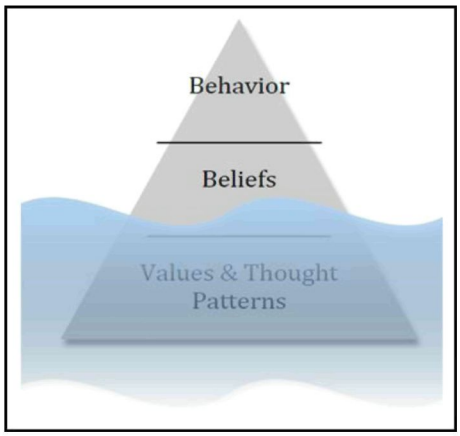


Figure 2.4 Iceberg Model of Culture Model

Sources: Updated by Romford (2022)

In Figure 2.5, the knowledge iceberg concept emphasises the idea that actual expertise or a thorough understanding of a subject necessitates going into the deeper layers of material, discovering intricacies, and acquiring insights that may not be immediately evident – so that significant of think aloud can be visualized by the verbal protocol analysis (VPA) qualitative method clinically. In the other hand, the verbalization of metaphor is frequently used in education to urge students and / or the beginner (participant as young designer) to look beyond the surface level material and grasp the breadth of knowledge available in any given topic which is design

manuscripts' enables to synthesis the ecological form of ecodesign identity. Hence, the visible elements are represented to the digitization of product form; product system, selection and material use, product marketing, ecodesign communication, product life cycle methodology and environmentally-friendly product design.

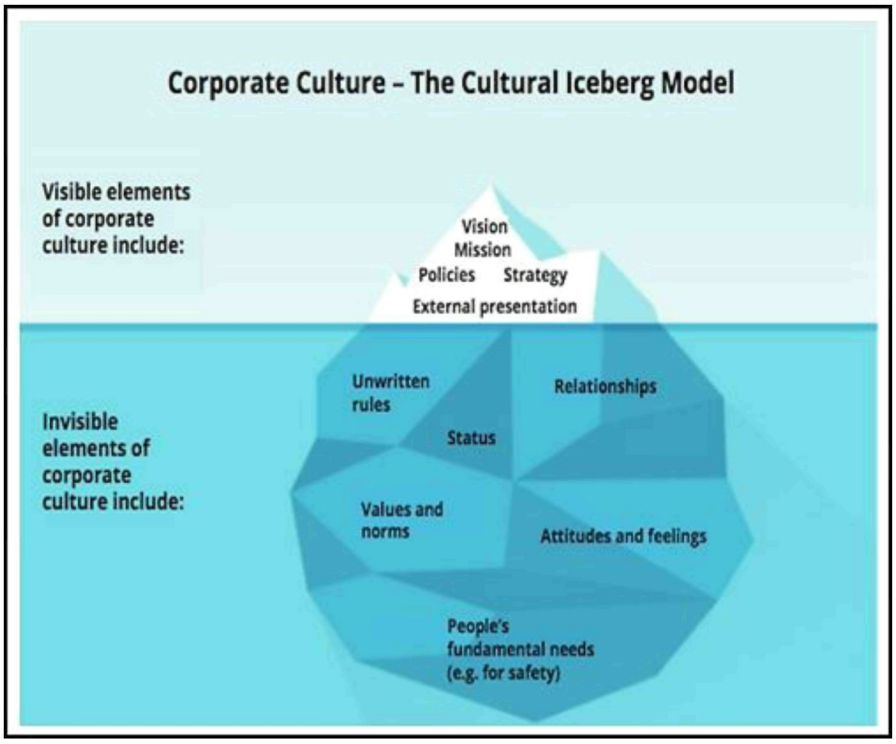


Figure 2.5 A Company's Culture of Iceberg Model Conception

Source: Casalino et al. (2019)

Meanwhile, the invisible refers to the ecological form of ecodesign identity following a think aloud and behaviour – the comparison between design thinking and system thinking, gestalt law – visual perception, idea development, quality of design, product perception, products' aesthetic and think aloud of designedly behaviour.

In Figure 2.6, constructive alignment often aligns with bloom's taxonomy, a framework that classifies cognitive skills into a hierarchy. Essentially, the hierarchy level includes lower-order thinking skills (Remembering, Understanding, Applying) and higher-order thinking skills (Analysing, Evaluating, Creating). Therefore, constructive alignment (CA) which is emphasizes aligning learning objectives, teaching methods, and assessments to enhance researcher learning. The research study provides information on how CA works, in a general sense, may possibly related to hierarchy

levelling of high and low-order thinking following to the taxonomy bloom of cognitive domain fundamentally (Casalino et al., 2019; Romford, 2022).

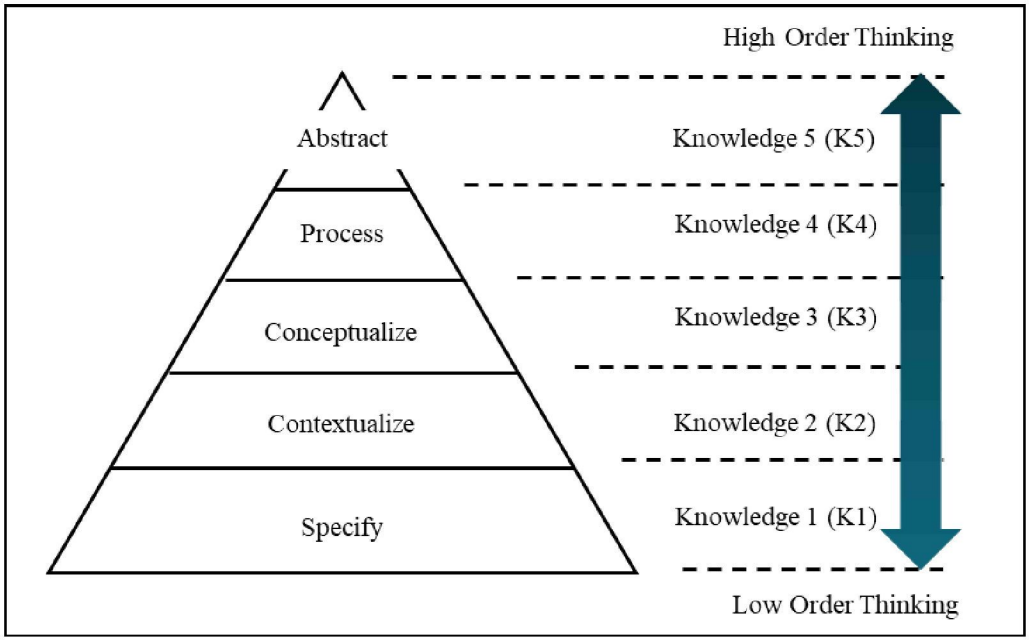


Figure 2.6 The Knowledge Domain Developed by CoCA

Source: Adapte from Anderson and Krathwohl (2001)

A comprehensive the embodiment of knowledge domain between the research objectives and the research questions establishes the context of constructive alignment and its functional itself through the strategy of mapping approach. Addressing the research questions' contents of DRM framework process is significantly challenges that the horizontally hierarchy levels positioned from the research objectives should be met concurrently. Due to the mode of fundamental and / or basic research requirement, two steps of logical flow that it's clarifying the answer for "what", "why", and "how" together are based on the prescriptive study (PS) and descriptive study II (DS-2) such as (1) mapping approach strategy – using the CoCA to screen the hierarchy levels horizontally and (2) synchronizing the cognitive levelling and verbs related – the indication of the beginning lowest level as referring to the "low order thinking" increasing up to the "high order thinking" progressively. The relationship between research objectives and research questions is critical to the overall coherence and efficacy dissertation of literature review. Overall, the link between research objectives and research questions in a thesis is an important part of study design and presentation.

It guarantees that the research is well-structured, targeted, and capable of producing significant results that directly contribute to the larger aims indicated in the objectives.

Further, the engagement of learning process for a researcher as designedly knowing how into the knowledge domain in the perspective of design thinking, an ideal concept of literature review will be looked more convergence that it supposedly supports the research design understanding in the mode of fundamental and / or basic research requirement.

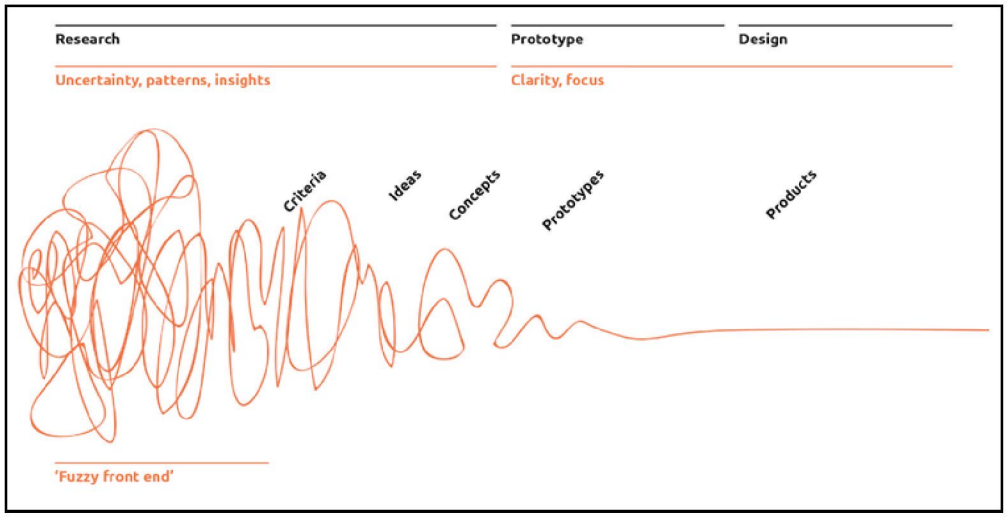


Figure 2.7 A Squiggle Concept of Design Development by Damien Newman

Source: Bailey (2018)

In Figure 2.7, the design squiggle is beneficially promotes the design thinking for several reasons, the researcher will be able to apprehend the term "squiggle" in design thinking relates to the "design squiggle," which is commonly used with the product design (Bailey, 2018; Overdiek & Warnaby, 2020). The design squiggle represents the iterative and often messy character of the design process via two pinpoints following,

i) *Visualization* - Visualization gives a visual representation of the dynamic and evolving character of the design process, assisting teams and stakeholders in understanding the path from problem investigation to solution.
ii) *Flexibility* - The squiggle model emphasizes that the design process is not linear and requires flexibility and adaptability to changes and new insights.

About the feasibility as the last point from the dissertation of literature review following the study of research title, this research component placed in the design research phenomenology - product semiotics and semantics - under the basic research study for industrial design research context. The concept of end-to-end has clearly occurred in the research study. Turner (2017) and Bailey (2018) emphasized the fundamental and/or basic research tradition of producing studies, claiming that the research foundation was created by the nature of the research and challenge. It aids in identifying an effective design solution in the research niches.

2.3 Sustainable Design for Environment (DfE) Framework

The goal of the sustainable Design for Environment (DfE) framework is to include environmental factors into the creation of new products. The framework seeks to reduce adverse effects on the environment at every stage of a product's life cycle, from the extraction of raw materials to disposal. The DfE framework offers rules and concepts for designing sustainable and environmentally friendly products when applied to concrete ecodesign product forms. The research study breaks down the DfE framework's elements into three steps, which may help to clarify the designer's process involved in designing an eco-friendly product (Romli, Rahman, & Ismail, 2015).

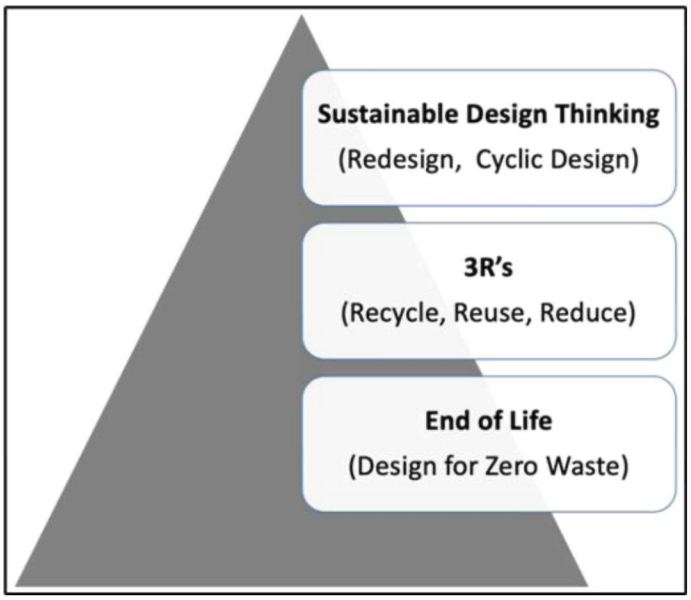


Figure 2.8 Pyramid of Sustainability For Cities

Source: Denzi (2021)

These phases are as follows: DfE Phase 1: (1) life cycle thinking; (2) material selection; (3) energy efficiency; DfE Phase 2: (4) design for disassembly; (5) environmental impact assessment; DfE Phase 3: (6) end-of-life management; and (7) regulatory compliance and certifications. Denzi (2021) asserts that in order to achieve a sustainable development, all stakeholders must work together to create a collaborative culture and design a comprehensive system that encompasses all three phases of sustainability. A culture of circular awareness must also be fostered among all parties as Figure 2.8.

The research convey in DfE Phase 1 is cantered on life cycle thinking (LCT) in life cycle assessment (LCA). LCT is a comprehensive approach that considers a product or process's social, environmental, and economic impacts at every stage of development, production, and disposal. Its objective is to identify strategies for reducing side effects and stopping problems from escalating to later stages of the product's life cycle. In Figure 2.9, the cradle-to-grave approach and the cradle-to-cradle approach are the two methodologies that make up the LCT. The research study for the cradle-to-grave strategy takes into account every stage of the product's life cycle, including material extraction, manufacture, distribution, usage, and disposal at the end of its useful life. In the meantime, the cradle-to-cradle method concentrates on creating products with components that can be continuously recycled through technological or biological processes, reducing waste and its adverse impacts on the environment (Chumiran et al., 2014; Alli, 2015; Chumiran et al., 2020).

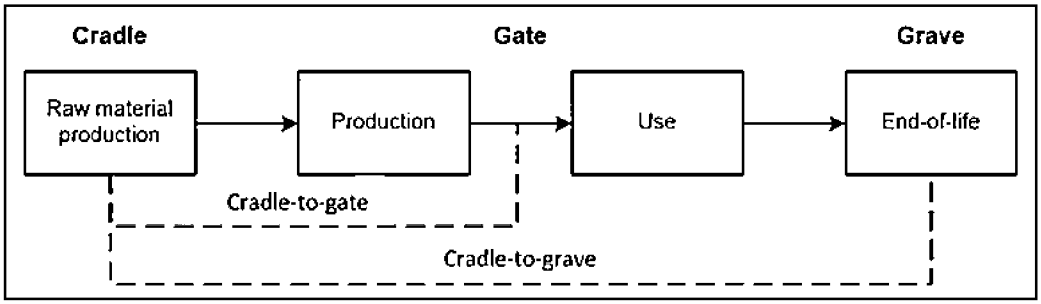


Figure 2.9 Cradle-to-Gate and Cradle-to-Grave System Boundaries of LCA

Source: Kokare, et al. (2023)

The energy efficiency and material selection define the cradle cycles supporting sources system. The utilization of sustainable materials is crucial, with a focus on selecting materials that are renewable, recyclable, or biodegradable. Take into account

how the extraction, manufacturing, and disposal of materials may affect the environment. However, by utilizing substances or materials that are hazardous to the environment or human health, it is possible to evade the assumption that certain products are not poisonous. Hence, prior cradle cycles have reflected on resource efficiency, which is the expectation of using materials efficiently to reduce waste and minimize resource consumption. Finally, energy efficiency is intended to highlight two types of energy approaches: low-energy manufacturing and energy-efficient consumption. The design methods aim to reduce energy usage during production. So consider using green energy sources. On the other hand, energy-efficient design involves using goods that consume less energy during their use phase, such as energy-efficient appliances or gadgets (Alli, 2015; Chumiran et al., 2020).

In DfE Phase 2, the continual involvement of cradle cycles is referred to as Design for Disassembly (DfD). Modularity is the foundation of DfD. Design goods that can be easily disassembled for repair, upgrading, or recycling – 3R's method. This extends the life of the product and makes it easier to recover materials at the end of its life. The DfD requirements must be aligned with product standards. The functional uses standardized components and connections to make disassembly and recycling easier. Thus, cradle cycles design has an impact on minimalism by encouraging the design of products with minimal complexity and fewer components, thereby lowering material usage and simplifying production. While focused on the minimalism context, the use of multifunctionality results in products that serve numerous uses, eliminating the demand for additional products. However, the evaluation and justification of the DfE Phase 2 can be assessed through the environmental impact assessment (EIA), which includes core guidelines based on the life cycle assessment (LCA). The purpose of conducting LCAs is to assess the environmental implications of various design options and identify chances for improvement in conjunction with the specific carbon footprint analysis. As a consequence, the product's carbon impact will be measured and reduced throughout its life cycle.

DfE Phase 3 serves as the final explanation concerning end-of-life (EoL) management. The concept of EoL consists of five components: (1) recycling, (2) upcycling and reuse, (3) biodegradability, (4) consumer education, and (5) supply chain collaboration. The explanation of the research study is as follows,

i) *Recycling* - Create goods that, when their useful lives are over, may be readily recycled. To enable appropriate sorting and recycling, items might benefit from labeling.
ii) *Upcycling and Reuse* - To increase the useful life of products or components, promote their upcycling or reuse.
iii) *Biodegradability* - Use naturally decomposing biodegradable materials for things that cannot be recycled.
iv) *Consumer Education* - Remind customers how to use and dispose of the product responsibly, as well as its benefits for the environment.
v) *Supply Chain Collaboration* - Collaborate with suppliers to guarantee that the materials and procedures used are socially and environmentally responsible.

Nonetheless, certifications and regulatory compliance are essential to eco-certification and compliance. The product has to comply with all applicable environmental legislation and standards in the markets in which it will be sold. As an alternative, eco-certifications call for obtaining certifications like Energy Star, the ISO self-declaration series, or Cradle to Cradle in order to verify the product's environmental performance. Moreover, the moral and social implications of fair work norms and procedures. By committing to fair labour practices, upholding the rights and welfare of workers, and being sensitive to cultural differences, the product is designed and produced with consideration for its possible effects on local communities and ecosystems. A comprehensive approach to sustainability is emphasized by the DfE phases of framework in tangible ecodesign product form, which incorporates environmental issues at every level of the design and production process. By adhering to these guidelines, designers may produce goods that are not only visually beautiful and useful, but also reduce their environmental impact and help build a more sustainable future (Alli, 2015; Chumiran et al., 2020).

2.3.1 The Understanding of New Product Development (NPD)

Developing novel and ecologically conscious goods is the goal of new product development (NPD) in the context of sustainable design for the environment (DfE). This methodology incorporates sustainability principles into all phases of the product development process, guaranteeing that the final product satisfies market and customer

demands with the least amount of adverse environmental impact. Developing a new product from scratch includes ideation, concept development, design, production, and market introduction. NPD entails incorporating sustainable concepts at each stage of the product's development to guarantee that the finished product is not only commercial and functional but also environmentally conscious in the context of product form as an ecodesign identity. In light of this, the research study identified five crucial NPD components related to ecodesign identity in the context of product form: (1) ideation and concept development; (2) design and form giving; (3) prototyping and testing; (4) manufacturing and production; and (5) marketing and branding (Abidin, 2012; Alli, 2015; Abd. Rahman, 2023)

During the first stages of new product development (NPD), sustainability is a basic principle that guides ideation and concept development. The product concept is developed with sustainability as its central focus. This means that from the very beginning, ecological factors such as limiting waste, employing renewable resources, and lowering environmental impact - are fundamental to the shape and functionality of the product. In addition, a highly designer approach to eco-innovation emphasizes that the ideation phase concentrates on creative answers to environmental problems. This could entail redesigning conventional product forms to make them more environmentally friendly or developing completely new forms that support ecological principles, including modular designs that prolong the lifecycle of the product or forms that are modelled by natural forms, or what is commonly referred to as "biomimicry" designs.

The choice of materials is crucial in ecodesign since it plays a crucial role in the design and formulation of important features. Sustainable materials, like those that are recyclable, biodegradable, or recycled, are given priority in this context by NPD. The product's form is intended to draw attention to these materials, highlighting their physical attributes and highlighting the product's ecological character. It facilitates the synergy between form and function. The product's form is intended to be both ecologically authentic and intrinsically practical. For instance, a product can have a shape that makes it easier to disassemble for recycling or a minimalist form that uses less material. The design should make sustainability a central component of its identity by physically and visually communicating its eco-friendly character.

Conversely, the idea of user-centered design states that the shape of the product should take into account the user's experience, making sure that features that are

sustainable are easily understood and available. This might entail creating goods that promote environmentally friendly behaviour, like a receptacle that is simple to use and refill, which would reduce the need for single-use packaging. Where necessary, a crucial approach for testing and prototyping must be taken before making the final selection. Using life-cycle assessment (LCA) specifically for the NPD prototype process entails assessing the product's environmental impact at every stage of its lifecycle, from the extraction of raw materials to disposal. This guarantees that every step of the product's design reduces its influence on the environment. The product form identity and the iterative design stage are closest. Sustainability guides each version as the product's form is developed over several rounds. Testing feedback is cantered on how effectively the form fits the product's ecodesign identity, in addition to functionality and user satisfaction (Abidin, 2012; Chumiran et al., 2020).

The NPD process comprises the selection of manufacturing procedures that minimize pollution, conserve energy, and decrease waste. This is one way to facilitate the product form in the manufacturing and production. Sustainable manufacturing processes can be given. These factors may impact the form of the product, for example, by designing sections that use less energy or material to make. The NPD process prioritizes local production whenever feasible in order to lower transportation-related emissions and boost regional economies. The product's form may be created to make the most of regional resources or manufacturing capacities, so enhancing its sustainable character.

Finally, the communicating ecodesign identity needs to take branding and marketing into account. In most cases, a product's form is crucial to its branding and marketing. The product's tactile and visual elements are employed to convey its sustainability, making the ecodesign brand a crucial selling feature. For instance, the product's environmentally conscious packaging may be simple or constructed of recycled materials. In addition, a design reputation for storytelling can help marketing efforts explain the story of the product's shape, including how environmentally friendly materials were utilized, how it was developed with the environment in mind, and how eco-friendly manufacturing techniques were employed. The product's ecodesign identity is made more emotionally relatable to customers by the narrative it contains. Hence, the implementation of lifecycle management and market launch methods can genuinely address end-of-life concerns and sustainable distribution. Environmental effects are taken into account in the new product's distribution plan. This can be

lowering transportation distances, providing digital items as an alternative to tangible ones, or employing environmentally friendly packaging.

Therefore, NPD in the context of ecodesign also includes end-of-life planning for the product. When a product is no longer in use, it may be made to be easily disassembled, recycled, or composted, preventing it from contributing to environmental deterioration. By integrating sustainable DfE into NPD, goods are designed with an integrated understanding of their environmental impact. Businesses may develop goods that not only satisfy consumer demands but also improve the environment by incorporating sustainability into their operations from the conception stage all the way through to end-of-life management. This strategy not only fits with the increasing need from consumers for sustainable products, but it also improves brand reputation (Alli, 2015; Abd. Rahman, 2023).

2.3.2 The Understanding of Sustainable for Product Development (SfPD)

Sustainable for Product Development (SfPD) embodies a holistic approach that integrates environmental considerations throughout the entire product lifecycle from initial design and material selection to manufacturing, distribution, and end-of-life management. Central to this approach is the concept of ecodesign identity, which not only emphasizes the functional and environmental aspects of a product but also its emotional and narrative connection with consumers. Ecodesign identity reflects a product's commitment to sustainability through its design elements, such as the use of recycled or biodegradable materials, energy-efficient manufacturing processes, and storytelling that communicates the product's environmental journey. This narrative aspect enhances consumer engagement and fosters a deeper understanding of the product's ecological impact (Romli et al., 2015).

In the context of SfPD, Original Equipment Manufacturers (OEMs) and Original Design Manufacturers (ODMs) play pivotal roles. OEMs, traditionally focused on producing components or products for other companies, are increasingly adopting sustainable practices in their operations, including the use of eco-friendly materials and energy-efficient processes. ODMs, responsible for both designing and manufacturing products, have a unique opportunity to embed ecodesign principles from the outset, ensuring that sustainability is integral to the product's conception and realization (Gutterman, 2023).

Furthermore, SfPD incorporates lifecycle management strategies that address end-of-life considerations, such as designing for disassembly, recyclability, and the use of biodegradable components. Sustainable distribution methods, including reducing transportation emissions and utilizing eco-friendly packaging, further minimize the environmental footprint of products (European Commission, 2024).

By integrating ecodesign identity with the strategic roles of OEMs and ODMs, SfPD fosters the development of products that are both environmentally responsible and emotionally resonant. This synergy between design, manufacturing, and sustainability contributes to a more sustainable future and supports global environmental goals.

SfPD enhances conventional NPD by incorporating sustainability into every phase—from ideation and prototyping to production and market launch. While traditional NPD typically emphasizes performance, cost-efficiency, and consumer appeal, SfPD adds crucial criteria such as material sustainability, carbon footprint, and ethical sourcing. This ensures environmental considerations are prioritized from the start, rather than retrofitted later. Integrating SfPD into NPD allows businesses to innovate responsibly while maintaining competitive advantages in market responsiveness, user engagement, and long-term value creation.

2.4 Semantics Design Thinking Strategies to Derive Formgiving Development

The demand for SfPD has increased from a decade ago, since the importance of minimising environmental impacts has occurred in many countries; an every national player applied the SfPD development using the three main pillars - such as environmental, social and economic influences throughout the world (OTA, 1992; Howarth & Hadfield, 2005; Lee, 2005; Chumiran, Abidin & Sirat, 2014;). Under SfPD, an object's form in industrial design (ID) is revealed through the vital product form concept. The engineering design field has assigned the form of object design has always depending on the material used (Roozenburg & Eekels, 1995; Howarth & Hadfield, 2005; Ceschin & Gaziulusoy, 2016). Using the right material selection, there will obviously be criteria, characteristics and capability (3C's) of an ecological form system (Howarth & Hadfield, 2005; Chumiran, Abidin & Sirat, 2014). This selection of materials usually supports the recycling methodology behind the green manufacturing activities such as reuse, reduce and recycling (3R's) method (Chumiran et. al., 2019).

At the above global design scenarios, the researcher consciously found the basic research exists for this essential of thesis scope in research orientation. The knowledge enquires representatives the exploration of the design artifact phenomena where the design philosophical assumption was occurred in this research topic. Thus, the motivation facts have been identified by three major components of building consistency with (1) WHAT is the logic improvement? (2) WHY the coherent of ecological form identity? and (3) WHAT a designing methodological trait? Here, all three questionnaires will be explained in the further assumptions and / or research paradigm sub-topic. According to Glasersfeld (1990), the concept of research question is related with a designs notion in nature of sciences study. Further, it will be aligned the research TITLE following the basic research principle simultaneously (Newman & Covrig, 2013). Both experts had delivered a basic characteristic or quality explicitly through research design qualitative knowledge. It has placed philosophical subject - matter under investigation. Using the term "consistency building" from qualitative experts Newman and Covrig (2013), this fundamental research principle accommodated the "logical alignment" in order to interact psychologically with a conceptualization of realism, especially conceptual construction (Glasersfeld, 1990).

The logical consistency of building that the logical flow (Burks, 1988) has been validated by the term of the mechanism (Glasersfeld, 1990) will definitely be used and the teleology continuum will be synchronized conceptually (Burks, 1988; Friedman, 2000). For a logical study, Burks (1988) has expressed the logical mechanism as "final cause involved - concept of causation, Glasersfeld (1990)" derives the teleology continuum with two basics of consciousness (intuitive) such as (1) immediate experience and (2) functional consciousness. Therefore, this research will extend the distinction of design sciences dealing with the functional consciousness in basic research orientation. By the teleology continuum, the researcher can be screened the research enquiry and let enhance the Akner-Koler (2007) evolution of form (EoF) theory in the industrial design field such as Plate 2.4. The teleology method is preferably applied in this research study due to the nature of qualitative methodology suites a logical case studies dimensions and design evolution in ID field. An earlier search and research suggestion are very important to understand the "final causal" of the research conception segment, research roadmap and creating a new distinction of design knowledge (Burks, 1988; Friedman, 2000; Cyras, 2007).

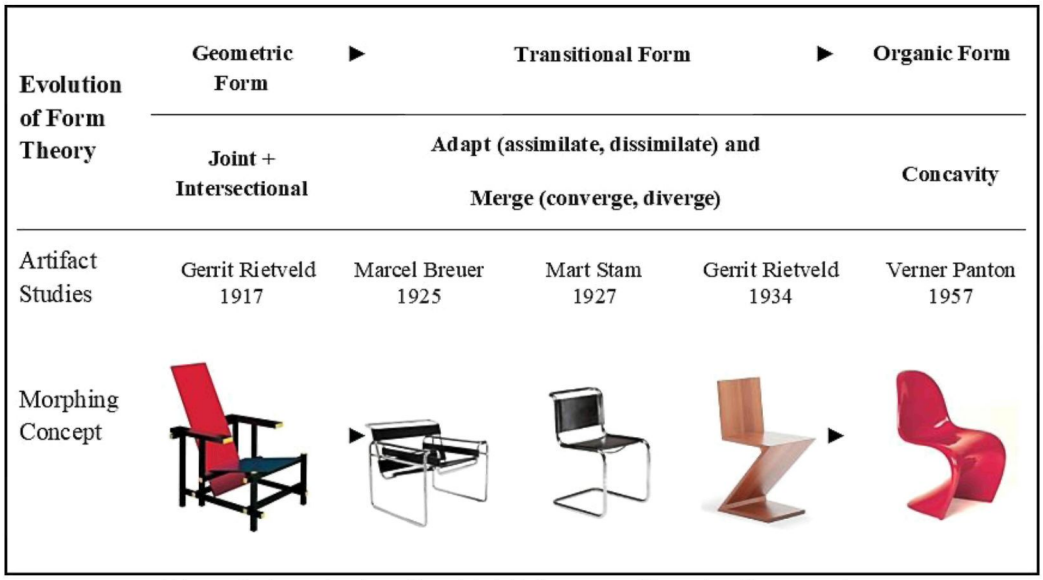


Plate 2.4 An Earlier EoF Theory of Basic Conception

The online dictionary Merriam Webster (2019) has literally sorted several teleological versions with meaning "(1a) the study of evidences of design in nature; (1b) a doctrine (as in vitalism) that ends are immanent in nature; (1c) a doctrine explaining phenomena by final causes; (2) the fact or character attributed to nature or natural processes of being directed toward an end or shaped by a purpose and (3) the use of design or purpose as an explanation of natural phenomena." In order to simplify the understanding of the definition of teleology, the researcher justified using the word "conception" that phenomena of the design process could be easily explained. Normally, artifact timelines study - design phenomena allow for the definition of research design. For example, the researcher initially developed the intangible ecological form in the history and/or timeline of product design.

Coding analysis for semantics is a systematic way of interpreting and classifying the associations, feelings, and meanings that users or designers attach to various design aspects. It is one of the methods used in design thinking processes to define product form. As the study's primary objective, it is first necessary to identify semantic aspects in order to comprehend how they affect design choices and product shape. What significance do users assign to various design elements is one of the questions that the research study must pose and/or investigate. Furthermore, what impact do these interpretations have on how they view the product's form? Next, the source of the coding pattern—data collection for inductive reasoning using a qualitative methodology—will be understood. In situations such as focus groups, user observations, surveys, and

interviews, where participants talk about how they feel about and perceive various design components, a strong design theory foundation is needed. The product form pertaining to the design artefacts is typically used to gather the parameters for the designing study topic.

The qualitative process of gathering data meant semantically completely can be expressed in the materialization of designing tools and equipment such as sketches, prototypes, mood boards, and design briefs. Once the data collection process begins, the screening stages of source design are completed. To further describe certain semantic categories, a coding scheme must be developed. The explanatory approach will be directed towards the think aloud of designing manuscript evidently. This strategy of designing categories development may be based on the emotional, functional, and associative meanings of design elements as known with some good examples such as "elegance," "robustness," and "innovation"). As a result, some identifying and defining characteristics (such as lines, forms, colours, and materials) that contribute to each semantic category will be permitted for the descriptors function. Contextual elements play a major role in the research study's design and coding, as it directly influences the semantics through cultural, social, and environmental contexts.

The research study must search for patterns in the relationships between various semantic codes and the overall product form in order to design pattern recognition. Specifically, by linking semantic codes to particular design choices and demonstrating how they affect the product's shape, materials, colours, and other formal elements, the application of mapping semantics to product form consistently develops a human-centered design framework.

Design principles are therefore derived from the coded data by synthesizing design thinking findings. If "elegance" is the desired meaning, for example, find the design elements that consistently elicit this perception. But as you develop or improve product concepts, make sure they follow the intended semantics by using the coded insights. The study's approach to the subjects' testing requirements is based on the validations of design patterns. To make sure the intended semantics are understood correctly by the intended audience, user testing is used to derive the product forms for coding validation. As new information and insights become available, the coding scheme is continually revisited and refined through an iterative process of continuous improvement based on semantic design thinking methodologies to derive formgiving development. As an iterative process, design thinking calls for flexibility in how the

semantics analysis is developed. It is ensured by this structured approach that the semantic components of design thinking are methodically examined and included into the process of developing new products.

2.4.1 Qualitative Structure

Here, the researcher's case studies folds two important pinpoints from the EoF theory of artifact teleology continuum with (1) basic conception morphs geometric to organic form and (2) beyond conception morphs invention to innovation form.

First, the researcher has physically displayed modern classic furniture to project the sequence of an ecological form movement in Plate 2.1 and 2.2. It can be traced from the observation study (using the quality review in mind) within the heuristic approach (Chumiran et. al., 2018; Chumiran & Abidin, 2019; Chumiran et. al., 2020). Consistently, the timeline showed the form evolution that gradually indicated and performed a linear extrapolative morphing concept processes from 1917 (Gerrit Rietveld) until 1957 (Verner Panton). After 1957, the intangible ecological form evolution ceased due to the midst of second industrial revolution, which had promoted new material contents in the further technological era: new technology findings, the application of manufacturing process and the design interest for the large scale consumers known as mass production (Baker, 2003).

Second, the researcher believes the experts Akner-Koler of formgiving theory exist can be traced another design artefact such as Plate 2.5. This EoF theory has proven and shown other the intangible ecological form from the electrical fan product phenomenally. It began with design invention such as American Electric -Curtis & Crocker (Early 1880 - 1900) to the innovation Dyson Multiplier AM06 12 inches (2009). In the middle of design space, the others three of product range had been placed consequentially with (1) General Electric fan blade - 12 inches (1908), (2) Emerson fan blade - 12 inches (1940) and (3) Techie Japanese Vintage - 12 inches (1970s). Using by topology approach, the extrapolative strategy needs to scale the photographic images that it will be semantic digitized the product form which is to screen the emergence of visual elements (VE) in cantilever design principle morphologically.

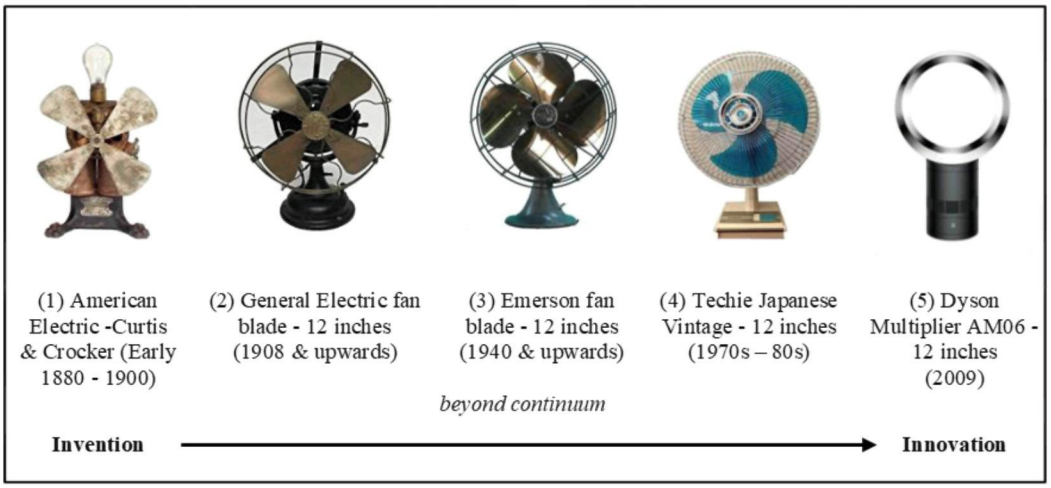


Plate 2.5 The Semantics Conception of Beyond Continuum

A twice wave of design phenomena had occurred and the teleology continuum of artifacts could have been explicitly reflected from the expert theory of Akner - Koler EoF. It refers an intangible ecological form search, is based on the both of product form evidence from the morphing concept: within an extrapolative strategy (Abidin, 2012) and decades of the direct evolution of designs as called historic development of ecodesign (Heskett, 1991; Bharma, 1999 & Sherwin, 2000). According to Friedman (2000), the nature of evolution of design phenomena refers to the word definition of "design" and the meaning of a design process. To initiate an inquiry into the design process, the teleology must first be compulsorily understood. Friedman (2000) agreed to coincide with the expert Fuller (1969: 319) at the Creating Design Knowledge - IDATER 2000 Conference, where a series of steps were mandatory for the subjective search and research process with "teleology → intuition → conception → apprehension → comprehension → experiment → feedback". This notion of formalizing design has contributed to the teleological method in the development of "the goal in laws concept" (Cyras, 2007). In this context of design law, the term "laws" has a different meaning logically (Burks, 1988; Burke, 2003; Cyras, 2007). But as inspired, the researcher has specifically aligned the laws of term introduction and suggested Cyras' (2007) qualitative methodology. This purpose of formalization of the law is to examine the goal in laws concept of the research study that it is implemented and operated through the gestalt theory (GT) laws principle such as (1) law of similarity; (2) law of common fate; (3) law of symmetry; (4) law of parallelism, and (5) law of continuity or good continuation and (6) law of closure. Thus, the "teleological order" emerged from the laws of GT motivation, the researcher found the view point of knowledge representation

(KR) that it established a knowledge base (KB) of component structure as a teleology mechanism building where the teleology construction was called entirely (Cyras, 2007).

However, the research study proves the earlier artefact design phenomena based on the movement of the two teleology concepts in semantic interpretation for the context of ID teleological explanation. Using semantic digitization design strategy, the search for an intangible ecological form moves morphologically towards pictographic reflections. With regard to the ecodesign identity, design communication will enhance the understanding of product semantics (Monö, 1997: Abidin, 2012) and allow a systematic approach to a teleology continuum (Burks, 1988; Burke, 2003; Cyras, 2007). Therefore, the specific design method distinction for intangible ecological form element will be generated from the readiness source of research conception at the earlier DS - I stage of primary dataset, and "the method exploratory of ecodesign identity" should be interpreted by PS stage in further main observational case study. Consequently, due to the appropriation on the ecodesign identity theory between the fields of designers and engineers, numerical value evaluation for comprehensive support will be evaluated at the DS - II stage. As a same ecodesign roadmap, the teleology method has thus facilitated the earlier "final causal" and/or attribute to the rigorous research concept following a paradigm of design research, meaning that the philosophical assumption of design delivers sequentially methodology processes namely an ontological → epistemological → methodological.

In addition, the researcher uses the DRM framework to acknowledge the theory of intangible ecological form. These all exist in artifacts by means of a compulsory test following the structure of the ecodesign model. The expertise in engineering design (ED) could therefore easily determine the morphing algorithm in accordance with the visual and/or photographic representative based on system thinking (Roozenburg & Eekels, 1995; Newman & Covrig, 2013). The field of ED will accordingly know and accept the new method distinction of distinguishing basic research referred to as product semantics + semiotics as design phenomenology (DP). In this case of design research, the researcher will intentionally describe in further Chapter 3 under the "research design" sub-topic.

2.4.2 Quantitative Structure

In a design research study, a quantitative structure comprises of the systematic measurement of the aesthetic appeal of superior drawings, the analysis of visual features, and the design outputs, particularly in the context of (1) superior drawing and (2) visual process activities. This framework makes it easier to evaluate the effectiveness, efficiency, and creativity of the design process objectively in respect to the ecological form of ecodesign identity.

In the setting of superior drawing, the performance of the product form in terms of aesthetic appeal is crucial to the identity of the product design. It is necessary for the assessment plan to gauge aesthetic attributes based on balance, harmony, and visual impact utilizing a Likert scale or other comparable rating system. The size, proportion, and complexity variations of design objects as they are rendered at various phases of the drawing and visualization process are referred to as the "scale of design object drawing transformation" in a design research study. To comprehend how these modifications affect the design outcomes under specifically, accuracy, detail, and usability that this transition can be quantitatively examined. Measuring and assessing these modifications in an organized manner is part of the quantitative framework for examining the extent of design object drawing transformations. On the other hand, providing case studies that show how quantitative analysis can be used to enhance drawing and other visual process tasks. The bipolar scale is realistically employed in the majority of case study settings to evaluate the media artefacts' and/or product designs' visual appeal and design calibre. An instrument for measuring attributes or characteristics along a continuum between two opposing poles is a bipolar scale. This could entail evaluating a design attribute, such as complexity or abstraction, from one extreme to the other in the context of design object drawing transition. Based on their qualities, design objects or drawings are given a numerical value on the bipolar scale using the scale measurement. A highly sophisticated design, for instance, would receive a score of 9 or 10, whereas a very simple design might receive a score of 1 or 2. Due to benefits, the bipolar scale is a helpful tool for analysing changes in design item drawings quantitatively. It enables thorough comparison and evaluation of design characteristics on a continuum from one extreme to the other by academics and designers. This bipolar scale helps design research evaluate different design decisions more objectively and offers insightful information about the user experience, creative process, and overall

design quality and aesthetic appeal. This methodically planned approach makes it easier to make decisions on industrial design that balance the practical, artistic, user-centered, and human-centered aspects.

To effectively analyse the visual elements in the visual process activities, industrial designers need to be proficient in applying line quality while sketching manually or digitally. Line qualities could be shown to vary in terms of thickness, smoothness, and continuity, while being consistent due to the precision of the measurement. A rubric based on originality, uniqueness, and problem-solving techniques can be used to assess the quality of the final work. Hence, assign numerical values to visual components and illustration methods according to predetermined standards by involving design specialists. The visual hierarchy structuring context is now necessary. It is easier for viewers to comprehend the significance and connections between various parts in a drawing when designers use heuristics to help them create a clear visual hierarchy. Through the use of heuristics and the heuristic technique, industrial designers can employ visual symbols and metaphors that visually speak to viewers and help them understand abstract or difficult concepts. A certain sign, symbolism, or metaphor pattern will be recognized by the industrial designer as the result of the visual hierarchy. Industrial designers can make abstract or difficult ideas more approachable and clearer by applying signs, visual symbols, and metaphors that engage with viewers through the application of heuristics. As a result, once the last step of the visual element analysis process is completed and the results are fully interpreted or filtered using numerical values, the design pattern discovery will be made available.

The quantitative structure in the design outcome determines the product form's functionality. Check if the planned functional objectives or user needs are met by the visual outputs. Heuristics simplify design processes, speed up and improve decision-making, and improve product form alignment with user needs by focusing on pragmatic, experience-based approaches. More creative product designs, more effective research, and ultimately more useful, user-centered, and human-centered goods are the results of combining heuristic methods with quantitative analysis. Utilizing this method guarantees that the final product shape satisfies both performance and practical requirements while also fostering innovation and reducing complexity. Furthermore, describing and quantifying the ways in which particular theoretical concepts are applied and manifested during the design process is a necessary step in operationalizing design outcomes for variables in design theory. This procedure guarantees that variables or

abstract design ideas are converted into concrete components that may be methodically assessed and improved. One can build a connection between theoretical ideas that are abstract and real-world, quantifiable design results by operationalizing design theory variables. This procedure guarantees that choices about design are theoretically supported and flexible enough to fit into particular design contexts.

The systematic assessment of the aesthetic appeal of outstanding drawings, the examination of visual elements, and the design outputs are all part of the quantitative framework for drawing and visual process activities in design research. Through the use of instruments like computer-aided design (CAD) software, image processing, observer evaluations, and statistical analysis testing methods, researchers can assess and refine the visual elements of design in an objective manner, aiming to achieve design representation. At the moment, the Gestalt principles of visual perception can currently be used to describe design representation with ease. Heuristic approaches frequently use Gestalt concepts like continuity, proximity, and similarity to aid in the intuitive organization of visual elements so that the numerical value purpose can be presented and demonstrated. Comprehending these ideas enhances one's ability to create visually appealing and logical drawings. Industrial designers can create more effective drawing composition and layout by using heuristics to quickly find patterns and relationships among visual elements. Taken together, these systematic methods enhance the effectiveness and efficiency of the design process and support the industrial design community in creating more innovative, aesthetically pleasing, and practically sound products. Stated differently, system thinking is well-developed because each of those elements is embodied as a whole.

2.5 A Stimuli of Metaphor Pattern Emerges Ecodesign Identity Understanding

Understanding the triggers that cause metaphor patterns is critical for comprehending ecodesign identities. In ecodesign of product form context, metaphorical language is frequently used to communicate sustainability concepts and principles. Industrial designers may create more environmentally sensitive identities for products, systems, and businesses by understanding the underlying inputs that prompt metaphorical expressions. This understanding enables more effective transmission of sustainability values and develops stronger bonds between users and environmentally friendly designs. Stimuli are events, conditions, or inputs that cause an organism,

system, or process to respond or react. Stimuli are external or internal variables in human perception and cognition that cause sensory experiences, thoughts, emotions, or behaviours to occur.

In psychology, stimuli might include sights, sounds, scents, tastes, textures, and any other sensory input that influences human perception and behavior. Stimuli in design and / or communication could include visual clues, language prompts, contextual conditions, or any other aspect that evokes a specific response or interpretation. Thus, the research study emphasizes the design representation as the main contents of the literature review. Here, two pinpoints of critical thinking have to elaborate the design representation using the organizational knowledge iceberg (Haider, 2009; Salleh et al., 2015) following (1) tacit knowledge and (2) explicit knowledge.

a) *Tacit knowledge* - First, the tacit knowledge generates from the engagement of individual, group, organization, inter-organizational levels and networks to the degree of tacit dimension until the knowledge model creation (Haider, 2009: Simon, 1991; Kogut & Zander, 1992; Nonaka, 1994). In the research of design sciences, designer communities is always put the paradigm in a priority that it merely assigns and / or determines the use of think aloud for the scientific research of DRM framework including designs' testing methods. For example, an appropriate selection of design methodology will assist the researcher to answer the research questions according to the purpose of the study for the qualitative reasoning and / or research objective for the quantitative reasoning respectively. Because of belief and / or perception, the research activities will be influenced by the pattern of design representatives that with an expectation of DRM framework will be answered all the research questions accordingly. Fundamentally, in the context of the iceberg model, the "tacit meaning" refers to the deeper, underlying meanings or messages that are not clearly stated or visible at first glance. The iceberg model is frequently used to explain matters of communication, specifically the layers of meaning in interpersonal interactions.
b) *Explicit knowledge* - Second, for the explicit knowledge, the study focuses on the methodological digitization of product form as well as ecological form of ecodesign identity. This digitization of material sources (secondary data)

generated and collected from the artificial intelligent of supply chain or networking namely the design representation. Using the pattern of the product form, the young designer usually develops and creates the new idea of product design refining to the design movement record or history. Heskett (1991) expressed the design laboratory developed from the Bahause movement era that the key factor of the design supply chain had related with the product form imagery as commonly used under the product aesthetic. For the VPA approach, the researcher uses the pattern of artefact digitization that the photographic will be morphed the intangible ecological form of ecodesign due to the communication of design phenomenon.

Again, the explicit knowledge context as visible elements correspond to the methodological digitization of product form - product system, material selection and use, product marketing, ecodesign communication, product life cycle methodology, and environmentally friendly product design. Meanwhile, the tacit knowledge context as invisible refers to the ecological form of ecodesign identity following a think aloud and behaviour according to the set of belief and / or perception - the contrast between design thinking and system thinking, gestalt law - visual perception, idea creation, design quality, product perception, product aesthetics, and think aloud of designedly behaviour.

Subsequently, as the above lessoning, the research study identifies the design phenomena of critical thinking have developed some logical methodology that it enables to screen the three components of the ecological form of ecodesign identity such as (1) the form follows function principle, (2) tangible and intangible formgiving and (3) Gestalt theory towards ecodesign concept pattern.

2.5.1 The Form Follows Function Principle

The notion of "form follows function" holds significant influence in the field of industrial design, having shaped the evolution of contemporary architecture and product design, among other areas. The late 19th and early 20th centuries, when industrialization and technical advancement were booming, are when its history began.

American architect Louis Sullivan made the saying "form follows function" prominent in the late 19th century with his 1896 essay "The Tall Office Building

Artistically Considered." In contrast to ornamental or historical forms, Sullivan maintained that a building's design should be determined by its intended use or purpose. His maxim, "form follows function always," was eventually adopted as a design tenet for industrial and modern architecture. Early 20th century and Modernism: Walter Gropius's German design school, the Bauhaus Movement (1919–1933), was instrumental in popularizing the "form follows function" school of thought.

The Bauhaus placed a strong emphasis on the fusion of technology, craft, and art with a particular emphasis on functional design. Bauhaus architects and designers such as Marcel Breuer and Ludwig Mies van der Rohe produced simple, efficient furniture and structures with straight lines. As the International Style of architecture and design evolved in the 1920s and 1930s, the tenet "form follows function" became essential. The use of contemporary materials like steel and glass, together with functionalism and minimalism, were valued in this design. Buildings and items were designed with an emphasis on practicality, reducing them to their most basic forms. The industrial design movement introduced functionalism in product design in the middle of the 20th century. The "form follows function" philosophy was adopted by Scandinavian designers of furniture and products from the 1930s to the 1960s, including Hans Wegner, Arne Jacobsen, and Alvar Aalto. Their designs merged functionalism with a focus on human-centered design, resulting in items that were comfortable and aesthetically beautiful in addition to being useful.

Concurrently, the "form follows function" theory was incorporated into the designs of American industrial designers such as Charles and Ray Eames, Henry Dreyfuss, and Raymond Loewy. They produced goods that were easy to use, practical, and ideal for large-scale manufacturing. For instance, the straightforward, ergonomic shapes of the Eames chairs turned them became symbols of modern design. The "form follows function" phenomenon emerged during the 1970s–1990s Postmodernism era, when designers like Philippe Starck and Michael Graves rejected the dogmatic functionalism of modernism. They created goods that were frequently witty or sardonic by experimenting with forms, colours, and historical allusions. Nonetheless, the correlation between form and function persisted as a crucial factor in postmodern design. The "form follows function" idea has been redefined in the context of sustainability now, in the twenty-first century, as the reframing of product design functionality. These days, product designers also take the product's life cycle and environmental impact into account in addition to its intended use.

As an outcome, items that are not only useful but also economical with resources and the environment have been produced. Technological developments, along with an increasing focus on user experience and the advent of user-centered design (UCD) and human-centered design (HCD), have led to a more sophisticated understanding of utility. These days, industrial designers take into account how people interact with things, resulting in designs that are user-friendly, ergonomic, circular economics and adaptable regarding digital and interactive design. The development of digital technology has also changed how "form follows function" is used. When designing software, apps, and digital interfaces, form follows functionality in terms of usability and visual clarity, while functionality is frequently characterized by how well a product helps users achieve their goals.

According to the chronological timeline of the industrial design movement, the "form follows function" principle is a fundamental design concept that posits an object's shape should be primarily determined by its intended purpose or function. This idea assumes a special form in the context of ecodesign identity phenomena, where the design respects the environment in addition to fulfilling its functional requirement. This is how ecodesign identity embodies the "form follows function" principle:

i) *Functionality with Environmental Consideration* - The design's main goal is to minimize its adverse environmental impacts while simultaneously satisfying the user's functional needs. The product's intended usage and its potential for increased sustainability both influence its form. The product design is optimized to use the least amount of energy and materials due to efficiency. As an illustration, a product may have a straightforward, unadorned design that reflects the need to minimize material waste (Jiang et al., 2021).
ii) *Material Selection and Application of Eco-Friendly Materials* - The form is directly influenced by the materials selected. Biodegradable polymers, bamboo, and recycled plastics are examples of sustainable renewal materials that are chosen for a product's design and functioning in addition to their positive effects on the environment. The natural qualities of the materials used may be emphasized in the product's shape via the material expression. To highlight their sustainability and give the product a genuine, environmentally friendly character, recycled materials' texture and look, for instance, could be left

apparent (El-Naddar, 2024).

iii) *Minimalist Design* - When it comes to ecodesign, minimalism frequently leads form. In order to meet both functional requirements and a dedication to using fewer materials, excessive decoration is avoided and the design is reduced to its most basic components. Modular forms are another way to expand a product's adaptability and ensure that it continues to function over time. They make it simple to upgrade or replace individual elements. As a manifestation of user-centered design, the form is simple to use and straightforward, guaranteeing that the product performs as intended with minimal manufacturing and usage waste. For instance, robust product forms that are made with durability in mind are intended to be created in order to ensure that they endure longer and lessen the need for frequent replacements. Frequently strong, uncomplicated, and classic, the form adds to the product's lifetime and lessens its overall environmental effect (Gumber, 2023).

iv) *Energy Efficiency and Resource Use* - Energy efficiency is a design feature of products, both during production and during usage. For example, the form may be modified to minimize energy consumption during usage or for energy-efficient assembly. The form is made to use resources as efficiently as possible based on resource efficiency. This could be using less material in the design process, utilizing renewable resources, or coming up with a shape that is simple to deconstruct for recycling (Shu & Sakao, 2017).

v) *Biomimicry and Natural Forms* - Naturally Inspired Since an organism's form is closely related to its function and surroundings, ecodesign frequently takes influence from nature. In order to create solutions that are naturally sustainable, biomimicry entails developing goods whose forms resemble natural processes, structures, or systems. A sense of harmony with the surroundings and a reduction in visual pollution can be achieved by designing the product's form to fit in with the natural surroundings, all while utilizing the harmonizing Forms feature. The product's form may clearly convey its purpose and manufacturing process in the apparent functionality, encouraging openness and truthfulness in design. This could be demonstrating how parts fit together, where resources come from, or how the product can be disassembled and recycled. In order to give the product a form that communicates its eco-friendly and socially responsible identity, an ethical resign requirement that follows the product form

may represent ethical considerations, such as fair labor methods or sustainable sourcing (Benyus, 2002).

vi) *Circular Economy and End-of-Life Considerations* - Design for Disassembly (DfD) guarantees that a product's shape is designed with the end-of-life in mind, making it easy to disassemble for recycling or other purposes. This could include modular designs that can be disassembled without causing damage to the various parts. The products are designed on a circular economy paradigm that heavily relies on closed-loop technology. This contributes to a more sustainable lifecycle by making it easier to recycle, upcycle, or reuse things (Formentini & Ramanujan, 2023).

vii) *Cultural and Social Identity* - Product forms that are culturally relevant are those whose designs primarily include cultural norms and preferences, guaranteeing that the form is not only long-lasting and practical but also aligned with the users' cultural identity. The product's design and manufacture may be influenced by the design society and community involvement, with a focus on local craftsmanship, sustainable techniques, and environmental consciousness. Because of its association with a timeless design, an ecodesign identity frequently concentrates on producing forms that are ageless and do not rapidly go out of style. This promotes a longer product lifecycle in addition to lowering waste. The product's sustainable purpose drives its aesthetics, resulting in a form that is aesthetically pleasing and will hold up over time (Ghazali et al., 2021).

The "form follows function" principle incorporates sustainability into the design fundamentals, beyond the idea of merely structuring a product according to its intended purpose in the physical ecological form of ecodesign identity. The product's form embodies ethical issues, resource efficiency, and environmental sensitivity in addition to reflecting its usefulness. This method produces goods that are in line with the fundamental principles of sustainable design and are not only useful but also have a beneficial environmental impact.

2.5.2 Tangible and Intangible Formgiving

Hence, the designing cognition (think aloud) passes through by the ecological form of ecodesign identity results and delivers from the subjects' participant

concurrently. The exploratory of design research is very significant for the researcher to seek the overview designing category and / or theme for the dissertation of literature review. The subject of design sampling (young designer as participant) in the focus group study will be projected the quality of design manuscript from a think aloud exploration following the VPA method. Then, the grounded assessments of design quality have to gauge and measure where the evidence-design based can be proven by the design validity itself. This VPA method of research activity related with the type of design research identification. Usually, three types component of design research study such as (1) basic research, (2) grounded research and (3) clinical research has to be decided clearly by the researcher according to the research title intuitively.

Tangible formgiving is fundamentally about a product's physical attributes, such as its shape, materials, textures, and general appearance. These components directly affect how the user interacts and experiences the product in the physical world. Natural shapes, such as organic curves or biomimetic designs, can serve as inspiration for products to foster a physical connection to the natural world while also promoting a sustainable brand. This can be observed in patterns that imitate the forms of leaves, shells, or other natural elements; these patterns not only have a beautiful appearance but also stand for environmental balance. The sustainability of a product is strengthened by its easy-to-use, repair, and disassemble designs. Here, tangible formgiving entails making things ergonomic and user-friendly, promoting extended product life, and cutting waste. Products created using the modular approach and including upgradeable or interchangeable parts exemplify sustainability in their physical form because consumers can simply upgrade or replace pieces without having to throw away the complete device. A product's surface polish and texture can also reveal aspects of its ecological identity throughout the form finishing process. The product's sustainable origins can be emphasized by using non-toxic, natural finishes or rough textures that draw attention to the raw, unprocessed quality of the material.

Conversely, intangible formgiving describes the non-material characteristics of a product, such as its emotional appeal, cultural importance, symbolic meaning, and the ideals it stands for, that help to define its identity. These components affect the product's perception in addition to its physical characteristics. The story a product tells and the values it symbolizes are part of its intangible form, and they are determined by its brand identity and value. Customers that respect environmental responsibility are emotionally drawn to products that convey their sustainable origins through branding, message, or

design clues. An effective intangible component of a product might be its backstory, which includes information on the materials used, how it was manufactured, and how it affects the environment. Design storytelling elevates a product beyond its utilitarian nature by fostering a more profound comprehension and admiration of its environmentally conscious features. Additionally, intangible formgiving might entail the use of symbols or design features that are representative of sustainability, such as leaf patterns, green colours that evoke nature, or circular shapes that symbolize the circular economy. The ecological values of the product might be discreetly conveyed to customers through these symbols. In the framework of educational design, products that raise consumers' understanding of sustainability through informational or design elements also contribute intangibly by promoting environmental consciousness. A product's ecological identity is enhanced, for instance, by packaging that provides instructions on how to properly recycle or compost it.

Thus, in this dissertation of literature review, the researcher found the nature of study called the set of belief for design representation generated by design experience, is suitable with the design thinking approach under basic research orientation accordingly. Tangible and intangible formgiving are both crucial in creating a strong ecodesign identity. Tangible elements, such as materials, shape, and functionality, directly impact the physical experience of the product, while intangible elements, such as emotional appeal, symbolism, and values, shape the perception and cultural significance of the product. Together, these aspects create a cohesive, sustainable design that resonates with consumers, fostering a deeper connection to the product and the principles of ecodesign.

2.5.3 Gestalt Theory Towards Ecodesign Identity Concept

This attribution is oriented by gestalt law – visual perception explicitly in many designerly cognition. Gestalt psychology, which first arose in the early twentieth century, studies how humans perceive and organise visual elements into meaningful wholes. Gestalt concepts are frequently applied in a variety of design disciplines, including product design, to produce visually appealing and effective designs. Gestalt psychology, which first arose in the early twentieth century, studies how humans perceive and organise visual elements into meaningful wholes. In the knowledge of visual laws' perception, Gestalt concepts are frequently applied in a variety of design

disciplines, including product design, to produce visually appealing and effective designs. There have seven ways of gestalt principles that it can be applied to product design identity such as (1) closure, (2) proximity, (3) similarity, (4) continuity, (5) figure-ground relationship, (6) symmetry and balance and (7) common fate. Young designers can increase the overall visual appeal of their products by integrating these gestalt principles. These principles assist designers understand how consumers perceive and interpret visual information, resulting in more effective communication and engagement.

Firstly, the closure principle describes the inclination of humans to view incomplete shapes as whole. This can be applied to ecodesign by creating goods that, while some aspects being left up to the user's perception, intuitively suggest their entire function or lifecycle. A modular product, for instance, might be made to imply several configurations or applications, promoting adaptation or reuse over disposal. Second, the proximity principle can be used in ecodesign to improve usefulness and resource efficiency in the layout of features or components. For instance, in a product design, grouping related pieces together minimizes the need for wasteful material or energy consumption. Third, items that share a similar appearance are thought to belong to the same group, according to the likeness principle. In ecodesign, a product's sustainable character can be communicated by utilizing comparable materials throughout. A product composed completely of recycled materials, for example, can support the sustainability message. Fourth, the term "continuity" in ecodesign describes the smooth transition between a product's lifespan phases, such as the procurement of materials and recycling or disposal. A product that is created with continuity in mind will lead the user through each step of the process in an intuitive manner, guaranteeing that sustainable practices are adhered to throughout the product's life. Fifth, the figure-ground approach in ecodesign can be applied to draw attention to a product's most significant sustainable qualities by making them the main focus. One way to emphasize a product's eco-friendliness would be to design it with a recycling symbol that is clearly identifiable and sticks out against a more neutral background. Sixth, stability is linked to symmetry and balance, which is demonstrated by ecodesign’s balanced use of materials and resources. A symmetrically designed product may imply a sustainable, well-balanced strategy that uses resources sparingly and effectively. Seventh, Gestalt theory's principle of common fate describes people's propensity to see components that move or change in unison as belonging to a single group or cohesive whole. This idea

can be used in ecodesign to make systems and products that are viewed as cohesive, integrated, and ecologically conscious.

Therefore, the design thinking is suitable practice of designer's cognition as well as think aloud, to use among the young designer that the beginning of the design representation will be evoked the design process - to - output during the designing of new product development. The advantages and benefits of incorporating Gestalt theory into ecodesign result in products that are not only visually beautiful and useful, but also naturally convey their sustainability. Industrial designers can produce ecodesign products that are more than the sum of their parts—items that support and embodies environmental responsibility in their very shape and function—by utilizing concepts like proximity, similarity, continuity, and closure. This strategy supports the development of a powerful, unified ecodesign brand that appeals to consumers and promotes environmentally friendly behaviour.

2.6 Summary

Empathy mapping allows industrial designers to deeply understand users' emotions, thoughts, design philosophies, Gestalt principles, and behavioural patterns by analysing their interactions with sustainable resources and data. By adopting users' perspectives, young designers can uncover subtle needs and aspirations that drive sustainable values and practices. This empathetic approach supports the creation of human-centred products that align with ecological awareness and emotional engagement. Empathy maps illustrate how users emotionally connect with environmental issues, encouraging designers to become more aware of behavioural influences within specific contexts. Through this process, young industrial designers can engage in reflective thinking, enabling them to design solutions that subtly guide sustainable behaviours and decision-making, while remaining attuned to the motivations, circumstances, and lived experiences of their target users.

In synthesizing the literature review, this study identified a non-linear design model that employs mind mapping as a heuristic tool, grounded in prior design phenomena. Mind mapping supports the visual structuring of ideas, often through sketches or diagrams that it emphasizes conceptual relationships and enabling critical examination of the intersections between sustainability, design, and user experience. By distinguishing between different design sources, emerging industrial designers can

analyse how patterns in product form are visualized, which informs the development of fusion design strategies aligned with industry practices. Mind maps thus become instrumental in articulating the intangible ecological form of a product, linking ecological values with emotional, cultural, and ethical design dimensions. This is particularly relevant in visualizing a product's ecodesign identity. Embracing a holistic design approach is essential, ensuring that future / novice designers consider a comprehensive range of ecological concerns, and that ecological attributes are coherently integrated into design outcomes that reflect deeper sustainability principles.

Nonetheless, the application of design thinking techniques like critical cognition as a heuristic approach offers an organized but adaptable method for moulding the intangible ecological form in industrial design. These tools help designers make sure that the final design not only satisfies functional and aesthetic requirements, but also explores, tests, and refines non-physical components of a product, such as emotional resonance, cultural relevance, and ethical ideals. Additionally, it strikes a profound ecological connection with users. Young industrial designers may contribute to a future where people care more about the environment by using these skills to make products that have a strong, sustainable identity. Thus, a follow-up methodological analysis chapter will look into the prescriptive study and consider designerly approaches in which the subjects' participation in the VPA method should give the grounded theory explanation through think-aloud investigation.

CHAPTER 3
RESEARCH METHODOLOGY

3.1 Introduction

This chapter describes the ideation of design insight, which is the designer's human cognition and argumentation of research methodology area towards an intangible ecological form of ecodesign. The aim of the study is to seek the recognition of the ecodesign identity phenomenon using a systematic methodology called design research methodology (DRM) that can be suited to the young industrial designers' understanding of its iterative evidence-based design process. In Figure 3.1, the illustration begins with the bold, grey arrows referring to research clarification (RC) – descriptive study I (DS-1) – prescriptive study (PS) – descriptive study II (DS-2) stage until the direction of the sequence processes forms a cycle, returning together into four stages, respectively. For the iteration review, the white arrows vertically move from the bottom to the top representing the quality of key factor evaluation increasingly revealed by the DS-2 stage. Then, it transitively steps up to reach the support stage, as evidenced by the PS stage, to strengthen the understanding of the DS-1 stage. Lastly, the researcher will reach or refer to the goals' research setting in the RC stage, known as the problem statement, research goal, research aim, and research questions, all of which are supposed to be fulfilled systematically in the DRM manner.

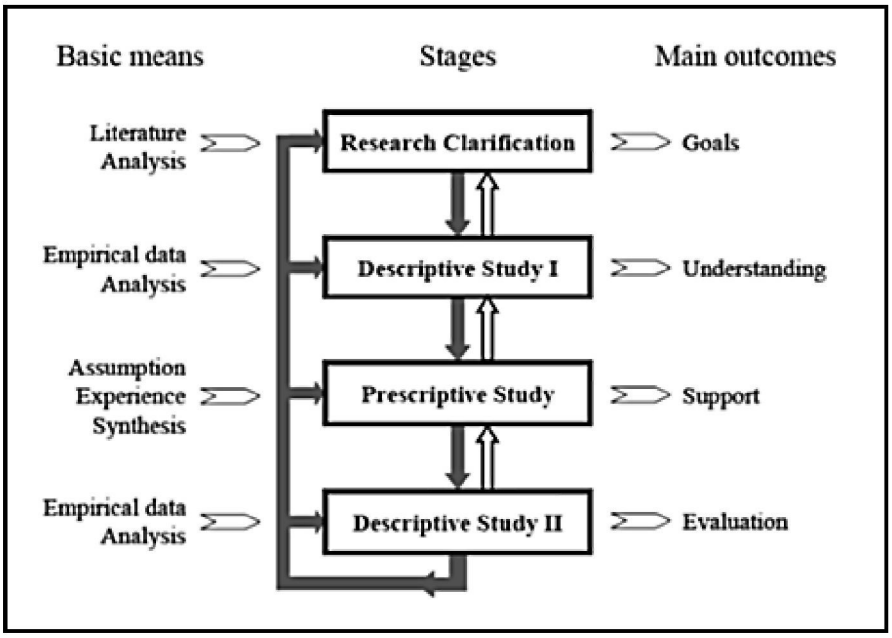


Figure 3.1 Design Research Methodology (DRM) Framework

Source: Blessing and Chakrabarti (2009)

From the DRM lesson, the research methodology study will assess the importance of the empirical study, which refers to the best or ideal testing method and design approach. It possibly describes how the industrial design field research is assigned to approach the systematic research methodology (see Chapter 1) following the research theme/topic required. Basically, in this research methodology chapter, the study intuitively emerged as the latest formulation of design methodology for the green design era, which is very significant in preserving the nature of ecosystem study. The conventional methodology formulation towards the iterative process thinking approach from the new product development (NPD) era coined by old master expert John Heskett (2002), such as *"design is to design a design to produce a design"* (p. 03), has not realistically adopted the fundamentals of ecodesign approach model (EAM – ISO 14021, 2008) from the earlier pioneers Wimmer et al. (2004). These design iterative factors have reflected and implicated the human activities that the environmental problems have to focus on a new ecological form model initiative, which possibly performs the sustainable for product design (SfPD) within its historical ecodesign perspective. This approach presents a very realistic industrial ecology (body of knowledge) cycle in every particular field and/or discipline, revealing various benefits via the research conducted, especially in handling the global environmental impacts concerned and minimising the kinds of pollution (OTA, 1992; Hammond et al., 1995;

Pereira, 1999). Definitely, the design insight study using fundamental research will help solve the knowledge/methods/research gap following the empirical design experience that could explain the understanding of the designer's way of knowing and design thinking simultaneously.

Here, in order to elaborate the research methodology, the design research project of the DRM framework is needed. According to DRM experts, Blessing and Chakrabarti (2009), there are seven types of DRP in the DRM framework. The purpose of DRP is described as, *"...based on whether the state-of-the-art with respect to a particular stage requires a comprehensive study or whether a* ***review-based study*** *is sufficient. The research questions and hypotheses, and the available time and resources will determine the type of research to be undertaken. A review-based study is based only on the review of the literature. A* ***comprehensive study*** *includes a literature review, as well as a study in which the results are produced by the researcher, i.e., the researcher undertakes an empirical study, develops support, or evaluates support (Blessing & Chakrabarti, 2009)."* Obviously, the DRP has a similar design conception, and it is significantly based on the prescriptive study following the norm of product innovation promoted by product design experts Bradbury (1989) and Roozenburg and Eekels (1995). The experts agreed that the comprehensive study can only be done upon the proper conduct of the basic/fundamental research study that uses the prescriptive model. They suggested that the basic cycle of the product design process must be through certain model phases of the design process. In Figure 3.2, the illustration presents "Option 6" as the best type of selection of design research along this current mode of DRM framework. There are two phases combined, namely: (1) Reviewed-based phase: RC and DS-1; and (2) Comprehensive phase: PS and DS-2.

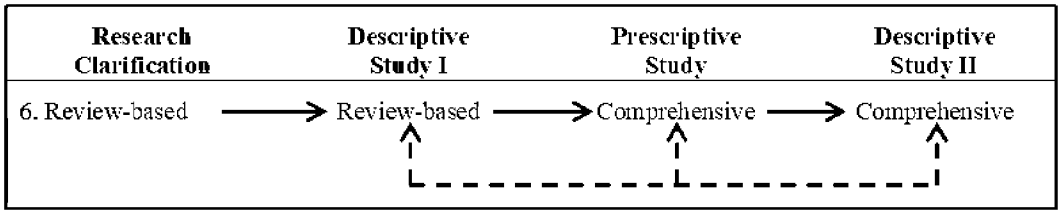


Figure 3.2 Option 6 - Type of Design Research Projects and Their Main Focus

Therefore, Blessing and Chakrabarti (2009) noticed that the design methodology theme must be used and presented with the nature of the empirical method. Focusing on the word "design" represents the PS and DS-2 stages concurrently. Thus, the

researcher will begin the study with a fundamental research methodology as the expert's suggestion (Bradbury, 1989; Roozenburg & Eekels, 1995). Also, it was aligned with the Heskett model of design iterative process in the earlier discussion. However, the conventional Heskett model should be converted with the old master model of design namely "form is to form a formgiving to form an ecological form of ecodesign" as the ecodesign identity information (the change in environmental communication) is grammatically recognised as a noun – verb – noun – transitive verb. This was inspired by rethinking waste the innovative design thinking. Because of the nature of design studies, this research topic uses the DRM to support the design belief (goal setting) using the understanding of the empirical design testing method. At the same time, the study is related to the earlier three design disciplines which had been described in Chapter 1 consistently. Hence, the reflective practice happened in the DRM activities upon the identification of the problem statement, knowledge gap, and the limitation of the study. Consequently, the further responses and acts in the research study will be approached by the model of Schon's Theory of Practice. This reflective practice knowledge is the design strategy that the researcher needs to manage the component of the research methodology structure as well.

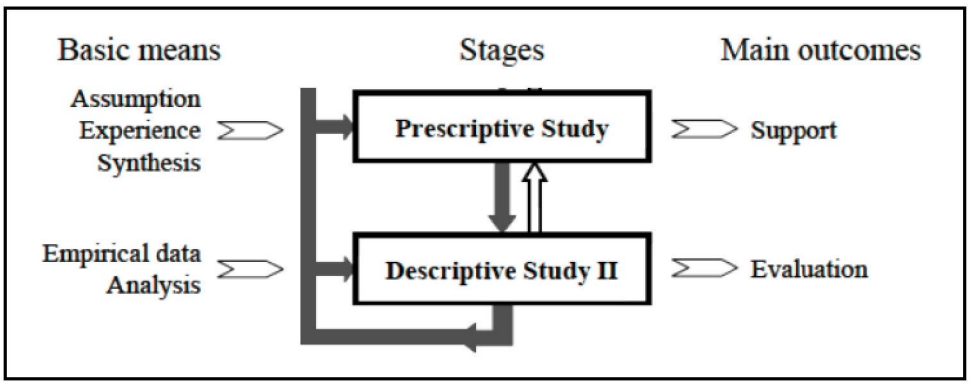


Figure 3.3 Verification of DRM Framework Flow

For the verification of the research methodology, the researcher displays an exact framework as Figure 3.3. At this time, the study used methodological approaches that could easily compare the role of design research framings (Hovath, 2007) and let the perspective of art and design that it was extending beyond design research following the specific industrial design area (McMahon, 2014). Here, the first Review-based phase was hidden from the DRM framework flow due to the RC and DS-1 studies were

grouped under the proportional research in the design perception context. This verification of the DRM framework is preferably aligned with Option 6 as mentioned earlier. The researcher demonstrated two processes with the PS study and DS-2 study stage to suit the current chapter of research methodology. The PS study refers to the rigorous verbal protocol analysis (VPA) method following a qualitative methodology that the "think aloud" of design experience producing the ecodesign identity in the product form context – the human beings practice a design activity to solve an aesthetic problem by human-centred design concept and/or orientation. Through the drawing and designing experience, there was an emphasis on the phenomenon of design patterns via a reflective practice approach using the imagery interactions between interpolative and extrapolative strategies. On the other hand, the DS-2 study outcome should present an encoding of the designer's human cognition framed by the design pattern existence within the reliability test interpretation, relationship, and association testing methods under the quantitative methodology. This statistical analysis testing method is purposely used to measure the quality of design experience resulting from the PS stage accordingly. Hence, the PS stage will be supported by the evaluation of the descriptive study – 2 (DS-2) stage in the DRM framework systematically.

Meanwhile, these two characteristics had engaged between the type of design research project and verification of the DRM framework together. Thus, two characteristics of methodology significantly developed the philosophical assumption of design research, namely: (1) design-inclusive research (fundamental research) and (2) the existence of practiced-based design research (applied research). It will be reviewed to correlate the philosophical assumption that it may refer to the ontology, epistemology, and methodology of design research concurrently (Hovath, 2007).

3.2 Research Frameworks

The research framework introduced a design logic model, and it preferably applied the systematic research framework consistently. The fundamentals of the logic model require that system thinking is commonly used for designing, planning, implementing, and evaluating the stages or phases in business research framework study. In the area of product design markets, the elements of business logic model study occurred following the certain/some methodology reasoning into the research framework activities that it synonymously uses to match with the similar and/or other

patterns of system thinking. Because of the nature of design domains, the industrial design (ID) field has been subordinated by the system thinking platform to approach the manufacturing technology (MT) under the engineering design (ED) area whereby (1) the specific gap of framework processes and (2) the similarity human cognition happened along the design studies knowledge. These two causes of pinpoints mentioned delivered the direction of a comprehensive research framework in the holistic design thinking context. Here, the evidence was screened during the process execution and the researcher has identified the two signs of methodological assumption together with some questions, such as: (1) the grounded of design activity: what kind of qualitative and quantitative methodology to comply with the logic model strategy; and (2) the underlying of conventional Heskett model: how to change and validate the current design activities by an existing concept of the old master logic model.

According to Kellogg (2004) and Knowlton and Philips (2012), the basic logic model describes the kind of activities or practices or essence behaviour to reach the goal setting of the research process together with a theory of change model. However, this nature of research enquires is highly based on the basic/fundamental research mode due to the real world of design experience (design insight addressed by think-aloud protocol), which refers to investigating the nature of design enquiries, the theme of the design studies, philosophical assumption and the triangulation of design methods. It is hermeneutically supported and/or the specific methodology within design theories was done via the verbal protocol interpretation and models measurement using the statistical descriptive approach to demonstrate a trustworthy finding from the rigorous research methodology processes in design perception.

In this context of the research framework, the study will address and engage the phases of product form development (design activities) to explain the understanding of relationships (or connections) among the certain elements programmed until reaching the goal setting. Systems thinking is commonly used in this logic model application according to the business organisation (green manufacturing in MT field context) and marketing programme (green marketing in IM field context) as the designer's human cognition of ecodesign platform purposely. Based on an analogical study, the SfPD is produced by green manufacturing where the conception of the ecodesign product has been set up from the element of environmental impacts and its sustainable design requirement needs. In the ID field, design thinking is very significant, and it refers to the aesthetics of product form context in which the design taught relation between

design thinking engages with the system thinking explicitly. Thus, the understanding of the ecodesign theory model, which is the "form is to form a formgiving to form an ecological form of ecodesign," will emphasise the distinction between the ecodesign model and environmental communication following the fundamentals of the logic model itself. The researcher will visualise the design and plan referring to lessen the two types of models programmed in further process.

To elaborate on the essential logic model in this chapter of research methodology, the study uses two types of models: one logic process is the essential of two phases in the research methodology framework, namely: (1) a theory of change model; and (2) programme logic model. These two types of models are preferred by the experts, Kellogg (2004) and Knowlton and Philips (2012), where they had noticed that the practitioners could change the logic model under certain/some methodology reasoning. Here, the study will describe the definition, role, and function following:

a) Theory Change Model (TCM) – In the product form context, the TCM describes the simple general representation with enquiries of design representation in which it delivers the question of how the design belief will shift our understanding towards future changes. From this definition, TCM allows and encourages the model transformation needs which means, it can be reflected in the latest scenarios, situations, operations, and phenomena in the design leadership development. This TCM demonstrates the transformation of the model required using the two mechanisms, namely: (1) strategies; and (2) results in the modus operandi along an internal mental framework. The evidence-based practice is commonly used from an existing model with the latest enhancement model emphasises the context of domain study required – considerable knowledge, experience, research, and practice: the conventional Heskett model will be changed to the current ecodesign identity model. For the visual aid, in Figure 3.4, the basic ecodesign identity theory of change was established. The form artifact orientated the TCM into the human-centred design obviously that it embedded a design belief including two design components of the product form context. Meanwhile, the transitional change theory has emphasised a belief assumption by informing a theory of change in Figure 3.5.

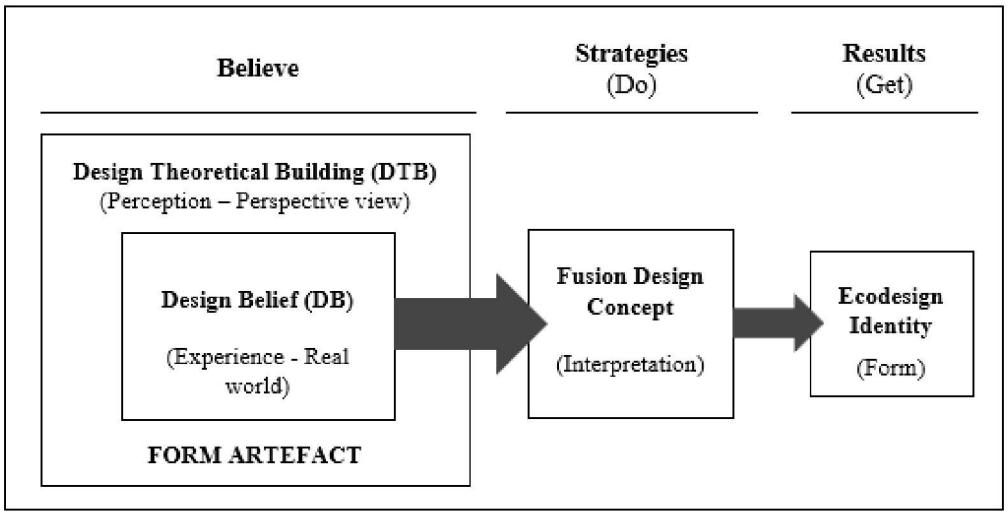


Figure 3.4 Ecodesign Identity Theory of Change (ToC)

Source: Kellogg (2004)

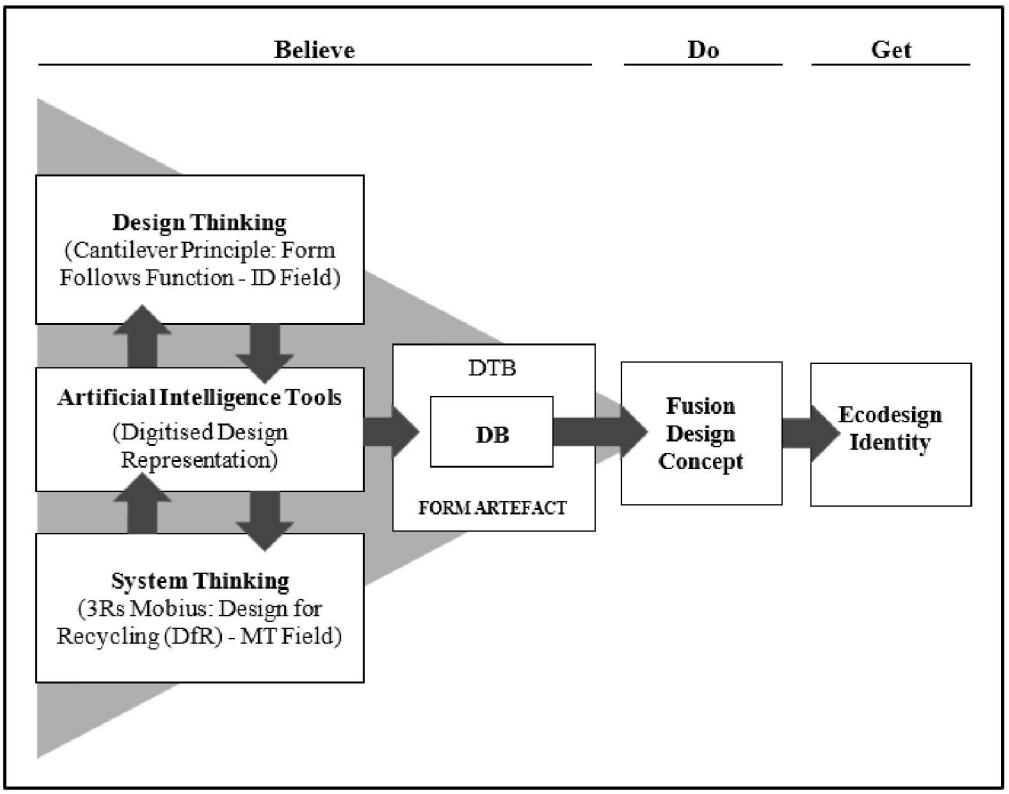


Figure 3.5 Informing A Theory of Change (ToC)

Source: Kellogg (2004)

b) *Programme Logic Model (PLM)* – In the second meaning context, the PLM iteration refers to the number of programme settings. The set of pictorial programmes shows some sequence of design activity that the individual programme has engaged with other programmes until the end of the process

where it reveals the intended results. It commonly depended on the certain timeframe which is the time duration used in the reflective practice approach to recognise the detail sources, planned activities, and their output and outcome consistently. For the impact, the transformation of intended change will happen via an organisation, community, or other system and it will allow the design implication for the beyond programme. At this time, the iteration of design activities should be tested with the hypothesis lesson (using "If"-"then") following each set of pictorial format programmed as Figure 3.6. The PLM has sorted the hypothesis statement using the two phases of reflective practises called (1) planning/strategies: resources to activities and (2) intended results: outputs to outcomes to impact accordingly.

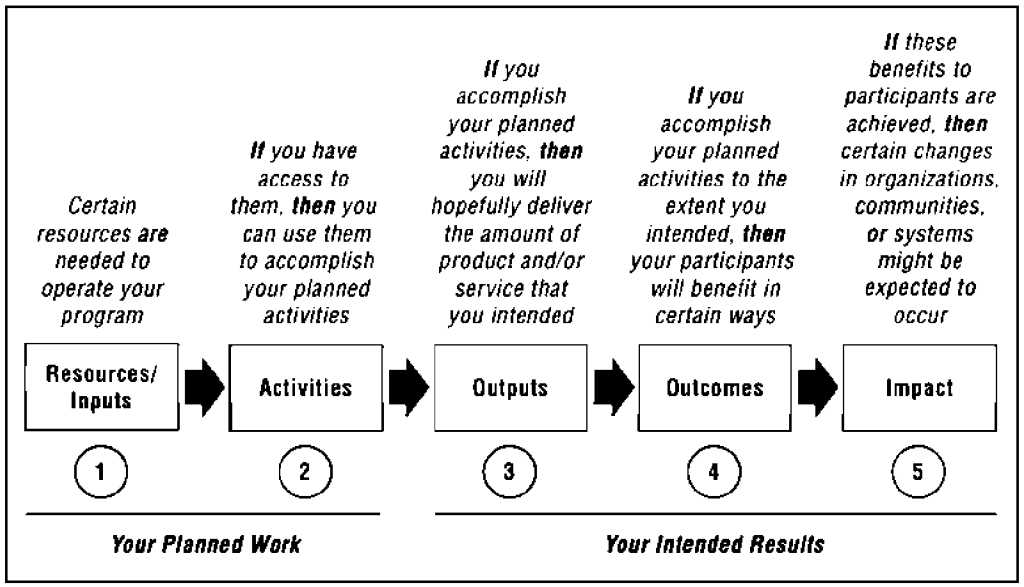


Figure 3.6 How To Read A Logic Model

Source: Kellogg (2004)

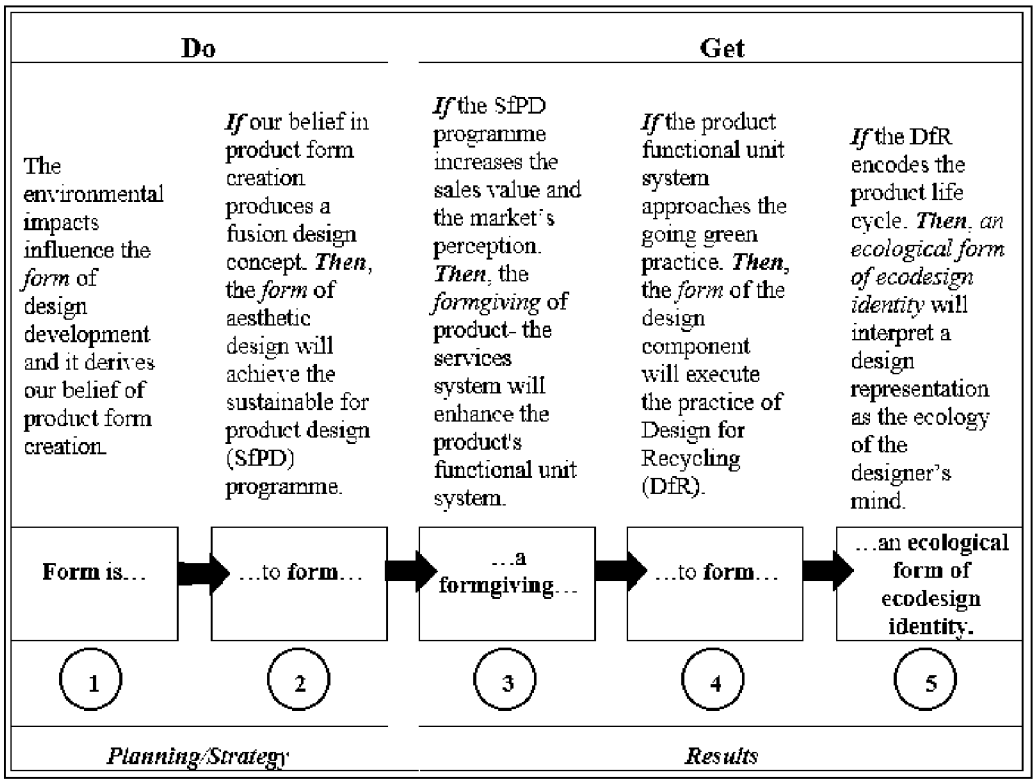


Figure 3.7 An Ecodesign Identity Model Underlies The Programme Logic Model (PLM)

Source: Adapted from Kellogg (2004)

In Figure 3.7, the specific PLM of product form context is demonstrated by the supply chain of hypothesis statement (direction) in which the ecodesign identity model is engaged and validated with the activity programme of the research framework individually. This analytical hypothesis statement is significantly structured by the belief in the ecodesign identity concept in the design activity programmed. However, the design activities of the ecodesign identity model must be emphasised by the evaluation design in the PLM study. In Figure 3.8, the study addresses the detailed information of design activity enquiries regarding the five key evaluation questions such as (1) Will the SfPD programme do it right; (2) Does the SfPD do things right; (3) What is the difference between participants in the SfPD program; (4) What has the SfPD programme made a difference across the practitioner community; and (5) What are the ways the SfPD programme can and should meet practitioner community needs. The function of the five key evaluation designs identify the relationship evidence from the programme to other phases of the programme. If the summative contents are not clear and the description of the evidence is incorrect, then, the evidence relationship is not

validated, which means the previous literature review has not been synthesised and tested accordingly. Here, the design activities of the ecodesign identity model must be emphasised with the evaluation design in the PLM lesson. This evaluation design significantly develops the foundation of enquiries reasoning in every design activity programmed. By the evaluation design, the five answers can be allocated into certain design activities programmed.

Based on the two modelled visualisations, the model information conveys the notion of methodology traits and the testing method characteristics. These two models of information guide the researcher to lesson causal thinking. For instance, using the time horizon of the methodological model, the qualitative methodology applies the longitudinal analysis (induction reasoning) approach "the statement of purpose of the study". Meanwhile, the quantitative methodology is empirical with cross-sectional analysis (deduction reasoning) containing "an objective of the study" respectively. Based on the scenario mentioned, there will be grounded two models of framework differentiated due to the nature of research methodology namely (1) conceptual framework: as qualitative methodology and (2) theoretical framework: as quantitative methodology (Cresswell & Clark, 2007; Jaccard & Jacoby, 2010; Imenda, 2014). However, causal thinking is preferably identified as the role of methodology application for the fundamental/basic research.

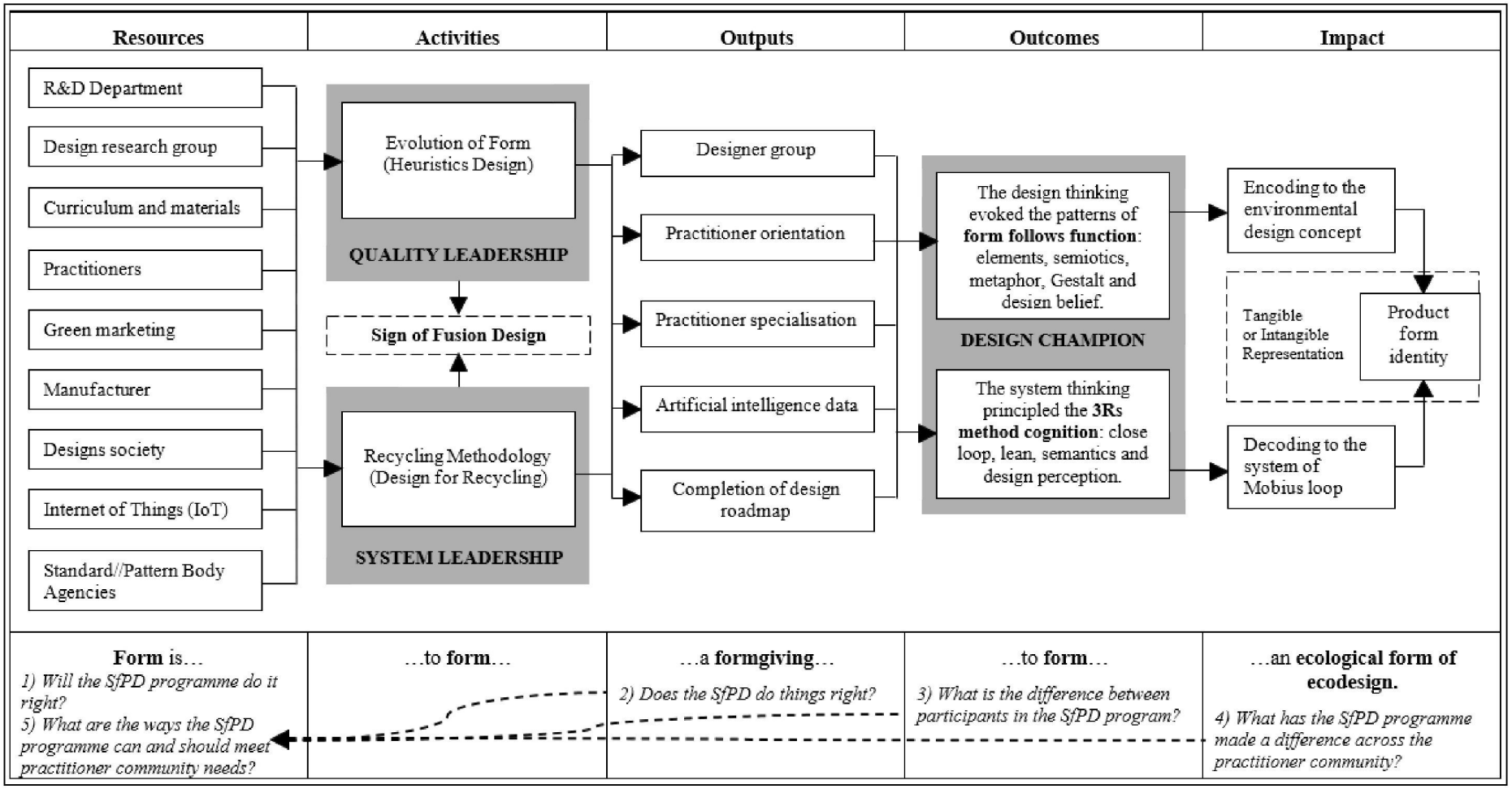


Figure 3.8 Ecodesign Identity Model for Evaluation Design of PLM

Source: Adapted from Kellogg (2004)

Again, plausibly, the set of intellectual rigour formats using both TCM (Ecodesign Identity Theory of Change - refer to Figure 3.4) and PLM (Ecodesign Identity Model - refer to Figure 3.7) modelled as recommended by the experts Kellogg (2004) and Knowlton and Philips (2012) to derive the foundation of models relationship: evidence-based connection is established and the beyond expectation emerges an impact that the composed of "strategies" and "results" are modelled the system. After the two types of logic models are accomplished, a further critical review phase is required to evaluate the foundation of TCM and PLM design originally. This foundation phase seeks the summative evaluation questions that will generate the real key features and prove the networking taxonomy as the essential qualitative reasoning. Further, to validate both TCM and PLM, the two modelled programmes must be merged and superimposed upon the testing effectiveness following (1) the strategy of TCM and (2) the activities of PLM as Figure 3.9. Next, the study will explain the two roles combination and its design function screening the relationship area (two pyramid shapes).

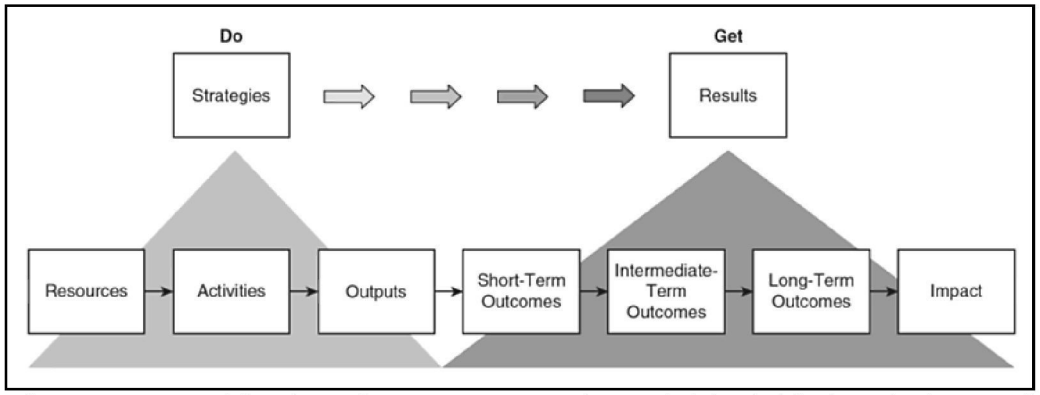


Figure 3.9 Combination of Programme Logic Model (activities) and Theory of Change Model (strategy) Relationship

Source: Knowlton and Philips (2012)

Firstly, Knowlton and Philips (2012) elaborated these two modelled inspections are very significant for the engagement processes that must be examined by the TCM using the "Strategies" (Do) and "Results" (Get) connection. This diagnosis makes the truth a logical representation that verifies the typical notion of domain knowledge from the literature review under "Review-based" existence. For instance, the study focuses the cognition strategies with two component approaches (1) name of strategies and (2)

category of strategies. These components of cognition strategies are based on the fundamental/basic research methodology.

Secondly, for the PLM activities, the "comprehensive" phase is required that it must be tested with the specific and/or kind of research empirical study approaching the qualitative or quantitative methodology. In the product form context, the PLM activities encoded a design experience as the methodology platform for reaching the think-aloud of human designer's cognition. It empirically planned a design development process in product form creation especially the ecological form of ecodesign identity. Thus, the set of design activity programmes has coincided with the notion of the impact's goal. Therefore, the logic model lesson will demonstrate the foundation of the models' relationship in the ecodesign identity model. In Figure 3.10, the summary of the study is to review the visual aid notion that the designing activities were navigated the fusion design (See Figure 3.8) using a product form context into the ecological form of ecodesign. It was clearly developed the model representative of design studies to reach the beyond impact systematically.

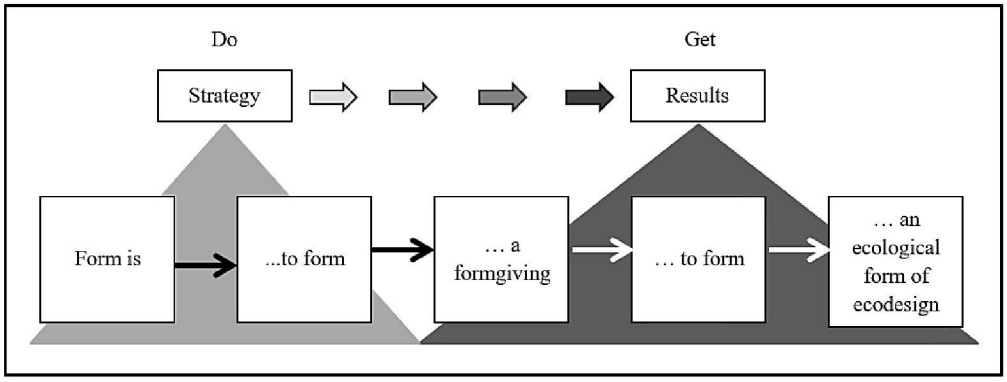


Figure 3.10 Foundation of Ecodesign Identity Model Relationship

Source: Adapted from Knowlton and Philips (2012)

Besides, the researcher intentionally developed and remained the essential of design studies research due to three major factors namely (1) the limitation of the research study: the participants, sample size and sampling; (2) the gap of the research framework: method of the ecodesign identity model transformation and (3) methodological assumption traits: to address the transdisciplinary existence in design studies (See Chapter 1 and 2). By the major factors, to test and relate with these two modelled processes, the researcher will not use "the suggestion of feasibility study"

towards a *Frequency* of occurrence, *Intensity* or strength of the given effort, *Targeted* at a specified market or audience (FIT) and *Specific*, *Measurable*, *Action-oriented*, *Realistic*, *Timed* (SMART). The SMART and FIT approaches are weighted to the business research implementation within the testing methods itself. Due to the nature of the design, the theme/area/topic is contained and used from the existing DRM framework suggestion. Hence, the feasibility study in this logical framework will be replaced with the methodological traits study, which means "How do we apply the design theory method?" Further, the replacement methodological traits can be suited with the practice-based evidence as Comprehensive Phase (Option 6 - design research project: see Figure 3.2) following the interpretive/constructivist as design experience of PS stage and the numerical value measures a design perception via postpositivist with the design empirical of DS-2 stage sequentially.

From the above conversion scenario, the modification of the research framework had preferably stated by the experts Knowlton and Philips (2012) following an earlier Chapter 1 – Introducing Logic Model under The Limitations of Logic Models and Modelling as,

> *They stated that "Typically, models do not take* ***unintended consequences*** *into account, although every programme has side effects. The modelling process usually does not include programme critics, and most stakeholders are not likely to be grounded in the research literature". (p.11)*

By the above citation, the researcher found the sign modification that the words "*unintended consequences"* had occurred and mediated the modelling flow in the midst of research methodology processes. The words encouraged the modification of research methodology traits and the processes to shift into the other feasibility study. It allows the researcher to use suitable strategies and testing methods especially the designing knowledge parameter and nature of design studies. Next, in a further emphasising statement (bold highlighted) by the experts, it found another sign of two evidence reasonings explicitly. Here, there are two signs of similarity research framework between the two logic models and the DRM framework obviously as follows,

> *"Both models had similarly matched with the selection of DRM framework systematically that "Logic models as both a tool and a strategic process offer considerable value to programmes and, subsequently, organisation*

effectiveness. They can be used for different purposes at different times in the life cycle of an idea (programme, project, or change effort). Theory of change models can dramatically influence programme planning because they rely on knowledge to offer choices about doing the right work. In this stage, the selection of strategies relative to results occurs. Programme logic models help with more precise decisions about which activities in a given strategy are most effective. Programme logic models can also be used to support evaluation design. They can assist in pointing to optimal areas of inquiry and help to determine whether progress is being made and what difference has occurred relative to results". (p.12-13)

Consequently, from the citation, a study found the tangible limitation of "plausibility" and "feasibility" study in the models' statement referring to the words "strategy" and "activities" respectively. The research initiatively seeks an appropriate design representation of the research framework following an existing Review-based – "goal" and "understanding" stages in the design research project of DRM: Option 6 (See Figure 3.1 and Figure 3.2). Therefore, the word "strategy" is equivalent to the word "goal and understanding". Meanwhile, the word "activities" matches with the "support and evaluation" in further DRM main outcomes. The experts of two logic models noticed that the practitioners are facing the modification of plausibility and feasibility study. The study found two words representing (1) "strategy" (TCM) and (2) the "activities" (PLM) that will shift to use the "review-based" and "comprehensive" phase which is a logical truth representation (Option 6).

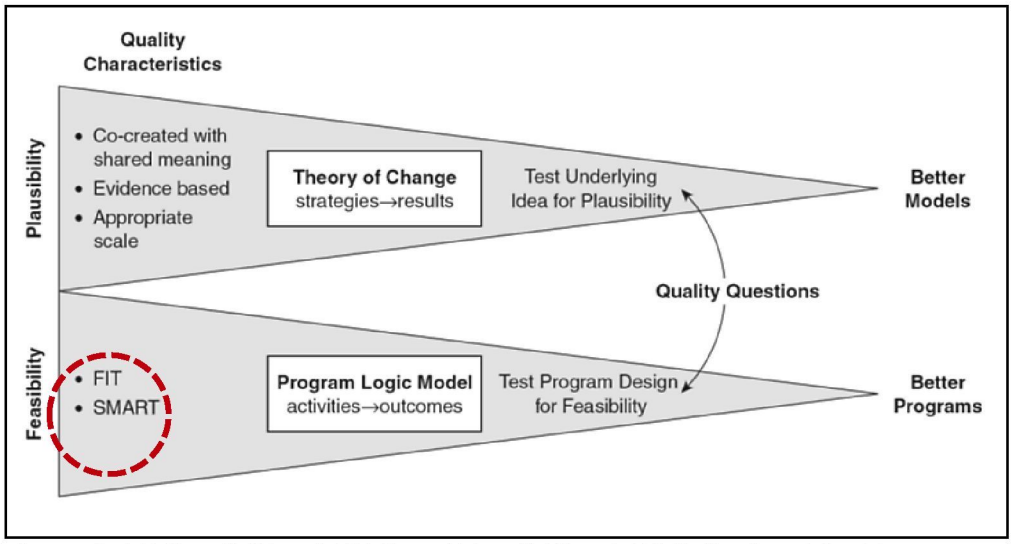


Figure 3.11 Plausibility (TCM) and Feasibility (PLM) Study – The Factors and Features of Quality Models

Source: Knowlton and Philips (2012)

In Figure 3.11, the two logic model experts illustrated the factors and features of quality models that the visual aid conveyed the consistency of modification reasoning. It allowed the cognition of methodological traits following the research design project – option 6 namely "review-based" to "comprehensive" stage. Hence, there was an explicit equilibrium between the notion of "plausibility" to "feasibility" study patterns. Definitely, the study uses the framework of the ecodesign identity model as "form is to form a formgiving to form an ecological form of ecodesign" (representing the plausibility study was established: DS-1 stage) the following the change in environmental communication as the ecodesign identity information (representing the feasibility study in the research study: PS to DS-2 stages). Also, this framework of the ecodesign identity model shows the notion and research direction along the roadmap of research methodology. Therefore, the PS stage and DS-2 stage are addressed in the research further research framework that will be grounded (qualitative methodology) and empirically tested (quantitative methodology) respectively in order to replace "the suggestion of feasibility study" of testing methods (refer to SMART and FIT) as red circle dashed lining in Figure 3.10.

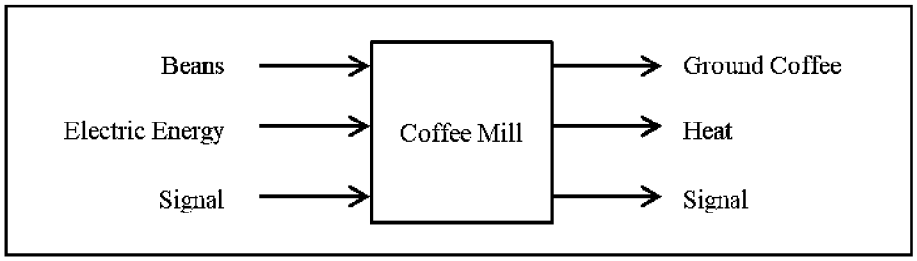


Figure 3.12 Designing Function of a Coffee Mill

Source: Roozenburg and Eekels (1995)

For the gap in the research framework, the study will use the quality questions (QQ) to bridge the both plausibility and feasibility study as suggested by the experts Kellogg (2004) and Knowlton and Philips (2012). This QQ requirement was established and it refers to Figure 3.11 content that the study will be gathered and developed a few number of question following the design methodology knowledge and/or discipline as ID concept context. By the product design innovation, the questionnaires had been defined under "the area of product function" including two QQs such as (1) why the researcher should believe the designing method for a desired direction of causal model; and (2) how will that a desired direction really behave as intended. These two QQs purposely need to engage between two logic models that could answer and establish the further "designing function as the Kernel of the design problem" by using the reflective practice approach. The Kernel knowledge is usually used for the designing process as a common practice and/or professional ethics in the innovation of product design development. This was related to the gap of research framework establishment that there had bridging two quality characteristics during these two logic models networked, which means the emergence of the Kernel knowledge conveying the embodiment of causal thinking embedded consistently. Hence, the gap in the research framework study approach the causal thinking to visualise the analogical design example as Figure 3.12 from Roozenburg and Eekels (1995) cited,

> *"In griding coffee, we want a final state S_2, which yields ground coffee (with a certain size of granule) and a coffee mill that is not too worn out. We assume that there is a beginning state S_1, which is characterised by a certain amount of beans of a certain kind, the availability of energy in a certain form, no extreme temperatures, etc. If we put the intended behaviour into the form of statements, we get the hypothetical form $S_1 \rightarrow S_2$ (read: if S_1 then S_2, or S_1 implies S_2)". (pp.56-57)*

At this time, the knowledge of product innovation is advisably needed to bridge both plausibility and feasibility study using "the Kernel of the design problem" (KoDP) that is detected by the reflective practice approach intuitively. The study coined the Kernel definition from the experts Roozenburg and Eekels (1995) is "*the descriptions – represented in whatever manner – of the form plus the use of the product form the design. The process of thinking, supported by all sorts of doing, which lead to these directions, is* ***designing*** *(pp.58)".* Thus, the case example has been framed with Figure 3.12 that "the form artefact" was representing the coffee mill in the middle of the causal model. Following the visual aid, it successfully demonstrated the form of the coffee mill function which is there has causability depended on incoming properties navigates to "the designing process" till further form of extended properties. Therefore, the study of the gap in the research framework manages to answer the two QQs using the causal thinking concept that this validation of the reflective practice approach is preferably addressed by the Schon theory (reflection in/on action) (Abidin, 2012; Gordon, 2017: Edward, 2017). In Figure 3.13, the study attempts to describe a simple causal model of designing a function that it was answering the QQs with,

a) Firstly, the researcher must understand the designing function as the roles of KoDP where it can be recognised. For beginners, they should study the hypothetical form for a desired direction of the causal model and there has been diagnosed with $Pd_1 \rightarrow Pd_2$, which interprets the Pd_1 implies Pd_2 obviously. Due to the impact of the causal's predictive statement, both pre-design and post-design have emerged from the understanding of plausibility (TCM) and feasibility (PLM) study individually. This KoDP encouraged the creation of form artefact via a desired direction of causal model forming an entry property into two extended properties whereby the conception of end-to-end (E2E) entities has been revealed and created including the "pre-design" entity and "post-design" entity heuristically (Coskun, 2010; Lee et al., 2018).
b) Secondly, the meaning of the Pd_1 implies Pd_2 navigated the study into the nature of research-based learning through scientific research. The word imply[7] is

[7] Definition of *imply*-verb (2): to involve or indicate by inference, association, or necessary consequence rather than by direct statement (source: Merriam-Webster.com Dictionary, Merriam-

specifically suitable for the methodological assumption in this orientation of research-based learning (Knowlton & Philips, 2012; USC Libraries, 2020). For instance, the variation of the hypothetical form for the word imply will provide a function μ containing the narrative event into the Kernel representation which is to create the proportional to the cognitive salience (Roozenburg & Eekels, 1995; Leon, 2016). Consequently, the notion of process reveals Pd_1 properties + μ(event) or μ(event) + Pd_2 properties. Therefore, the pattern of cognitive entity experiment shifts to decipher the narrative event in identifying the Kernel process together with the associated/articulated causal model as Pd_1 + μ(event) + Pd_2. The interpretation of the causal model is hypothetically found, and it enables the encoding of the associated U meaning to the union of two sets. Hence, μ(event) = U represents research-based learning had combining the two predictive statements differently. For example, the scientific research of clinical health or nursing programmes – such as the clinical adoption (CA) concept conducts two research-based learning together namely (1) evidence-based practice as EBP knowledge in plausibility study and (2) practice-based evidence as PBE knowledge in feasibility study respectively (Niedderer & Roworth-Stokes, 2007; Centre for Community Child Health, 2011; Sandars & Goh, 2020; USC Libraries, 2020). However, there will be no further study on both EBP and PBE knowledge in the research topic. The explanation of both knowledge is purposely comparing the meaning of healthcare or nursing concepts that it could be able to emphasise the context of methodological assumption in making the research study decision. Similarly, due to this reflective practice approaches introduced by Schon (1983) explicitly occurred and sufficiently enough during the intended process - reflection in/on actions: during and after an activity or event. Also, it enables the research framework study to answer a desired direction development on how it is intended to generally work.

Webster, https://www.merriam-webster.com/dictionary/imply. Accessed 15April 2020.

The identification of two mechanism components (tools of causal thinking) had been defined and answered by two QQs which meant the (1) hypothetical form and (2) KoDP are vital to the causability in the development of the research framework's gap.

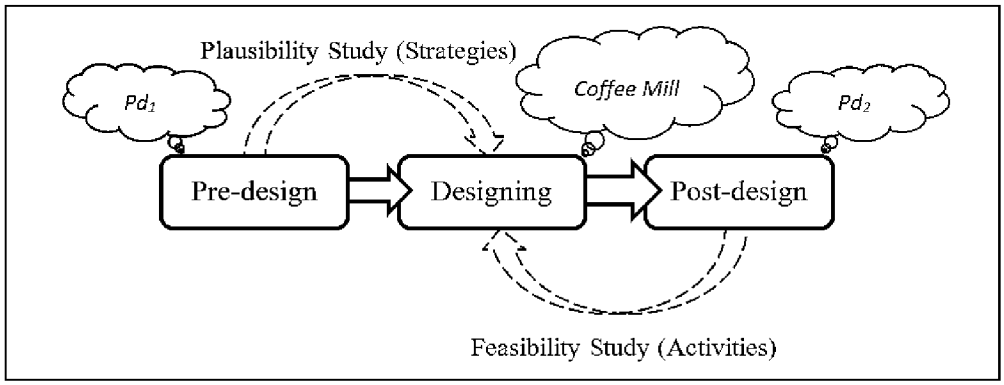


Figure 3.13 An Associated/Articulated Causal Model Emerged by Two Mechanisms of "hypothetical form" and "KoDP" as Designing Function

Source: Adapted by Roozenburg and Eekels (1995) - the function of a coffee mill as a black box, pp.57)

Evidence of causal thinking reasoning as Figure 3.13, there was shown the end-to-end building is obviously structured as the associated/articulated causal model following the orientation of research-based learning within the AI characteristic itself. However, the emphasis on pre and post-design discussion will be covered in the context of research-based learning through scientific research in further discussion.

In summary, the detail of causal model information regarding the research methodology will be emphasised in the further sub-topic containing the conceptual framework discussion, that the reliability and validity of model attribution can be discovered by the existing methodology of design experience within its design perception subsequently. Hence, the feasibility study of the current research methodology suggested the qualitative testing method to specifically apply and prescribe the verbal protocol analysis (VPA) method for the evaluation of design phenomenon that possibly examines the design belief is really exists. On the other hand, statistical analysis testing methods will approach the value interpretation using the Statistical Package for the Social Science (SPSS) in the quantitative methodology. This SPSS testing method's function is to gauge the perception of design belief that the design representation connects with the design communication for the designer's human cognition. Both research methods are well programmed in the earlier setting of the

DRM framework. However, the articulation of data sets happened and occurred from both nature methodologies of research framework information (Miles & Huberman, 1994; Creswell, 2003; Creswell & Clark, 2007; Jaccard & Jacoby, 2010; USC Libraries, 2020). Therefore, the method approach strategy is preferably used "the mixed methods research" in the framework of research methodology accordingly. This solution of mixed methods research will vary the actual pattern of conceptual framework following the method strategy of fundamental/basic research. The further explanatory study will emphasise the emergence of mixed methods by merging both qualitative and quantitative datasets to present the form of an articulated dataset consistently. All method approaches in the study will be determined and related to the method selection following further sub-topic.

3.2.1 Conceptual Framework

The visualisation of the conceptual framework using the DRM approach is very important for explanatory study in this sub-topic discussion. There had been engagement with the causal model information that something causes (problem) by the variability in intelligence. According to the phenomena observation, the causal context of relationships is fundamental to nature causality referring to the role's concept of causality in the model information (Jaccard & Jacoby, 2010). Thus, the model information is the essential way to trace and identify the causal model where the effect of variables will stress out the consequences reasoning namely (1) independent and (2) dependent variable. Upon the process, six types of model information are to be required and categorised which means the relationships' categorisation refers to the "causal" and "prediction" - must be decided specifically. Six types of causal relationships model provides more details on the two variables called "the independent variable or determinant", and it is supposed to be affected with the "dependent variable or outcome variable" together, such as (1) direct causes, (2) indirect causes, (3) moderated relationships, (4) reciprocal causality, (5) spurious effects, and (6) unanalysed relationships where there should enables to create extended of causal impacts clearly.

However, Creswell and Clark (2007); and Jaccard and Jacoby (2010) clearly noted that the causal model arose with cause-effect relationships, and it was classified with two patterns of relationships actually such as (1) predictive relationship and (2) causal relationship. Thus, while identifying both relationships that had been

categorised, the current study of research methodology is intentionally interested in the predictive statement following the experts Jaccard and Jacoby (2010) - "predicting job success context" towards fundamental/basic research. The predictive relationships model is a priority in the study due to matching with the DRM framework strategy purposely from the explanatory study context (Blessing & Chakrabarti, 2009). For instance, for the sign of causa-effect relationship study describes, AI of ecodesign identity (product form context) must use the combination of design thinking and system thinking where it had embodied from three components of transdisciplinary design (TD) as known with syntactic, pragmatic and semantic in formgiving development (Jantsch, 1970; Abidin, 2012). It was associated with the belief attribution to create and develop the form artefact using a fusion design that has looking up the design causes impacts. Once the ecodesign identity has resulted, the design phenomenon will affect the quality of product form along with the solution of human-centred design development (see Figures 3.4 and 3.5).

From an example of framework design conception as above mentioned, the research methodology study displays the "form artefact" obviously, especially in the pattern and/or sources of the data sets especially the predictive relationships model. In order to extract the conceptual framework successfully, there should be a focus on the innovation of product form using the design experience and behaviour context delivered by designedly-way thinking. The essential conceptual framework is based on the qualitative methodology that depends on the induction of the data set within the design belief itself. By this induction of successful reasoning, the conceptual framework can be produced by using the prescriptive primary data set. An evidence statement was cited from the experts Jaccard and Jacoby (2010) *"...the scientist does not care whether a causal relationship exists between the variables used to predict success and actual success; he or she is only interested in predicting job success"*. Meanwhile, the predictive relationship model was valid and available in this conceptual framework study. The causes of model variables show that both system and design thinking demonstrated associational relationship traits. The embedded data set of form artefact emphasises a fusion design until the impact of ecodesign identity is successful. In essence, two predicting variables (variation in A to predict variation in B) are identified the variable of "fusion design" properties assigned with the predictor variable properties and another extended variable of "ecodesign identity" properties indicated with the criterion variable. Therefore, there has not been any further explanation of what causes

variability in B that it achieves success – nothing explains within any root of causes reasoning. Due to the association of variables is accomplished predictably.

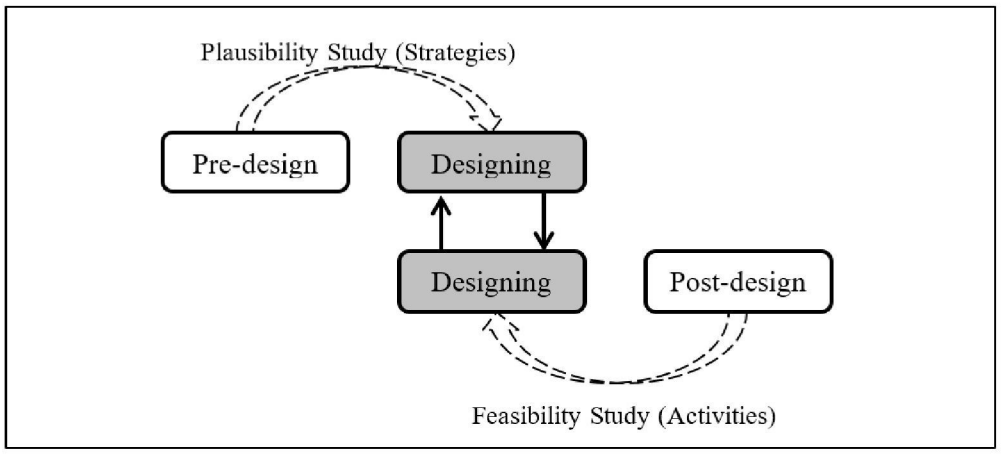


Figure 3.14 Pre-post Design Entity Delivers The Same Designing Function in The Understanding of Predictive Relationship Model Development

Indeed, to begin the structure of the conceptual framework following the above predictive relationship model scenario, this research study initiatively develops a conceptual framework strategy using the two tools of causal thinking as stated earlier. The selection of two tools of causal thinking was successfully evidence-based on the end-to-end structure and/or development. In the causal model development, the understanding of two mechanisms of "hypothetical form" and "KoDP" significantly tested the whole idea of the conceptual framework.

In Figure 3.14, the conception of the causal model was defined by two indirect variables of the design research process following (1) the plausibility study for pre-design shifting to designing and (2) the feasibility study taken from post-design returning to designing concurrently. The merging concept demonstrated the combination of two variables with a similar notion of conceptual framework study. The strategy of plausibility study was established firstly by using the measurement of qualitative, quantitative structure or mixed methods. On the other hand, the activities of the feasibility study should be grounded in the essence behaviour in order to address the basic/fundamental research in the conceptual framework development. At this moment, two of the designing functions are moving to merge together and an emergence of the Kernal representation develops a predictive relationship in the essential causal model.

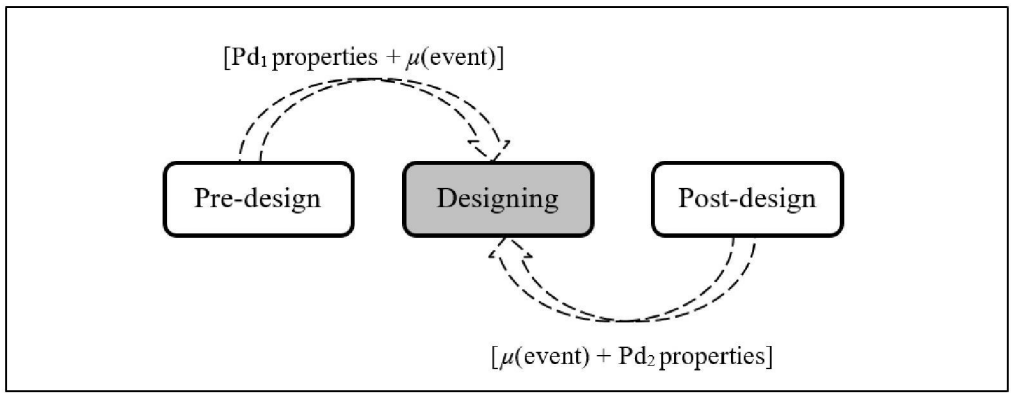


Figure 3.15 The Kernal Representation Develops a Predictive Relationship Model

Next, the combination of two properties aligned together that a pattern of the predictive relationship model proved the methodological assumption in this orientation of research-based learning. In Figure 3.15, the visual aid did not put an arrow indicator respectively which is the direction of process representing the flow or sequence from the variable into another variable. The indication of the arrow means the tool of causal thinking actually. It is very important to display the "name or category" of causal thinking due to the readiness design information delivering the research methodology which is the essential understanding of model information. Then, the visual aid lessoning demonstrates the formula of Kernel representation within the context of Pd_1 implies Pd_2 understanding. Hence, the form of research design can be easily shown and position the meaning of the conceptual framework specifically.

Lastly, the causal model exercise had been diagnosed by causal thinking as a tool or medium in model information as Figure 3.16. At this stage, the arrow indicator is used for the type of thinking process namely system thinking (re-think) and/or design thinking (ecological form). The pattern of thinking depends on the knowledge field according to the particular domain or area of study. The conceptual framework study will select an ideal causal thinking process that is usually related to the framework model within a goal setting and/or further section. For instance, the study had established the pre-design-to-designing phase that it structured from the review-based existence (end-to-end) previously in the application of causal thinking. Meanwhile, the comprehensive study following the designing-to-post-design must be elaborated into the completion of the research topic as the last phase of the study (see Figures 3.2 and 3.3). Thus, the development of the predictive relationship model emerged as a systematic cause-effect of the thinking process and the evidence on how it structured

the model information looking for especially about a conceptual framework lessoning. Also, the attribution of the reasoning model was made and it was very clear to screen an actual roadmap accordingly.

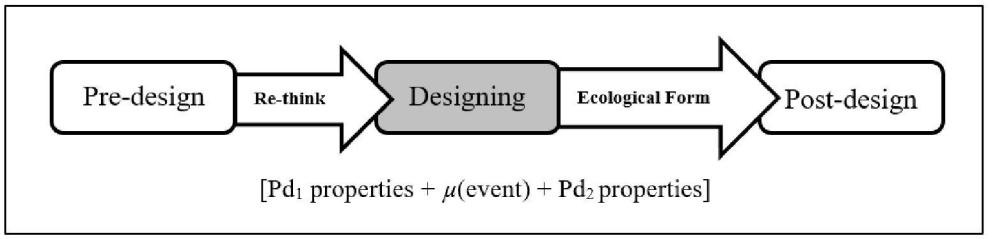


Figure 3.16 The Interpretation of The Predictive Relationship Model Demonstrates That Pd_1 Implies Pd_2 for The Kernal Representation In A Conceptual Framework of a Causal Model (Cause-Effect Relationship)

At the end of the conceptual framework study, the researcher initiatively defined the verification of the comprehensive study using the DRM framework stage. The study found three phases of the evolutionary framework are critically addressed in order to present the manipulation of the predictive relationship model into the appropriate conceptual framework according to the DRM framework systematically. The explanation of the three phases depends on the evolutionary process that the nature of the methodological (the way of philosophical assumption) such as methodological continuum, trait, reasoning and the approach itself (Weerd, Brinkkemper, & Versendaal, 2007; Van Stijn, Vlaanderen, Brinkkemper, & Weerd, 2012; Gabora, 2013). All components of methodology had influenced the model development and knowledge of evolutionary framework study accordingly. Therefore, the existence of a review-based study will begin to emphasise the pattern of the evolutionary framework at the understanding (outcome) of the DS-1 stage in the DRM framework. For the particular of the methodology way, this pattern of the methodological assumption is described and correlated in the earlier Chapter 1. The study has defined the exploration of an evolutionary process following three downstream levels of the main outcomes (Refer to Figure 3.1) that it had established from the existence of DRM framework concurrently namely with (1) existence of review-based study at the "understanding" of DS-1 stage, (2) an integrated framework development patterns from the continuum model of DRM framework by the evolutionary framework and (3) the conceptual framework through the "support" and "evaluation" for the main outcomes of DRM

framework which is according to the research content of comprehensive study specifically.

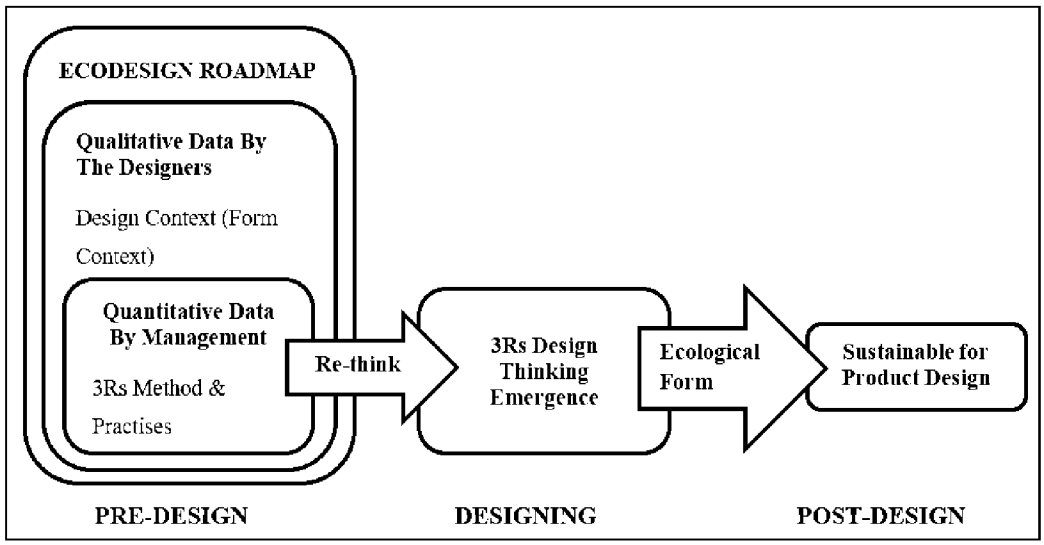


Figure 3.17 Phase 1 - An Existence of Review-Based Study as End-To-End Research at The "Understanding" (Main Outcome) Of The DS-1 Stage In The DRM Framework

In Figure 3.17, according to the TD study and its synthesised analogical lesson, using the simple 3R method (recycling methodology) to create a new ecodesign product concept enables the industrial designer to reduce the complexity of the ecodesign problems that the environmental issues commonly related with ecodesign information within it specific design concept. Using the semantic development, it can illuminate the novice or young industrial designer's cognitive thinking that it projects the ecological form design concept to evoke and feel the intangible of design theory intuitively. This example highlighted the evolutionary process to sequence of the pre-design stage that an existing review-based study under the phase 1 context. For the designing-to-post-design stage, the vital DRM framework is one solution for the existence or undiscovered design logic model and the 3Rs method phenomena to develop and reveal an intangible ecological form of ecodesign (a new design theory based on the form follows function) systematically (Chumiran, Abidin & Sirat, 2016).

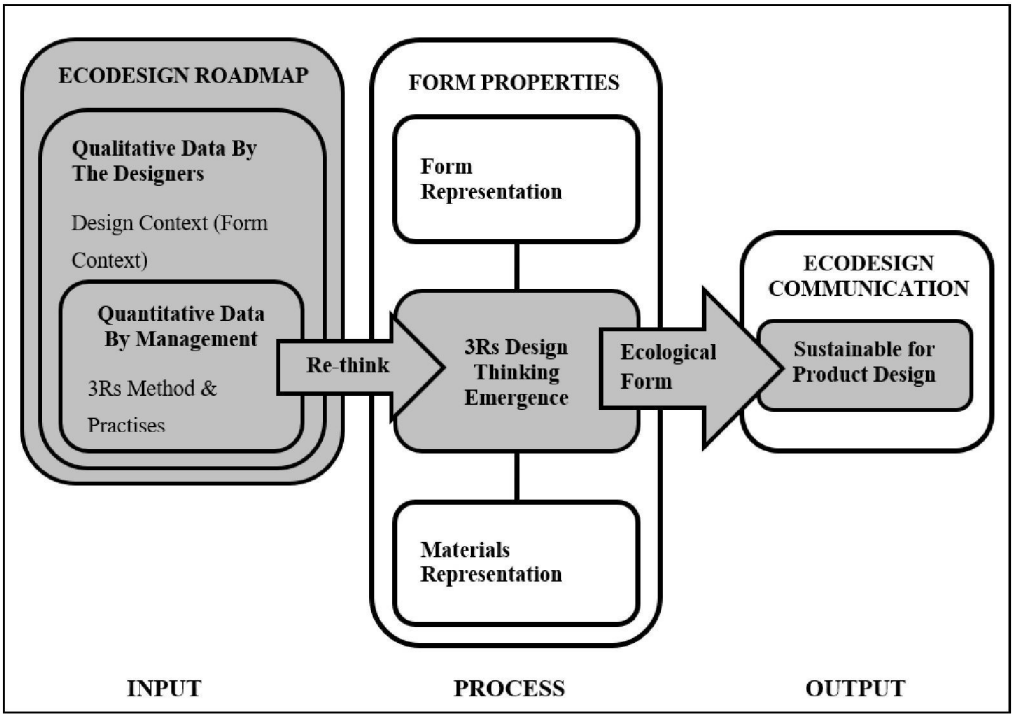


Figure 3.18 Phase 2 – An Integrated Framework Development (Input- Process-Output) Patterns From The Continuum Model of The DRM Framework

However, this research study milestone is required to present and express the significant domains within findings in a review-based study that the actual fundamental relationship among environmentally conscious manufacturing (MT field) and green marketing (IM field). They had complemented together to develop the predictive relationship model - which means it will spur a wider design supply chain concurrently. Because of closed-loop methodology and/or cycle common practices, the product engineers and product marketers are compulsorily aware of the industrial designer's roles, responsibilities and design concept communication can be revealed in the further comprehensive study logically. Hence, the objective of the SfPD creation is being easily structure and develop the cause-effect of the predictive relationship model (emergence of predictive relationship model) starting from an "ecodesign roadmap".

In Figure 3.18, phase 2 of the evolutionary process refers to the cause-effect of the predictive relationship, which can be used with the strategy of mixed methods. It had completely explored and screened the combination of data set articulated can be emphasised the context using an exact form of conceptual framework. Due to the nature of methodological assumption, this research study aims to solve the problem statement, knowledge gap, and the purpose of the study following the data set articulated. They

have completely differed to compare the other ontology and epistemology of philosophical assumption.

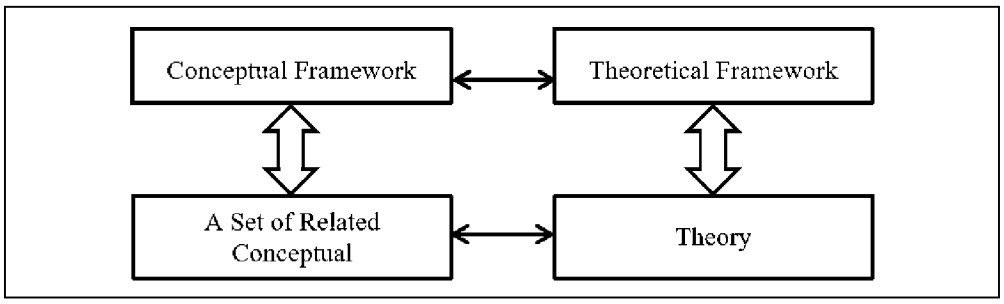


Figure 3.19 Derivation of Conceptual and Theoretical Framework

Source: Imenda (2014)

At this methodology assumption, the analogical study lessoning is required so that it can display the further detailing of comprehensive study in a conceptual framework context. By the nature of the study, it possibly used the derivation of a conceptual and theoretical framework that the expert Imenda (2014) expressed in Figure 3.19:

> *"...In general, one finds that whereas in the natural sciences one may be guided by, say, the theory of evolution in conducting an investigation that involves the classification of unknown fossil specimens, one often finds that in the social sciences, there is no single theory that one can meaningfully use in dealing with, say, academic achievement or challenges of poverty".*

This citation showed some particular evidence that the supporting and evaluating levels following the "derivation" word are obviously required. Therefore, the practice of analogical thinking defined the appropriate deduction reasoning tested by the quantitative methodology. On the other hand, the proper induction reasoning is categorised as suited to assist the qualitative methodology for encoding/decoding the thematic criteria. Both methodologies gradually functioned to address and extract the significant fundamental/basic research of conceptual framework.

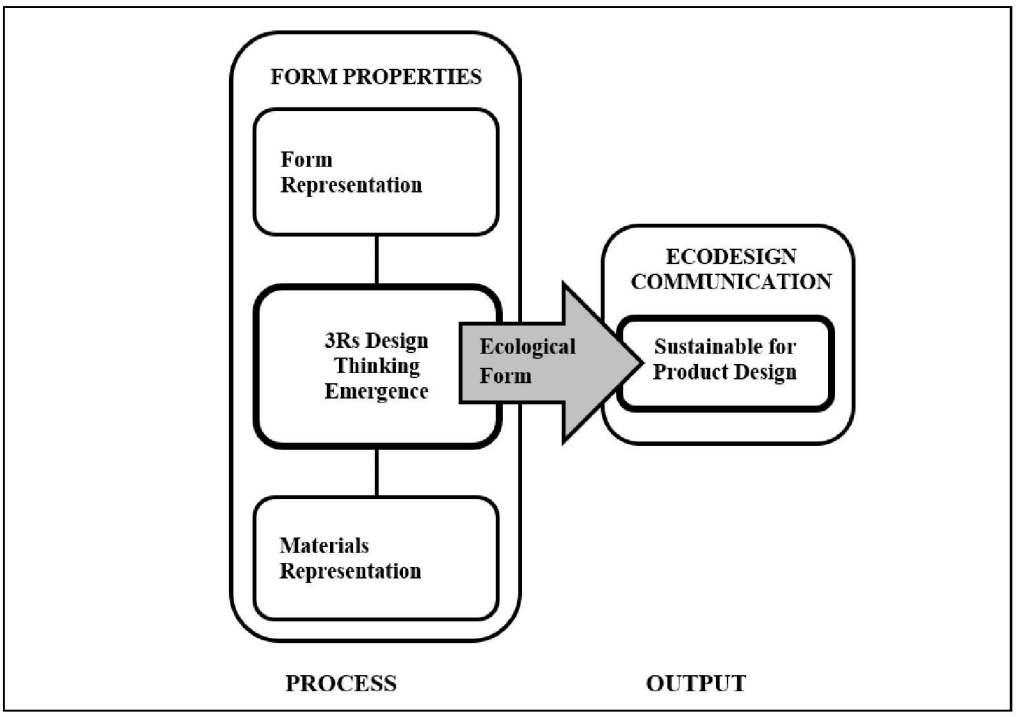


Figure 3.20 Phase 3 - Conceptual Framework Through The "Support" (Process) and "Evaluation" (Output) for The DRM Framework Outcome Using A Comprehensive Study

Meanwhile, the form properties (process stage) deliver ecodesign communication (output stage) using the ecological form of design thinking as Figure 3.20. The "process" word is evaluated by the observation of the VPA study for the grounded essence behaviour and the statistical descriptive study will measure the "output" performance to build the validity and reliability purpose of the fundamental research. Due to two comprehensive study stages importantly patterned phase 3 of the evolutionary process the variables of the causal model had been established in the section of research framework study; the main focus of option 6 - the type of design research projects in the DRM framework.

However, the lessoning study will explain and emphasise the conceptual framework approaching the sampling within data collection in Chapter Four. In the next subtopic discussion, there will be described the roles of code and/or encode findings (non-numerical) using the qualitative approach that it can deliver and project into the specific variables (numerical) such as independent variables (IV), moderate variable (MV), and dependent variables (DV). All these functions of the comprehensive framework construction are introduced to the predictive relationship of explanatory study. Due to the predictive relationships focus purely on association; there is no

inference or indication of causality, only that variations in A are connected to variations in B. There should be described everything that it will associate and embody to relate the issues of the philosophical assumption under ontology, epistemology and methodology. By this methodological assumption, exploiting the pinpoint of methodology reasoning where there can be demonstrated the research mode of design framework strategy (the continuum of review-based and/or comprehensive study in Figure 3.2) as a whole holistically.

3.3 Bubbling Model – Design Research Methodology

This study is based on the bubbling model of the DRM framework stage, which is a systematic methodology that can preferably be practised in the product form of human-centred design (Blessing & Chakrabarti, 2009). It was placed under the engineering design research platform due to this research study featuring the synthesis methodologies along the design research flow namely input-fieldworks-output.

In the output level, the beginning of the research topic is revealed from the literature review (LR) activities and processes that can be traced the certain, identify and/or specify the issues to present the causal problem statement as Figure 3.21. According to the LR activities and processes, three research components namely (1) research objective (RO), (2) research aim (RA) and (3) research questions (RQ) have to recognise the engagement of content and context study simultaneously. When some of the fulfilments of three components are ready for execution availability. Then, the identification of the title for the research topic can be puzzled properly.

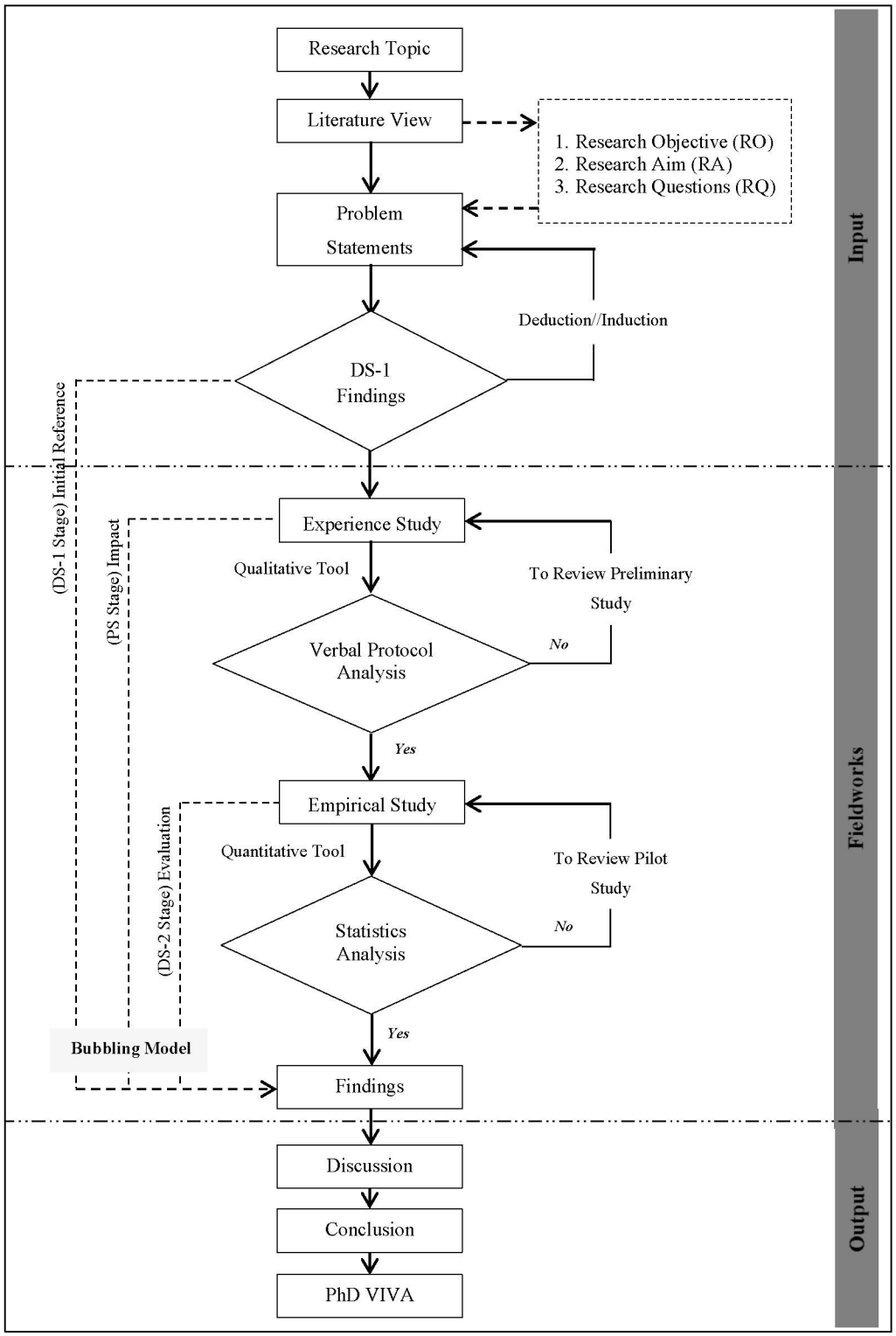


Figure 3.21 Research Design Flowchart

At this time, the essential of the bubbling model is formed by the criteria/elements' factor that explicitly displays the area and niche of study. The emergence of the criteria stage development will begin from 'the preliminary key factor' when every element's factor linkages appear and spread up the bubbling

connection. For the Initial Reference – DS 1 finding, the study shows the roles of the bubbling model in synthesising the content of LR together and enabling the content mapping of RC establishment.

At the fieldwork level, the study priority refers to the bubbling model of the DRM framework as a basic/fundamental research mode. This study focuses on both PS study and DS-2 study stages, where the two stages should reach: (1) the impact of grounded meaning and (2) the evaluation of assessment respectively. Hence, this research design flow has moved together with the bubbling model stage beside and/or along the research activities of design flowcharts' progress. The creation of an operational flowchart to the bubbling model in research methodology is very significant and the holistic analytical approach is preferred to use certain empirical and/or experience methods in reaching firm evidence (validation), especially for a new design theory following the research design flowchart. Using the DRM framework modelling, allows the researcher to figure out the specific formulation, validation of knowledge, approaches and tools measurement in order to establish the new design theory (to validate the methodological assumption).

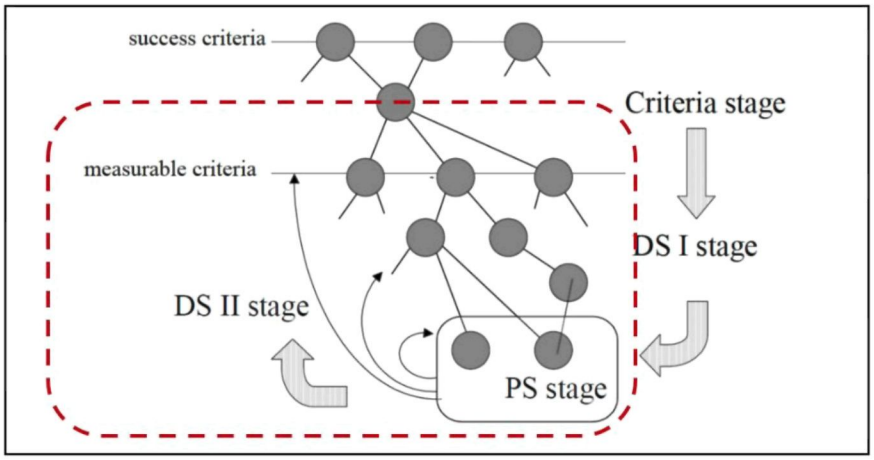


Figure 3.22 The Network of Influencing Factors

Source: Blessing and Chakrabarti (2002)

Further, by an earlier research source validation, "the network of influencing factors" derives and delivers a new theory modelling finding based on the framework modelling development representatively, such as: (1) initial reference: DS-1 stage; (2) impact: PS stage; and (3) evaluation: DS-2 stage models. In Figure 3.22, the experts

formulated "the network of influencing factors" to identify the appropriate reasoning factor that conveys and/or categorises certain areas of the research study.

The DRM framework is supported by these three criteria components starting from the "Criteria" stage, "Measurable Criteria" stage and "Success Criteria" stage. It can be navigated to the research theme and/or topic and allows the researcher to minimise the risk of the study during the research roadmap. Hence, the complementary research journey will demonstrate the two approaches between bubbling modelling and the research flow process concurrently. The red dashed line highlighted shows Figure 3.22, which purposely focuses the research study on how to test the both PS stage and DS-2 stage using a scale of measurable criteria. Therefore, the implementation of fundamental/basic research will be progressed and grounded with a systematic method where it has suited an appropriate selection of the testing methods accordingly.

3.3.1 Stage I: Descriptive Study I – DS-1

An earlier DRM framework, the DS-1 stage had been accomplished with the prominent findings of the primary dataset and it definitely answered the perception of design phenomenon. In the DS-1 study, the research contented "*the environmental elements such as the 3Rs method in addressing an ecological form of ecodesign*" (Chumiran, Abidin and Sirat, 2016). Next, the content actually referred to the nature of design theory building it represented a design perception for certain and/or every Malaysian industry community: the number of subjects designated who related to the SfPD programme under their roles and responsibilities in the research and development (R&D) department. For the research methodology, the researcher planned and used *"the qualitative methodology with empirical approaches"* which means the time horizon of both cross-sectional and longitudinal research was implemented under one methodology programme (DRM) as a design research strategy. This design research strategy is called methodological triangulation of the research onion concept. Meanwhile, under the prominent findings, the participants had emphasised design practitioners and it conveyed the setting of the manufacturing company as well known with the industry player. Those settings triangulated the type of sampling referred to as probability and non-probability sampling where it explicitly identified the cluster stage (random) and purposive sampling (focus group) accordingly. Both types of sampling indicated and represented the R&D company department (design working group) which

is a small-scale sampling complimented with research design methodology. Definitely, the small group of design sampling study used the sample participants following the concept of micro (quantitative reasoning) and macro (qualitative reasoning) sampling population. From this research lesson, the design phenomenon emerged by the attribution of design and/or manufacturing supply chain. Hence, three major domains were involved namely industrial design (ID), manufacturing technology (MT) and industrial marketing (IM).

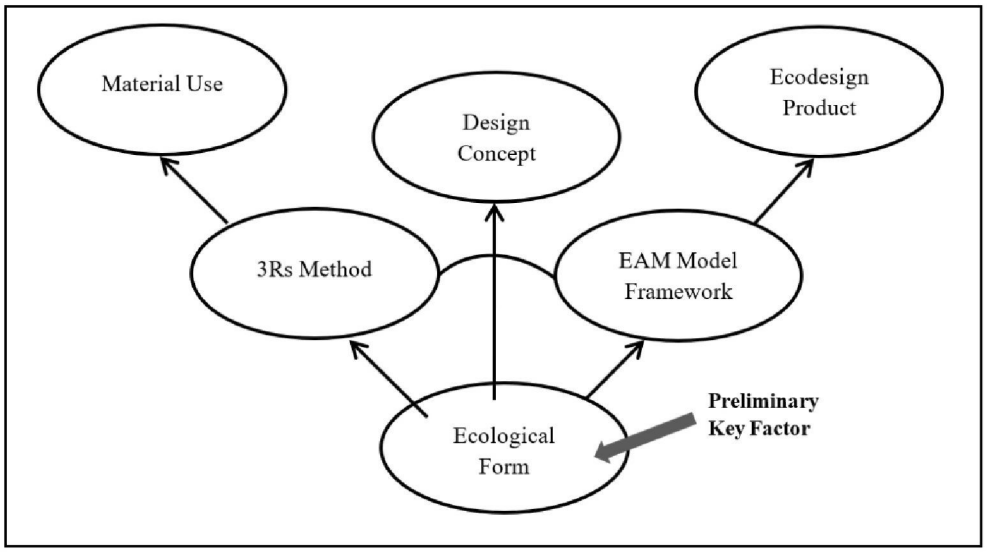


Figure 3.23 Initial Reference Modelled Along The RC Studied

In the DRM models, four stages of categories were delivered into the elaboration of methodology using an empirical and/or experience basic means with obvious effectiveness. By the initial research topic, the researcher has published the first conceptual paper entitled "*The Environmental-driven Elements Towards Ecological Systems of Furniture Design*" along the RC stage. Previously, the researcher has set up three-factor components such as criteria, characteristics and capability (3C's) all these components were managed by the literature map technique as the fundamental research strategy content. From the literature map chart, the researcher was able to extract and form the specific body/area/domain of knowledge, which is the relevant justification in the literature review judgment. The creation of a literature map assisted the researcher in developing Initial Reference and Impact Models as preferred by authors Blessing and Chakrabarti (2009).

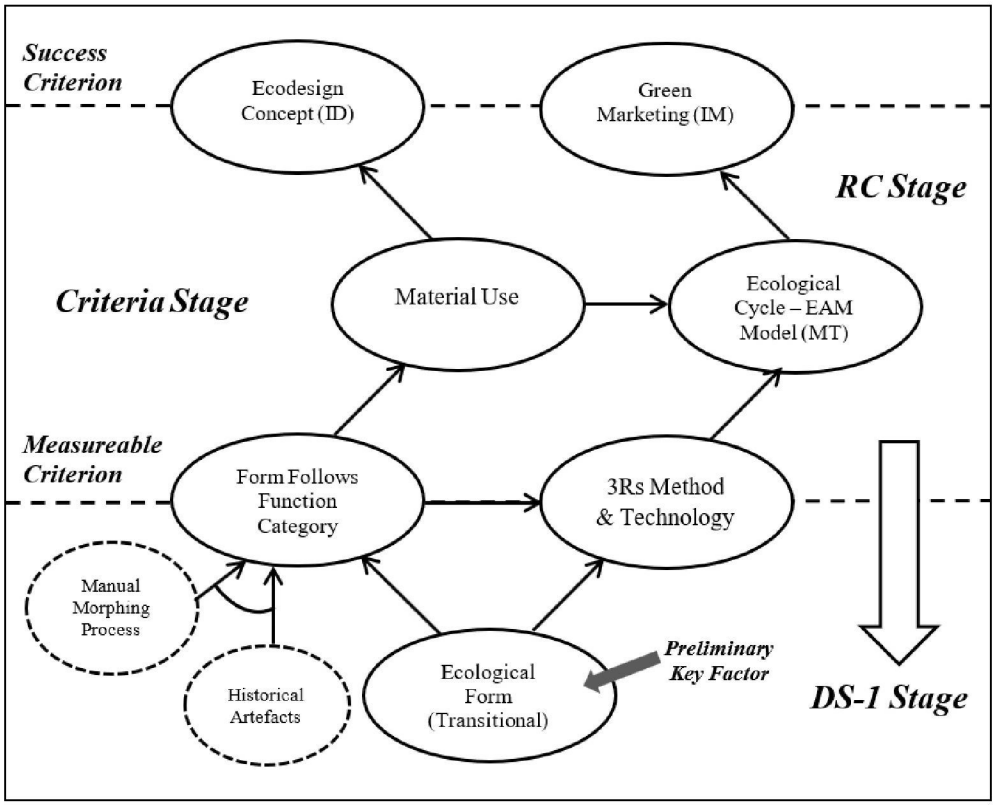


Figure 3.24 Reference Modelled in DS-1 Studied

In Figure 3.23, the initial reference modelled was only started and created from the RC stage. The actual scenarios or phenomena were forming and influencing the branches of bubble model creation. Starting from "the preliminary key factor", it was identified to create other kinds of bubble branches following the certain/specific influencing factors involved accordingly. Also, the proper creation of the bubble theory model contributes to the ID field following its functions, roles and responsibilities (Blessing & Chakrabarti, 2009). Creswell (2003) expressed that the right selection of research methodology use that it will assist the researcher in discovering new findings and clarifying the resources. The basic area of the study is very significant and the materials of research content and/or knowledge might coincide with the other topics in design sciences mainstream. All these materials of research content and/or knowledge from the proper procedure of the literature review are beneficially aligned with the domain of the design studies among the researcher community intuitively.

After the RC study stage within an initial reference model has been completed, the researcher is supposed to develop the DS-1 reference model. But, it can only happen once the DS-1 study stage is accomplished. Hence, the DS-1 reference model in Figure 3.24 has been developed using the DS-1 research findings (end-to-end). The bubble

formation was completely reformed by the influencing factors of the DS-1 study findings within its discussions.

Hence, the researcher has found and identified two measurable criteria alignment, such as (1) the form follows function category and (2) the 3Rs method and technology that these two measurable criteria reach upwards to another bubbled success criteria. In the form follows function category, the study emphasises the evolution of form (EoF) within the design concept using the design thinking approaches. On the other hand, the 3Rs method and technology will present the recycling methodology according to the system thinking approaches. Thus, the engagement of the methodological triangulation is needed and there must recognise the causal of a study in the further research design and method selection sequentially. These two measurable criteria are very significant for the study due to the pattern of methodological triangulation can be utilised and figured out easily to encode and/or decode the dataset. At this moment, the researcher can screen the meaning of the transitional context using the basic research method.

For the preliminary key factor, the ecological form (transitional) is a truth desired bubble for the two measurable criteria. It is placed under the measurable criteria alignment because the previous RQ1 in the DS-1 study recognised the findings with,

> *"One significant design characteristic was found in the survey that "cantilever principle design" knowledge has dominantly addressed the 3Rs element for an ecological form of ecodesign. The most consistent answer by many Malaysian practising designers was that they accepted and agreed on this cantilever principle because the roles of object or artefact's perspectives in among three historically product designs existence had driven the respondents to visualise an ecological form on their minds." (Chumiran, Abidin and Sirat, 2016. p.173)*

Therefore, the heuristic of cantilever principle design has fallen under the PS study and it allows the DS-1 study stage to proceed into the design experience (qualitative method) to seek the evidence of preliminary key factor. Further, stage 2 will elaborate the PS stage process effectively.

3.3.2 Stage II: Prescriptive Study - PS

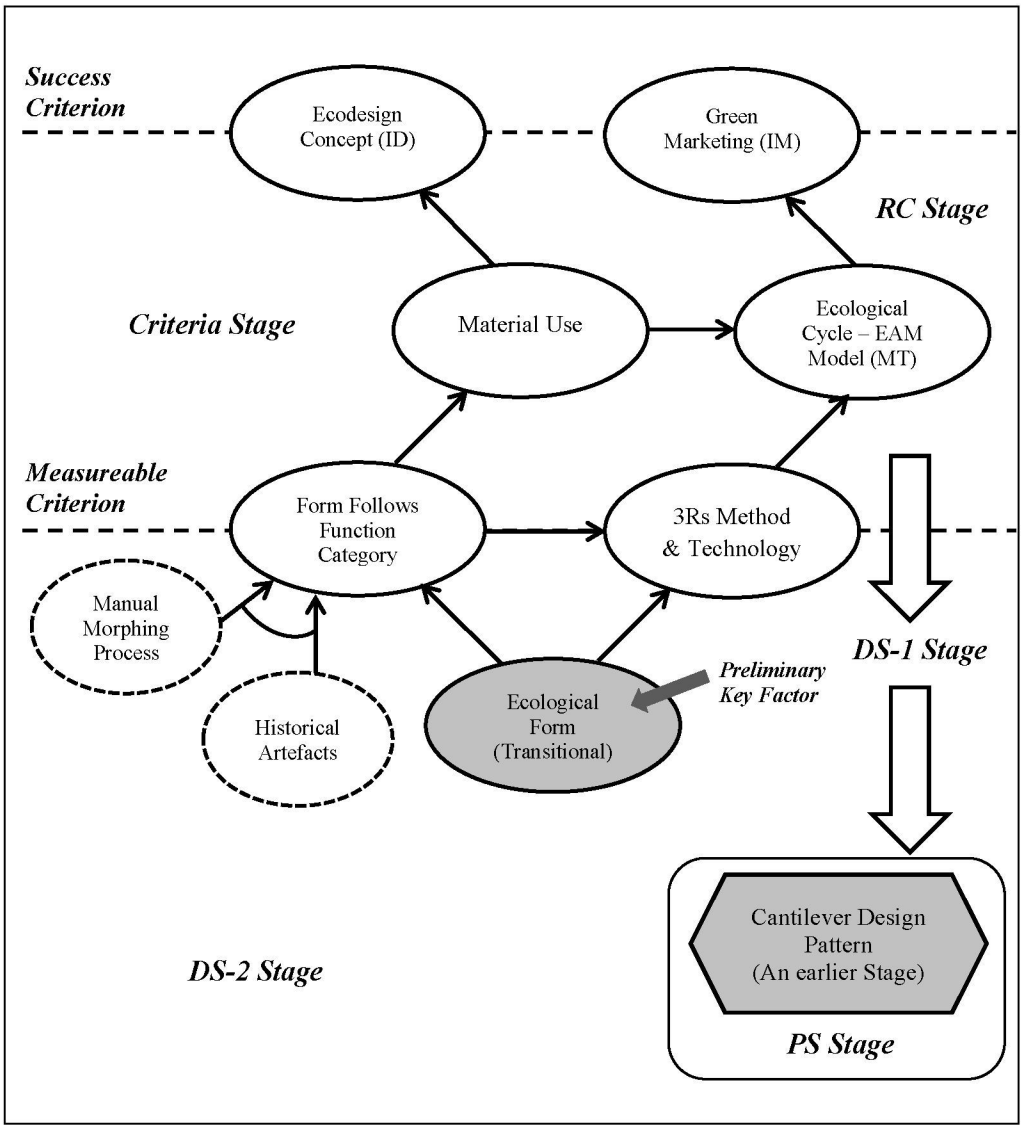


Figure 3.25 Support Model in PS Stage Study

This prescriptive study section will begin with the "network of influencing factors" investigation phase; after the researcher displays the emphasising impact modelled in Figure 3.25 and the area of framework in the DS-1 stage.

The spectrum of the bubble model had begun from the single key factor and it broke into the kind of measurable criterion bubbles along a margin's level respectively. This is meant for the DS-1 study that has trustworthy developed by the bubble model technique that this function is to represent the visual aid networks as well. However, the existence of reference modelled possibly shows the designing theory assumption PS stage (an elongated hexagon shape) and a single grey bubbled indication appears under

the two measurable criteria bubbled. Hence, another bubble (left-hand blank area provided) is required to connect these two stages; the middle key factors of the DS-2 stage emerge a bridge's desired situation.

3.3.3 Stage III: Descriptive Study II – DS-2

At the last DS-2 stage, three grey bubbles modelled will be investigated into the ecological form (transitional) bubbled. In Figure 3.26, the researcher compulsorily creates the modelled command and all the variables are set up from the key factors emergent as stated in the connection of the desired situation. The last three key factor bubbles show arrow directions representing the connection within its correlation. This sequential framework theory must be completed due to the evaluation of measurable criteria (Blessing & Chakrabarti, 2009). However, the unknown empirical result of detailing or decision can only be answered upon further research approaches and testing methods.

The survey will begin with the pilot test study as the initial strategies of variable inquiry validation for the quality of questionnaire items within its types of scale measurement purposely (nominal and ordinal data will be used in the survey). Using the minimum Cronbach Alpha value above such as 0.60 (good reliability) to 1.00 (very good reliability), this rehearsal will assist the researcher in seeking an accurate item instrument (type of questionnaire items) for the validation of instrument design before entering the actual fieldwork. However, designing a clinical survey from the fieldwork is required. This instrumentation of questionnaire contents measures the design representative that it revealed and resulted from the previous pilot test study. Realistically, the concept of designing a clinical survey made from the global coronavirus disease 19 (COVID-19) must be collected from the dataset using the digital platform virtually. Thus, the knowledge gap procedures of data collection occurred co-accidentally during the data collection process and this will be explained in the further chapter discussion

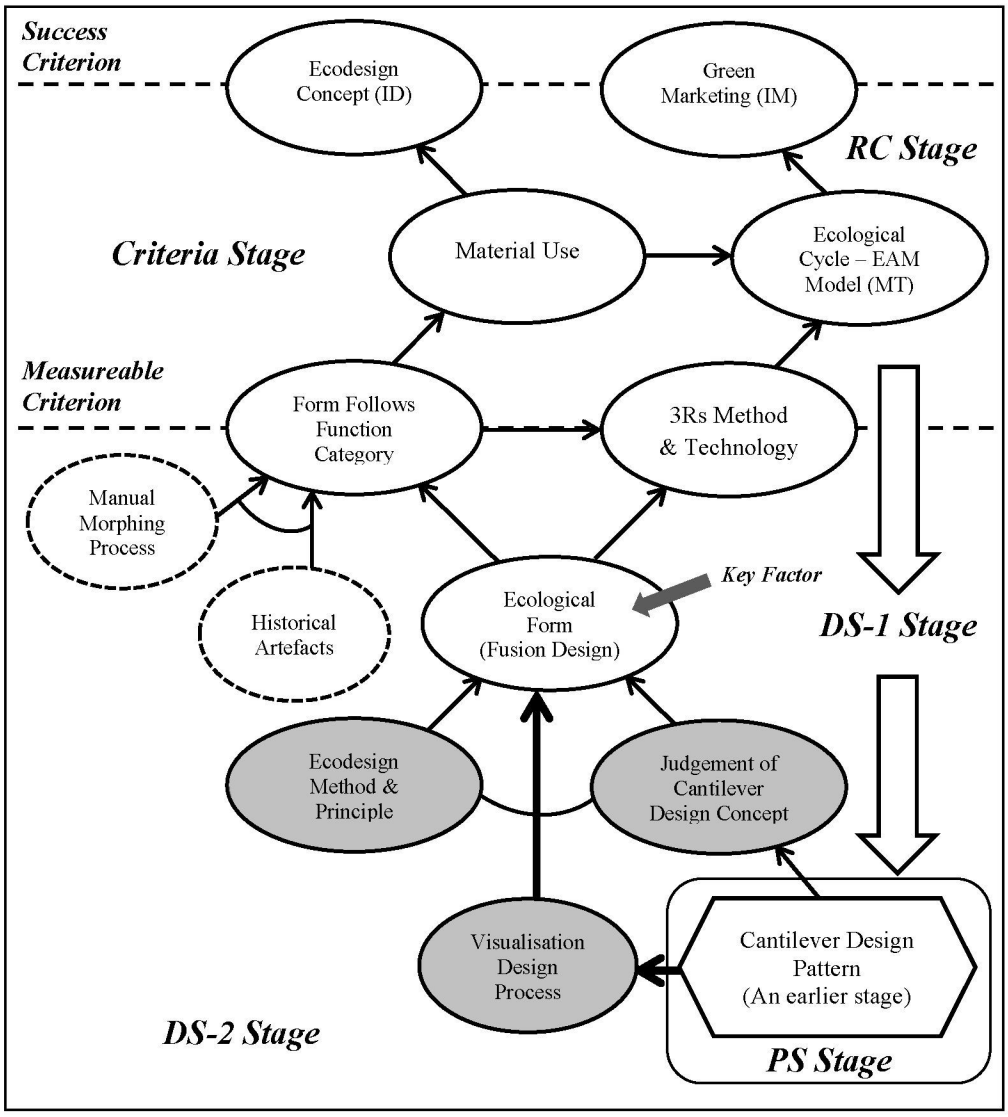


Figure 3.26 Evaluation Model in Further DS-2 Study

For the sampling pilot study, the researcher will get the rest of the academic respondents (similarity homogenous characteristic) from another competing group of ID schools in Malaysian public universities. This academic competition is required to prevent bias sampling study issues and an appropriate pilot test sampling in the respondent selection stage. Once the reliability test value is released, the researcher will reach the specific demographics using the target population in the sampling frame design along the probability type sampling group. Then, the data of respondents' fieldwork can be validated when all the instruments are completely tested; then it is ready to enter the actual sampling size as the research programme requires.

3.4 Research Design

The research design develops from the DRM framework following Option 6 (type of design research projects) – refer to Figure 3.2 initially that the conception of research onion strategy navigates to approach the explanatory study and the exploration study along the philosophical assumption concurrently. The concept of convergent thinking parallel via mixed methods is a formation of design methods in which the research study converges or merges to attribute the quantitative and qualitative datasets in order to provide a comprehensive analysis of the research problem as a real-world view into the realistic. In this research design, the investigator typically collects both forms of data at roughly the same time and then integrates the information into the interpretation of the overall results. Contradictions or incongruent findings are explained or further probed in this design (Creswell, 2014).

Table 3.1
Qualitative, Quantitative and Mixed Methods Approaches (Creswell, 2014)

Tend to or Typically	Qualitative Approaches	Quantitative Approaches	Mixed Methods Approaches
• Use these philosophical assumptions • Employ these strategies of inquiry	• Constructivist/ transformative knowledge claims • Phenomenology, grounded theory, ethnography, case study, and narrative	• Positivist knowledge claims • Surveys and experiments	• Pragmatic knowledge claims • Sequential, concurrent, and transformative
• Employ these methods	• Open-ended questions, emerging approaches, text or image data	• Closed-ended questions, predetermined approaches, numeric data	• Both open- and closed- ended questions, both emerging and predetermined approaches, and both quantitative and qualitative data analysis
• Use these practices of research as the researcher	• Positions him- or herself • Collects participant meanings • Focuses on a single concept or phenomenon • Brings personal values into the study • Studies the context or setting of participants • Validates the accuracy of findings • Makes interpretations of the data • Creates an agenda for a change or reform • Collaborates with the participants	• Tests or verifies theories or explanations • Identifies variables to study • Relates variables in questions or hypotheses • Uses standards of validity and reliability • Observes and measures information numerically • Uses unbiased approaches • Employs statistical procedures	• Collects both quantitative and qualitative data • Develops a relational for mixing • Integrates the data at different stages of inquiry • Presents visual pictures of the procedures in the study • Employs the practices of both qualitative and quantitative research

Source: Creswell (2014)

During the research designs project, the consideration of time horizon in the DRM research design derives the formation of design approaches and/or methods as Table 3.1. For example, the selection of the grounded theory (design belief) through the support of the DRM system can be gauged or measured by the descriptive study (design perception) that interprets the evaluation of the DRM system. Then, the So, there are possible reflections to view an actual continuum of research design.

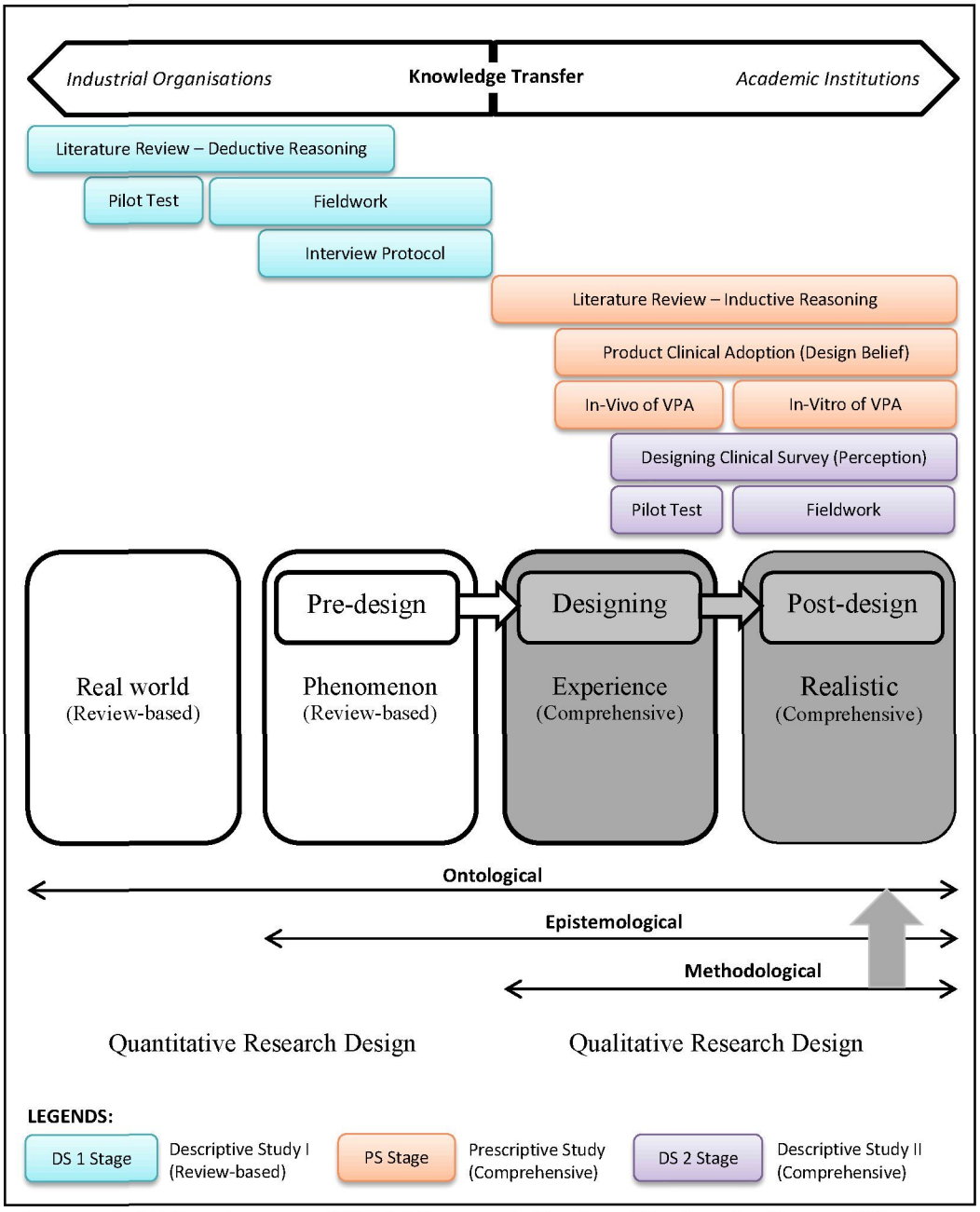


Figure 3.27 Continuum of DRM Research Design (Option 6 - Type of Design Research Projects) For The Knowledge Transfer of an Ecodesign Identity

In Figure 3.27, the fundamentals of the knowledge are established and begin from the knowledge transfer. Using the directional continuum, there are two areas of organisations namely (1) industrial organisations and (2) academic institutions. In the study, the dissertation of the research study approaches the academic institutions which is the development of young designers towards design education priority. It refers to the basic and/or fundamental of qualitative research that the grounded theory should be taken along the study. The application of the DRM framework is intentionally executed by the PS stage (support output) → DS-2 stage (evaluation output) option 6 for the systematic research methodology. Dominantly, the VPA method is suited for the design belief (grounded theory) in qualitative design education. Meanwhile, the clinical survey is interpreted to the design perception (theory building) for the numerical dataset consistency. However, the understanding of the comprehensive analysis is very crucial in the basic and/or essential research of the DRM framework. Due to DRM research project-based are orientally developed by the experience and empirical approaches concurrently.

Next, the challenge to apply the same subjects' following to the use of respondents and participants is to enable articulate structure datasets to be adopted into the one-directional research design programme, which is resultant of the DRM research design. In Table 3.2, the research study has placed to mapping the entire structure of the DRM research design from Option 66 - the type of design research projects concurrently.

For the overall comprehensive PS qualitative research, the goal of observation and/or simulation is to spot any instances of the hand sketches/drawing interactions revealed from the synthesisation of the think-aloud concept that seeks the mimicry solution of tangible and/or explicit design environment produced evidence of design manuscript. The research study collects verbal reports from participants through methods via think-aloud or retrospective strategy. During the process of the VPA method, the participants might be asked to describe their perceptions of a product's ecodesign identity, what aspects appeal to them, or how they interpret its ecodesign identity which is to screen the content of the design manuscript following to the mimicry solution. Overall, verbal protocol analysis is a useful method for investigating the complexities of product design identity within a grounded theory framework, offering information on how customers perceive and interact with produced artefacts. Therefore,

a further chapter's discussion will explain the specific comprehensive PS qualitative research that could elucidate the basic research of the DRM framework systematically.

Table 3.2
DRM Research Design in an Ecodesign Identity

Research Design for The Prescriptive Study (PS) Stage				
Grounded Theory (Verbal protocol analysis – VPA method)		**Assessment Approach/Method**	**Reliability (Consistency)**	
Descriptions			**Credibility**	**Transferability**
1.	Design scheme	Think aloud method	Thematic analysis	Semantics design
2.	Artefact categorisation	Heuristic method	Quality review of the procedure	Tacit pattern of design manuscript
3.	New product development		Design of product positioning	Design identity identification
	Design manuscript	Analytic Rubric Evaluation	Inter-Coder Reliability	Mimicry of product form
Research Design for The Descriptive Study II (DS-2) Stage				
Theory Building (Design survey method)		**Measurement Approach/Method**	**Validity (Accuracy)**	
Descriptions			**Internal**	**External**
4.	Pilot as clinical survey	Correlation of variables	Nominal, ordinal and scale ranking	Rehearsal of small sampling
5.	Fieldwork as clinical survey	Spearman Rho correlation*	Items' variables Sig. at the 0.01 & 0.05 level (2-tailed).	Generalisation
		Correlation coefficient*	Value interpretation - Strong	Setting population
		X^2 Independence Test*	Association - Strong	Labelling and bipolar adjectives
6.	Instrumentation of items	Reliability analysis and coefficient	Cronbach Alpha and Intraclass Correlation Coefficient (ICC)	

*Note: Non-parametric test

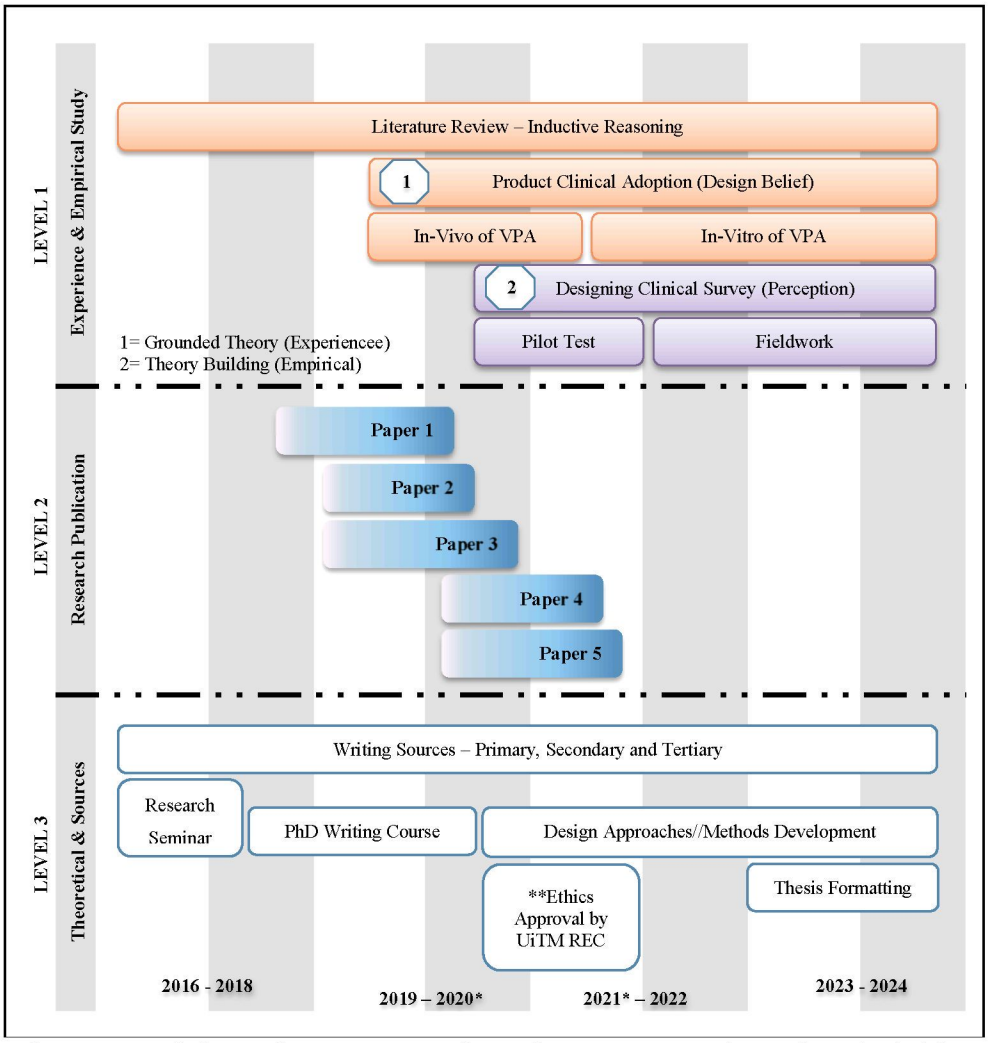


Figure 3.28 Schematic Representation of DRM Research Design Activities

Note: *Covid-19 pandemic (MCO started - Mac 2020 until ended - December 2021)
**Ethics approval within 12 months of validity period (21 October 2020 until 31 August 2021)

In Figure 3.28, the schematic representation of research design activities summarises the essential steps involved in designing and carrying out research within a PhD programme. However, particular information and durations may differ depending on subject, institution restrictions, and individual research initiatives. During this step, the available literature on the research topic is thoroughly reviewed. It entails identifying knowledge gaps, comprehending pertinent theories and procedures, and synthesising prior research findings. Based on the literature review, the researcher develops research questions or hypotheses that address the gaps discovered in the literature. These questions steer the research endeavour and help determine its scope. Three stages entail identifying suitable research procedures and methods to address the study issues as Level 1: Experience & Empirical Study, Level 2: Research Publication,

and Level 3: Theoretical & Sources. It includes selecting a DRM research strategy (prescriptive study or descriptive study), data gathering methods (video observation and clinical survey), and data analysis methodologies. After developing the research design, the research study may produce a research proposal detailing the background, research questions, methods, and expected results of the research study. Before beginning research, the academic advisor or dissertation committee would normally examine and approve the project.

In this stage, you will collect primary or secondary data in accordance with the research design and methodology outlined in your proposal. Data gathering methods may differ depending on the nature of your research and queries. After gathering the data, you will analyse it using relevant qualitative or statistical methodologies. This stage entails analysing the data to answer research questions and draw findings. Once the data analysis is complete, the researcher interprets the findings in light of current literature and theoretical frameworks. This step frequently includes examining the ramifications of research findings and how they relate to the larger field of study. Finally, the researcher intends to write up the research findings in the form of a thesis or doctoral dissertation. This paper usually has an introduction, literature review, methodology, results, discussion, and conclusion. After finishing the dissertation, the researcher defends it orally before a dissertation committee.

3.5 Methods' Concept of Product Clinical Adoption

This method selection evaluates the ecodesign identity model from previous PLM studies (see Figure 3.8) that two systems called (1) "Quality Leadership" signs an evolution of form (EoF) in heuristics design study and (2) "System Leadership" indicates the recycling methodology in design for recycling (DfR) concurrently. Based on the previous source, the study identifies the suitable method concept when the setting of the methodology has been reflected in the operating and administrating research activities from its method selection. The study coined and inspired by the scientific research of clinical health or nursing programmes to call the concept of product clinical adoption (PCA) most ideally structured in the research topic.

Based on the above justification, there should be followed by the two types of data sets of design sampling that it will be taken. Referring to the heuristic design, the qualitative method and/or approach have ready to use the verbal protocol analysis

(VPA) method that purposely describes the design thinking for think-aloud interpretation – to investigate the common practice of design experience from human activities (the novice and/or young industrial designer) into the design manuscript. The progression of designing the clinical survey must be released and gathered upon the VPA method's completion. Thus, it's very useful and related to the non-numerical dataset that the data collection always be used by video observation where the extraction of the dataset develops the kind and/or specific theme and/or coding context. Meanwhile, the DfR study examines the design perception of the ecological form of ecodesign by the designing clinical survey referring to the design artefact context that the novice and/or young industrial designer developing the product design is essentially creating the product form to deliver ecodesign identity. At this time, the numerical dataset is significantly used to measure the value using the SPSS software within a certain/statistical testing method. Thus, the descriptive study will emphasise the value and/or numerical interpretation following the rules of thumbs.

However, this method selection is only used for the research strategy and planning in a logical of mixed method sampling (MMS) and datasets particular itself. These method selection studies are systematically working on the mixed method due to the increment and enrichment dataset being a priority to increase the validity of fundamental/basic research. Realistically, the complementary two approaches – qualitative and quantitative datasets will properly figure out the concept of methodological triangulation in further study.

3.5.1 Qualitative Approaches: Event Observation Based on Verbal Protocol Analysis (VPA)

There are many definitions, approaches and types of verbal analysis (commonly used in qualitative methodology). For the PS stage, this study will use the VPA method as an observation testing method to support the findings. By the reference bubbling modelled, the researcher uses the key factor in an elongated hexagon shape – cantilever design pattern heuristically (See Figure 3.26), to investigate the respondent life experience on the cantilever principle behaviour and its practice as well (Abidin, 2012). The aim of the VPA study is to emphasise the ideation of sketches or drawing methods from the young industrial designers that refer to the pattern quality of designs elementary/principle explicitly. In the study, there is not to use and purpose of the VPA

for the investigation of the design emergence context following both targeted functions mostly refers to (1) the cognition of think-aloud and (2) the effect of the psychomotor during the drawing study. However, there is much focus on the directional designing method (designing tasks: (1) the design thinking evoked the patterns of form follows function and (2) the system thinking principled the 3Rs method cognition) where it must navigate an appropriate area of the fusion design concept. The VPA tools and equipment such as a recording camera, mood board, sketching book and other artwork instrument will be prepared during the PS stage session.

In the VPA method preparation, several existing design concepts will be used to seek the ecological form phenomenology following the Schön theory (reflection in/on action). This existing design concept commonly falls under three categories of industrial design product profiles: (1) product design, (2) furniture design and (3) transport design. Once all the participants completed this VPA method, the researcher will transmit the experiment data into the transcript form sheets using the qualitative coding analysis. Further, the consistency of design pattern frequencies is required and it will be delivered into the DS-2 stage within the evidence (to support the measurable criterion) using the same numbers of subjects' sampling. Therefore, by the PS analysis finding, the existing reference model can be firmly trustworthy because a prediction on the design theory is believed to have been launched with the *"3Rs cycle loop methodology and the practice model"*.

The drawing manuscripts method is usually used in the interpretation of qualitative data analysis studies. Creswell (2003) preferred this methodology due to finding the in-depth observation/narrative session from the particular subject referred which is the novice and/or young industrial designers who have had experience in designing or ideation concepts (Abidin, 2012). This will assist in establishing the validation of factors (measurable criterion) in the reference model that ideally explains how the ecological form phenomena happen in producing the SfPD. From the design pattern findings (and 3Rs method elements), the theory model will be revealed and developed approximately. Thus, it leads to an initial analytic rubric evaluation (ARE) development that the quality of criterion description is *to expose* the undiscovered relationships along the PS stage study context accordingly. The ARE assessment will deliver a rigorous finding observation that the increment validity of a study enables the enrichment of the PS dataset accordingly.

3.5.2 Quantitative Approaches: Designing Clinical Survey on Questionnaires Instrumentation

The designing clinical survey (DCS) refers to the collection of dataset strategy in the form of instrumentation within designing activities environmental – inspired by the scientific research of clinical health or nursing programme – a clinical adoption (CA) concept (Niedderer and Roworth-Stokes, 2007; Centre for Community Child Health, 2011; Sandars and Goh, 2020; USC Libraries, 2020). Because of the protocol designing method, this testing method should be structured with environmental steps or procedures that enable the study to reach the appropriate mental imagery in a morphological way from the subjects as the participants. Then. all participants have to answer the DCS questionnaires that they all are respondents who every individual randomly selected as well as cluster datasets of probability sampling. At this time, a changing mode of sampling types (from participants shifts to the respondents' sampling capacity) must be applied during the research methodology programme in a time horizon. There is a good practical strategy of method selection which means the designing timeframe underlying a research period for the dataset collection, in order to compare data, datasets are used frequently over an extended period of time. For example, the design ideation of drawing sketches has had continuous practice until the rapid prototyping stage is reached. This drawing period is not preferably finished and stops the design concept processing. Next, the dataset from the design survey from the marketing/business research team is required that it can be encoded and/or decoded by the use of dataset application repeatedly. However, a continuous design concept via repeatedly DCS understanding enables to promotion and/or produce the latest trend or design fashion in the conception of NPD. This impact brings benefits to the design practitioners to set up the future design direction.

For the fundamentals of instrumentation, the DCS will begin with the pilot test study as the initial strategies of variable inquiries validation for the quality of questionnaire items within its types of scale measurement purposely (nominal and ordinal data will be used in the survey). Using the minimum Cronbach Alpha value above such as 0.60 (good reliability) to 1.00 (very good reliability), this rehearsal will assist the researcher in seeking an accurate item instrument (type of questionnaire items) for the validation of instrument design before entering the actual fieldwork. For the sampling pilot study, the researcher will get the rest of the academic respondents

(similarity homogenous characteristic) from another competing group of ID schools in Malaysian public universities. This academic competition is required to prevent bias sampling study issues and an appropriate pilot test sampling in the respondent selection stage. Once the reliability test value is released, the researcher will reach the specific demographics using the target population in the sampling frame design along the probability type sampling group. Then, the dataset respondents of fieldwork can be validated when all the instruments are completely tested; then it is ready to enter the actual sampling size as the research programme requires the fieldwork. Thus, a small sampling size specifically justifies the focus group needs.

For the tool of accuracy measurement, the SPSS is required to test the numerical value that is commonly used to describe the finding result (descriptivism and/or inferential). In this DS-2 stage, the researcher intentionally seeks the numerical elementary that can be possibly used in further creations of the ecodesign model stage. Two testing methods will be tested, such as (1) the Pearson product-moment correlation coefficient between two variables to obtain the visual scatter plot pattern – whether it's a positive linear correlation or otherwise and (2) the single or multiple regressions testing method will conduct the data respondent to obtain a regression line (perfectly linear). Future, the finding will assist the researcher *in measuring* an accurate ecological form model possibly using a "venn diagrams pattern" that will convince a new ecodesign formulation establishment (a new theory model); the meeting point of the fusion design concept (as ecological form identity theory and/or belief). Therefore, the outcome of the Venn diagrams pattern will display, sort and determine the physical theory model pattern with two kinds of relationship models such as (1) overlapping circles or (2) a centre circle with a ring of outer circles, which means two or three circles correlation enabling to form the core principle of theory model (Suter, 2006). However, all these findings and assumptions create expected future research which is purposely studied and used for the key measurement of the performance of the Venn diagrams pattern. The main reason for this study should be to define the possibility and capability of the accurate statistical testing method provisionally. Due to the impact of the DCS signs the designing is significant in design field contribution.

3.6 Methodological Triangulation for Mixed Methods Approaches

In the study, the methodological triangulation is essentially divided into two method components. These two method components must have "the bridge" to connect with each other namely (1) EoF under the quality leadership and (2) recycling methodology represented by system leadership as Figure 3.29. First, the

Firstly, form in design was essentially functional. Products were created to serve specified functions efficiently, with little regard for aesthetics or user experience. Normally, the product form is concerned with user and/or consumer engagement. Aside from the product experience, the user and/or consumer are constantly concerned with the functionality of the product form. As the value of user experience became more widely recognised, design changed towards a more user-centred approach. In the context of quality leadership, the EoF context referred to producing things that were dependable, durable, and met fundamental functional standards, which expanded to include not just the product's functioning but also usability and user happiness. Forms shifted to prioritise user demands, preferences, and behaviours, resulting in more intuitive and ergonomic designs. As human factors and ergonomics research advanced, form design became increasingly informed by human-centred design concepts. To ensure that products were not only functional, but also comfortable, safe, and adaptable to human capabilities and limitations, product forms were optimised to reduce user fatigue, stress, and errors. Aside from functionality and usability, there was an increasing acknowledgement of the role of emotional appeal in design. As a result, ergonomics cognition will be expanded to include the emotional impact of products on users, with the goal of eliciting positive feelings and establishing emotional relationships. Forms began to use aesthetics, storytelling, and symbolism to provide meaningful experiences for users. As expected findings, the heuristic design approach has been important to quality leadership throughout its growth via design thinking. The design process is guided by heuristic concepts such as simplicity, consistency, feedback, and error prevention, which ensure that forms not only meet functional and emotional needs but also allow intuitive interaction and user satisfaction.

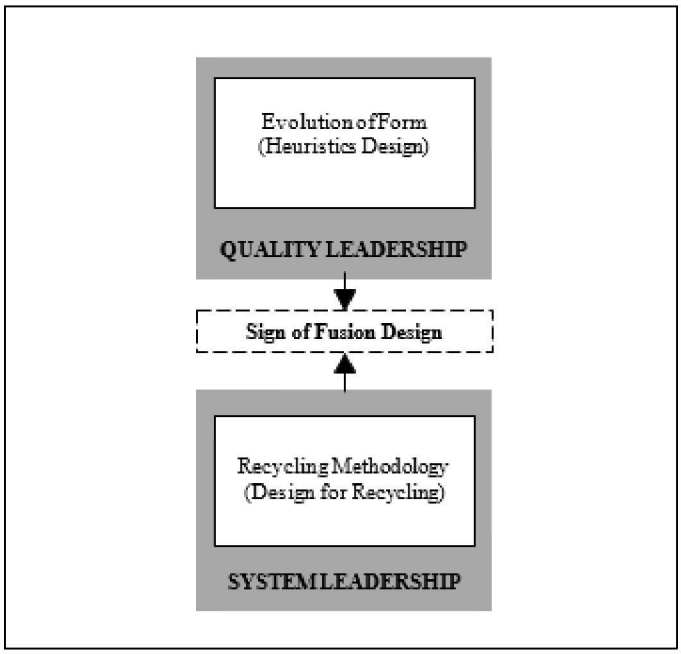


Figure 3.29 Elementary of Fusion Design

Second, design for recycling is an approach that incorporates recycling and sustainability ideas into product design and production processes. When designing for recycling in the context of system leadership, which entails steering and coordinating efforts across different stakeholders within a system, several crucial elements arise. To begin, they should use life cycle assessment (LCA) to understand the environmental impact of their products from raw material extraction to end-of-life disposal or recycling. The application of LCAs is to find opportunities to optimise product design for recyclability and reduce environmental impacts throughout the product's lifecycle. The various roles of people designated by the organisation refer to the function of the LCAs method, which is typically approached by designers, engineers, and material scientists to select materials that are recyclable, renewable, or biodegradable. The reflective practices will be advantageous to the materials involved, which implies that design optimisation entails selecting materials and manufacturing techniques that permit disassembly and recycling at the end of the product's life. The organisation's system executives then lobby for standardised design methods and material requirements to aid in recycling operations. Hence, developing goods with compatible components and materials makes separation and sorting easier at recycling facilities, increasing the efficiency and efficacy of recycling processes. However, system leaders play an important role in teaching stakeholders, such as designers, manufacturers, consumers, and legislators, about the significance of design for recycling (DfR) and the

benefits of sustainable product design methods. The DfR's communication initiatives may include increasing awareness, giving guidance and training, and sharing best practices for developing products with recycling in mind. The phenomenon of DfR communication has encouraged collaboration and partnerships among stakeholders across the value chain, including manufacturers, suppliers, recyclers, and government entities. Collaborative efforts can result in the creation of closed-loop recycling systems, in which items are designed, made, and recycled in a continuous loop, reducing waste and resource consumption as well as system thinking. Generally, system leadership in DfR entails organising coordinated action and promoting systematic change across different stakeholders in order to promote sustainable product design practices and build a more circular economy. System leaders can help develop new solutions that reduce waste, conserve resources, and protect the environment by engaging in strategic planning, collaboration, and campaigns.

Based on these two elements, the research study has a lesson for the sign of fusion design in product form identity. Furthermore, the specific two themes obtained by the heuristic idea (design thinking) and recycling concept (system thinking) can be triangulated together successfully - it is driven to energise and believe the sign of fusion design. As a prompt, the combination of heuristic design and recycling approaches for product form identity yields a tool of design methodology that produces an aesthetically appealing product while remaining environmentally responsible. It embodies the ideals of simplicity, efficiency, modularity, and durability, while also encouraging recyclability, resource efficiency, and circularity. However, there must be an explanation of the further theoretical framework which is the context of empirical study needed to describe the realistic perception in addressing the criteria of DRM research design.

3.6.1 Experience Study as Qualitative Approach

In the subtopic of the experience study, the research explains the engagement of the design thinking area within the DRM framework in the PS study context. Here, the experience study is based on the metaphor visualisation of designing activities from the design beliefs and participants' understanding. It enables to develop the emergence of symbolic interactionism for the Grounded Theory (Jaccard & Jacoby, 2010). Following the purposive of non-probability sampling, the novice and/or young industrial designers

called ID students demonstrate an understanding of the design concept of ecological form through drawing and/or designing activities by the visual elements (VE) study that enable them to produce and create the SfPD in the product form – "exploration on design belief to fusion design concept to product form identity". This VE study reflects an aspect of industrial design, such as morphing metaphorical imagery, in terms of quality of form. These ideation processes were generated from the small participant groups of ID students (focus group sampling) required to screen their pattern of think-aloud for non-numerical datasets. At this time, the EoF can be observed in the specific design movement simultaneously.

To realise the experience study, some preparation of the drawing instrument is needed. Due to an investigation of think aloud, the use of suitable multimedia such as ball pen, black technical pen, HB pencil and A3 drawing block essentially generated the rapid idea cognition in fast mode drawing sketches via its free-hand stroke at design mechanism immediately. In the drawing sketches, the various qualities of lines can derive a quality drawing technique – presenting the types of hatch, crosshatch, tonal, stipple, scumble, shading and blending. For the drawing perspective, the artefact must be drawn with two-dimensional (2D) or three-dimensional (3D) sketches which means the drawing perspectives develop the product form following the point of view (POV). Thus, the experience study identifies various studies of designing activities that support the theme of design belief components according to certain opinions on the designing iterative such as design practice, design behaviour, design semantics, and design concept. The theme's findings are very useful and important because they possibly create and provide a few naming and/or code categorisation in the essential basic research concept.

3.6.1.1 Stimuli Mental Model

At the beginning of the stimuli mental model, the study discovers the design belief through the framework of the perceptual product experience (PPE) model that the assessment of the metaphor visualisation must use the drawing pattern in the design representation. This is compulsorily coordinated with the VPA design scheme for the goal of design datasets and it should reach a good explanation of the ecological form of ecodesign identity: referring to the tangible or intangible product form. The VPA design scheme, there are generated by recording video observation of the participant's drawing

demonstration to seek and find out their ideation processes frequently called critical thinking aloud. In other words, the facts of the learning, lessoning and reflecting come out from the participants' cognition throughout together with their design semantics understanding. By the drawing pattern, the description of the design experience will be transferred to the design semantics into the design manuscript and the proper enrichment encodes and/or decodes the dataset representing the object/things/artefact content. Using the VE of design can capture certain meanings and/or specific contents of the design concept. At this time, the heuristic method assessment allows the researcher to screen the actual design representation where it should achieve the objectives as an ecological form of ecodesign identity.

Finally, the assessment of the rubric is required to evaluate the experience study systematically. The rubrics ranking called ARE assessment is used to present the quality of the study that it could be desirably delivered the ranging or categorising or levelling the quality of product design as the metaphor visualisation of designing activities (Chumiran, Abidin & Kamil, 2020). The inter-coder reliability (ICR), is described as a numerical measure of coders' agreement on how to code the same data. ICR can help to instil trust that systematic efforts were taken to guarantee the final qualitative data analytic framework is a credible and accurate representation of the data (Cofie, Braund & Dalgarno, 2018).

Hence, the evidence of design representation can be easily traced through the participants' experience study and enables an appropriate methodology trait for designing procedural methods. Here, an impact of evidence of design representation establishing a "reflection-in-action" which an expert Schön (1983) expressed,

> *"... the designer sees what is there in some representation of a site, draws in relation to it, and sees what has been drawn, thereby informing further designing."*

Therefore, the pattern of design representation is positioned and aligned under the visualisation of reflective practices and/or thinking in the Schön theory model (Abidin, 2012: Schön, 1983). It is consistently embedded in the earlier PPE model referring to the stimuli mental model. Of this phenomenon, the design paradigm has greatly led the design belief towards stimuli mental activities together with think-aloud

iterations. However, this detailed explanatory study will be emphasised in the next chapter.

3.6.2 Empirical Study as Quantitative Approach

The position of empirical study in the basic research is purposely measuring the qualitative research datasets using the application of quantitative methods. For the DRM framework, this empirical study commonly describes a causal effect on the kind of variables and enables the development of a theoretical framework to seek and/or review the expected findings via an output impact of the research study as numerical data. As an impact of this matter, the empirical study is inclusively embedded into the thematic categorisation of qualitative methods which is used to validate and reliable the dataset representations.

For instance, there have been a few numerical empirical studies articulated together with system thinking into design thinking understanding. Usually, the engineering design concept pertains to the analysis of fundamental problems, such as algorithm morphing in form integration. Hence, this study systematically approaches the strategy of mixed methods to describe the complex datasets in the basic research methodology itself. The content of the empirical study tells about the recycling methodology in the creation of the SfPD as the contextual of product form. As known, this recycling methodology comes out from the system thinking area which means the design for recycling (DfR) practice utilising the designing process in producing the product form identity.

To demonstrate the empirical study, the encoding dataset sources form the experience study in deep learning – a thematic categorisation that should be transmitted into the understanding of numerical lessoning within the semantics scaling. The attribution of variables will be defined and classified upon the understanding of the coding adaptation as well as conceptual of encode → decode.

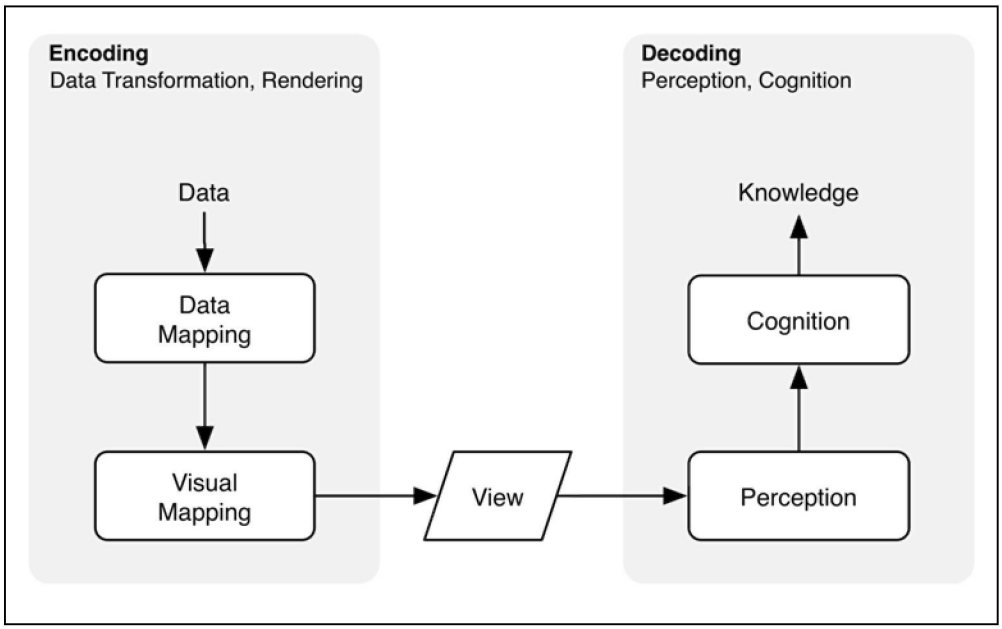


Figure 3.30 Visualisation for Communication Model

Source: Kosara (2017)

In Figure 3.30, the transformation of the dataset in the basic way of research study occurred from the sources of data node networking to the sources of knowledge building. In the context of product form, the research study used the Monö model and the design representation will be gauged by the signs system systematically. The function of the signs system in the research study is to describe the semiotics which means dealing with the structure, properties and role in socio-cultural behaviour (Abidin, 2012). At this moment, the reflective thinking heading the data visualisation for the design representation, the contribution of knowledge developed through cognitive constructivism in a proper structure designerly way.

3.6.2.1 Theoretical Framework

Next, the empirical study process is based on the reflection practice and/or thinking that the survey method can practically measure the datasets of the signs system accordingly. For the statistical testing method, the description of numerical datasets is used for the SPSS application and it will be interpreted as the value of statistical methods following the statistical procedural steps and the use of the rules of thumbs. For the design instrumentation, construct validity is required to define the categorisation of variables and it enables us to build the items of questions. The items of questionnaires

are classifiable and chosen to select the three kinds of scaling such as nominal (theme) scale, ordinal (semantic differential scale; Likert scale; numerical scale) and ratio scale (multiple choice questionnaires) according to the theoretical framework needs as Figure 3.31.

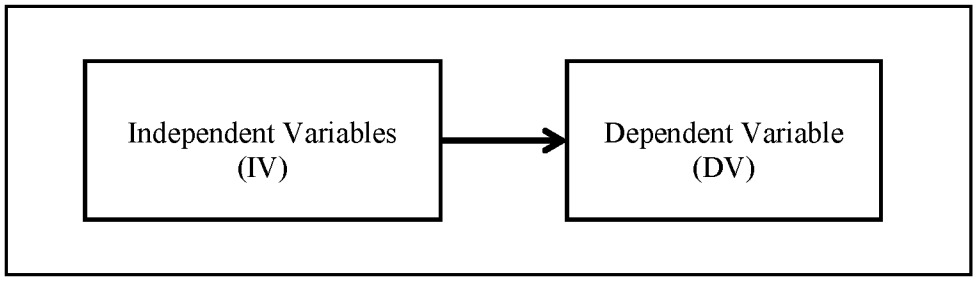


Figure 3.31 The Variables of The Theoretical Framework

Using the contents of the theoretical framework, there will be tested to the heterogeneity characteristics which the number of respondents is revealed and taken from the three small groups of heterogeneity characteristics sampling (target population from three differences of schools called heterogeneous) following three bachelor degree/level specialisation of industrial design courses – (1) bachelor of arts (BA), (2) bachelor of design (BDes) and (3) bachelor of science (BSc). The emergence of the theoretical framework developed by the understanding of the conceptual framework in an earlier discussed as Figure xxx. For the design of sample size, the young designers (number of respondents) are required that the quantitative research approaches verify the data collection and analysis using the survey method of clinical adoption.

Figure 3.32 shows the research study's theoretical framework for the ecological form of ecodesign identity, which includes an assumption of design theory in the sustainability of product design. The meaning of the theoretical framework is to define what is going on with the design theory (variables) underlying the directional predicted as normally known with one-tailed prediction. It is to indicate a causal relationship, each arrow should start from the independent variable (the cause) and point to the dependent variable (the effect). Thus, the study of the theoretical framework focuses on discovering the directional prediction that its underlying one-tailed prediction, is looking for – what are the null hypotheses and/or alternative hypotheses for a specific directional hypothesis or expectation about the relationship between variables. Due to the small sample size of 45 respondents (heterogeneity characteristics as earlier

mentioned) as less than 50 subjects of respondents ($n < 50$) which is related and matched with (1) the statistical assumption and (2) the appropriate use of the statistical test for the significant level of 0.05 ($p < 0.05$) namely the Kolmogorov-Smirnov test in the small sample size accordingly.

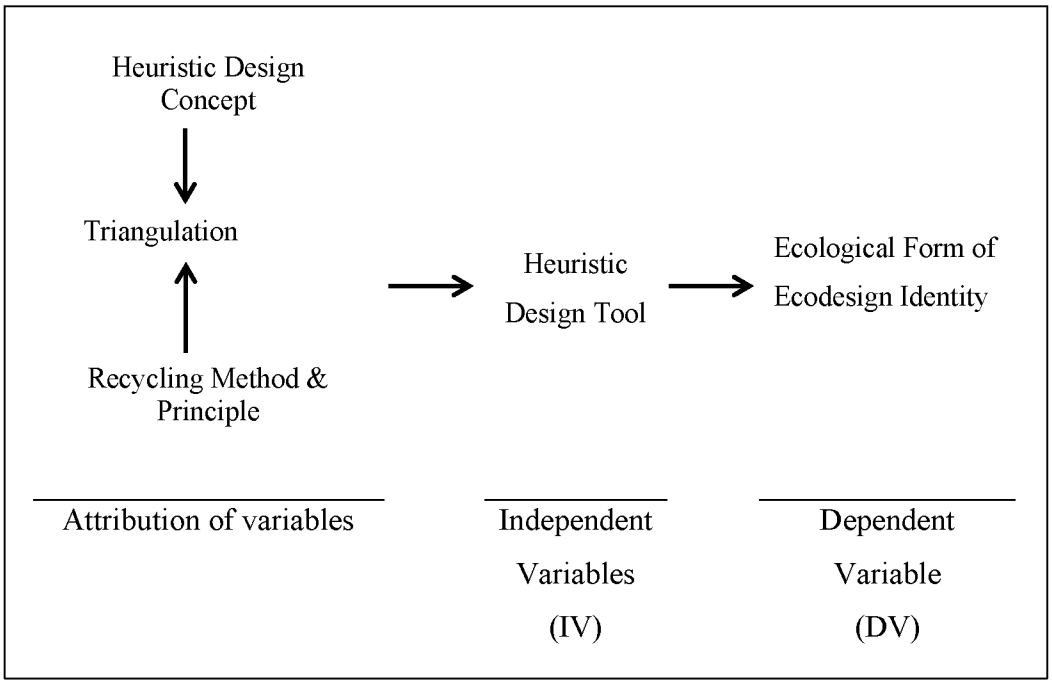


Figure 3.32 Theoretical Framework for The Ecological Form of Ecodesign Identity

Generally, this theoretical framework visualisation is motivated by and emerged from the previous sub-topic under the understanding of Methodological Triangulation's sub-topics. By reflecting in a designerly way manner, the research study builds the theory based on the design perception in the subsequent stages of data collecting and analysis.

3.7 Setting and Sample Design

Referencing the research aim sub-topic at the start of Chapter 1, the research study intentionally selects the Malaysian public universities as the setting region – geographical area, as it is clearly mentioned that the place or location should be highlighted. Due to the nature of the bachelor's degree programme, specific responses and/or participants are frequently used. These individuals are referred to as the subjects, and they are administered and directed by the course department of the programme

organisation within each faculty, school, or college. Realistically, there are potentially called the subjects' participants in qualitative methodology and respondents for a quantitative methodology that both subjects' positions could be delivered an appropriate number of the sample size.

Further, the engagement of the setting study is usually linked with the sample design study called sampling. The main reason for both correlations is to identify and validate the research sample design in seeking the differentiated area between population and sample size. By the differential matters, there should be assigned the type of sampling design where is formally known as (1) probability sampling and (2) non-probability sampling. Sampling is the process of choosing a selected group or sample to represent the whole population. Random selection is used in probability sampling, generally referred to as representative sampling, which enables the researcher to draw robust statistical conclusions about the entire group. The person from the population who will be chosen as a sample based on convenience criteria or other factors is unknown. However, this DRM framework is sampled the both parties it refers to the mixed methods methodology into the mixed methods sampling concurrently. The challenge to assigning mixed methods sampling (MMS) is about the availability of validity and reliability on the population of sample size merging together under the one roof of the research methodology programme concurrently. Thus, the same subject's involvement in research methodology will be influenced and determined by similar criteria, characteristics and capability via the two gaps of research methods conception namely methodological triangulation and an application of the research onion approach. It must consistently emphasise and demonstrate the study of sample design enabling to development of the funnel thinking emergent in the appropriate use of methods systematically.

3.8 Population Overview

The population of sample size refers to the number of students selected randomly their admission of study refers to the Degree and/or Bachelor of Arts or Design or Science through the specialisation of industrial design course in the Malaysian public universities. Initially, the criteria population is required in this study due to the limitation of the study and the sample unit is equally chances selected

referring to three Malaysian public universities. Based on this criteria population, an appropriate group of study defines three kinds of criteria namely,

a) Firstly, the programme's recognition of the Malaysian Qualification Agency (MQA) under the National Education Code (NEC) with 214 in design as referred to Table 3.3,

Table 3.3
Listing of Malaysian Public Universities for the Specific NEC Code 214 in Design

No.	Name of Institutions	Main Campus	Branch Campus
1.	Universiti Kuala Lumpur Kampus Cawangan Malaysia Italy Design. Institute (UniKL MIDI) (Previously known as : Universiti Kuala Lumpur - Institute of Product Design and Manufacturing (UniKL IPROM))	1	N/A
2.	Universiti Teknologi MARA (UiTM)	1	2
3.	Universiti Teknologi Malaysia (UTM) SPACE, Kuala Lumpur	N/A	1
4.	Universiti Putra Malaysia (UPM)	1	N/A
5	Universiti Sultan Zainal Abidin (UniSZA)	1	N/A
6.	DRB-HICOM University of Automotive Malaysia (Previously known as:International College of Automotive)	1	N/A
7.	Limkokwing University of Creative Technology (Previously known as : Limkokwing University College of Creative Technology)	1	N/A
9.	Politeknik Ibrahim Sultan, Johor	1	
10.	Widad College (Previously known as :Shahputra College Campus Pekan)	1	N/A
11.	Malaysian Institute of Art, Kuala Lumpur	1	N/A
12.	Southern University College (Previously known as : Southern College)	1	N/A
13.	German Malaysian Institute (GMI), Selangor	1	N/A
14.	Universiti Teknikal Malaysia Melaka (UTeM) (Previously known as : Kolej Universiti Teknikal Kebangsaan Malaysia (KUTKM))	1	N/A
15.	Universiti Sains Malaysia (USM) (Minden), Pulau Pinang	1	N/A
16.	Universiti Malaysia Perlis (UniMAP) (Previously known as : Kolej Universiti Kejuruteraan Utara Malaysia (KUKUM))	1	N/A
17.	First City University College (Previously known as : KBU	1	N/A

	International College)		
18.	Linton University College (Previously known as : Kolej Linton)	1	N/A
19.	Kuala Lumpur Metropolitan University College (KLMUC) (Previously known as : Kolej Universiti Antarabangsa Cosmopoint)	1	N/A
20.	Linton University College (Previously known as : Kolej Linton) Kuala Lumpur	1	N/A
21.	UNITI College, Negeri Sembilan	1	N/A

Source: Malaysian Qualifications Register (MQR) - The Malaysian Qualifications Agency (2020)

b) Secondly, full-time intake for mode of study and
c) Thirdly, bachelor's degree/level specialisation of industrial design course – bachelor of arts (BA) and/or bachelor of design (BDes) and/or bachelor of science (BSc).

However, the third pinpoint criterion has been made significant since the criterion of heterogeneity populations can be observed explicitly – three design schools orientation namely BA, BDes and BSc have occurred. This criterion should be exactly counted in the identification of sample units when the determination of sample size is to be required.

Focusing on the sampling frame strategy is a crucial approach to justify the area of population overview study that it must deliver the specific target population according to an approximate procedure step in establishing the proper selection of mixed methods sampling (MMS) accordingly. By referring to three knowledge sources of sampling contexts, such as: (1) practice guide report; Canadian Audit and Accountability Foundation - CAAF (2021), (2) the journals' experts: Journal of Mixed Methods Research - Mixed Methods Sampling: A Typology With Examples by Charles Teddlie and Fen Yu (2007) and (3) book reference; Research Methods for Business – A Skill Building Approach by Uma Sekaran and Roger Bougie, 5th Edition (2009), are preferably suggested to develop the sampling structure based-on the merging concept between qualitative and qualitative sampling components. All three experts have advocated for researchers to establish the appropriate area of methodological procedure steps upon defining the current and/or specific sampling frame strategy following their own field conception of the study.

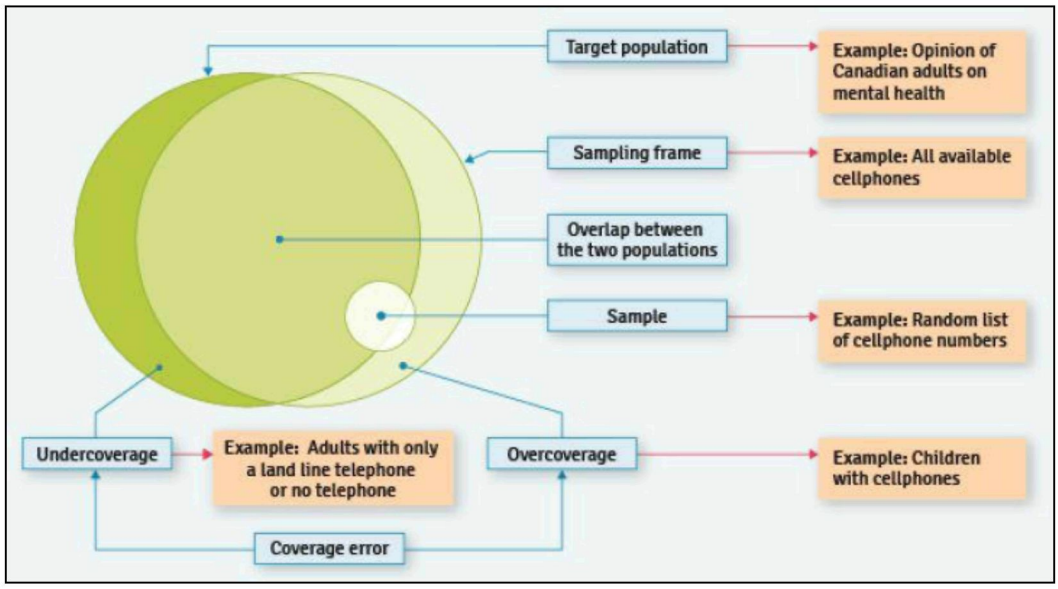


Figure 3.33 Illustration of Target Population and Sampling Frame in Survey Sampling

Sources: CAAF (2021) and Buskirk (2016)

Besides, this study places some benchmarks to develop the approximate level of sampling frame practice in reaching the target population of design study and/or equivalent of other related to design education study as Figure 3.33. The establishment of mixed methods sampling projects an illustration of the structure of the sampling decisions required by the basic topology thinking practice. The topology thinking explanation can be able to facilitate the sampling solution that the complexity issues within the MMS occurrence as a medium or tool for the knowledge and research gaps together. From the understanding of topology thinking, the accessibility tool will emerge to seek the population overview desirability.

Topology thinking is used in design professions such as architecture, industrial design, and urban planning to describe the spatial organisation and arrangement of parts inside a design. It entails considering the topological aspects of spaces, such as connectedness, enclosure, or circulation, and how they affect user experience, functionality, and beauty. Topology thinking emphasises the necessity of comprehending the underlying structure and relationships of complex systems or networks. Using a topological mindset allows practitioners to explore hidden patterns, detect emergent traits, and make educated decisions about system design, optimisation, or intervention.

For the data collection, the population describes the class and/or level of people (subjects) that contributed to the certain participants (qualitative research method) and

randomly selected respondents (quantitative research method) specifically. This population is usually interested in the kind of group or event or things – individual, object or measurement that can be figured and used for data collection, analysis, research approaches and/or methods testing until the prediction of the result finding itself (Singh, Abdul Ghani & Hoon, 2009). The expert's explanation of the population overview is made following,

> *"If collections of data (observation) are to be made from ALL students in the public universities, then this is called the census. Census means that all items (individual, object or measurement) are selected for the purpose of study. In this case, it is unrealistic to do this collection of data from all universities' students in Malaysia and because of this we need a sample of students to represent the population of students." (p.05)*

To observe the population study, the researcher has identified the numbers of the institutional communities that can be projected an approximate sample scale needs. In Table 3.4, the primary sources generated from the Malaysian Qualifications Agency – MQA (2020) under the Malaysian Ministry of Higher Education (MOHE) which listed 17 institutions namely Malaysian public universities registered the diploma and degree programmes in industrial design respectively. This observation of the study is important in that there will be the assumption of sampling size as the whole country and also to screen the number of subjects participants required. Then, it should facilitate the target population as the beginning of the sampling method that emerges the generalisation of subjects' representative using the method strategy of purposive - mixed - probability sampling continuum provisionally in Figure 3.35.

Table 3.4
All Programmes Listing of Industrial Design Course (Area of Diploma or Degree) in Malaysian Public Universities

No.	Area of Diploma/Degree	Name of Institution & Official Website
1.	Industrial Design (ID)	Universiti Kuala Lumpur Kampus Cawangan Malaysia Italy Design. Institute (UniKL MIDI) (Previously known as : Universiti Kuala Lumpur - Institute of Product Design and Manufacturing (UniKL IPROM)) midi.unikl.edu.my/
2.		Universiti Teknologi MARA (UiTM) (Shah Alam) www.uitm.edu.my
3.		Universiti Teknologi Malaysia (UTM) www.utm.my
4.		Universiti Putra Malaysia (UPM) www.upm.edu.my
5		Universiti Sultan Zainal Abidin (UniSZA) (Gong Badak Campus) www.unisza.edu.my
6.		DRB-HICOM University of Automotive Malaysia (Previously known as : International College of Automotive) www.dhu.edu.my
7.		Limkokwing University of Creative Technology (Previously known as : Limkokwing University College of Creative Technology) www.limkokwing.edu.my
8.		Widad College (Previously known as : Shahputra College Campus Pekan) www.widad.edu.my
9.		Malaysian Institute of Art www.mia.edu.my
10.		Southern University College (Previously known as : Southern College) www.southern.edu.my
11.	Product Design Engineering (PDE)	German Malaysian Institute (GMI) www.gmi.edu.my
12.		Universiti Teknikal Malaysia Melaka (UTeM) (Previously known as : Kolej Universiti Teknikal Kebangsaan Malaysia (KUTKM)) www.utem.edu.my
13.		Universiti Malaysia Perlis (UniMAP) (Previously known as: Kolej Universiti Kejuruteraan Utara Malaysia (KUKUM)) www.unimap.edu.my
14.	Product Design (PD)	First City University College (Previously known as : KBU International College) www.firstcity.edu.my

15.	Universiti Sains Malaysia (USM) (Minden) www.usm.edu.my
16.	Linton University College (Previously known as: Kolej Linton) www.linton.edu.my
17.	Kuala Lumpur Metropolitan University College (KLMUC) (Previously known as: Kolej Universiti Antarabangsa Cosmopoint) www.klmuc.edu.my

Source: Malaysian Qualifications Register (MQR) - The Malaysian Qualifications Agency (2020)

From the citation, Singh, Abdul Ghani and Hoon (2009) prefer the researcher to seek the appropriate population (institutional communities as a larger group) that can easily trace some or certain group - the class and/or level of people (subjects as small group) accordingly. Thus, the study will only use the specific three Malaysian public universities (institutional organisations) for the provision study that is sufficient enough to represent the class and/or level of people which is the small group subjects selected randomly – enabling to define the types of the sampling population. On the other hand, the larger group subject is referring to the generalisation as well as a population. Hence, the basic assumption on the population parameter study needs to apply when the expected and/or estimated numbers of students (novice and/or young industrial designers) that it is assumed that a population parameter is fixed or has just one possible value. Due to the fact that population parameters "pertain" to populations, they are rarely known and nearly never knowable.

In Figure 3.34, the fundamental overlapping process between the two populations is significantly highlighted in the sampling frame structure within the procedural steps. From these two sociology characteristics of the sampling population, a linkage through topology thinking as an accessibility tool strategy in merging both QUAL-QUAN methodology in mixed methods sampling (MMS). The unioned and management subgroups are important screening stages for process categorisation. Apart from all these homogeneity and heterogeneity populations, the study will demonstrate the topology of the sampling frame process by MMS context provisionally. The engagement understanding between the homogeneity and heterogeneity characteristics enables to development of the meeting point similarly since the hypothetical form of continuum process has been made such as the numbers of sample unit → heterogeneity < homogeneity population itself. Further details for this study will be accessed, and

discovered and knowing how to develop the sampling frame processes is supposed to be figured out in a systematic manner.

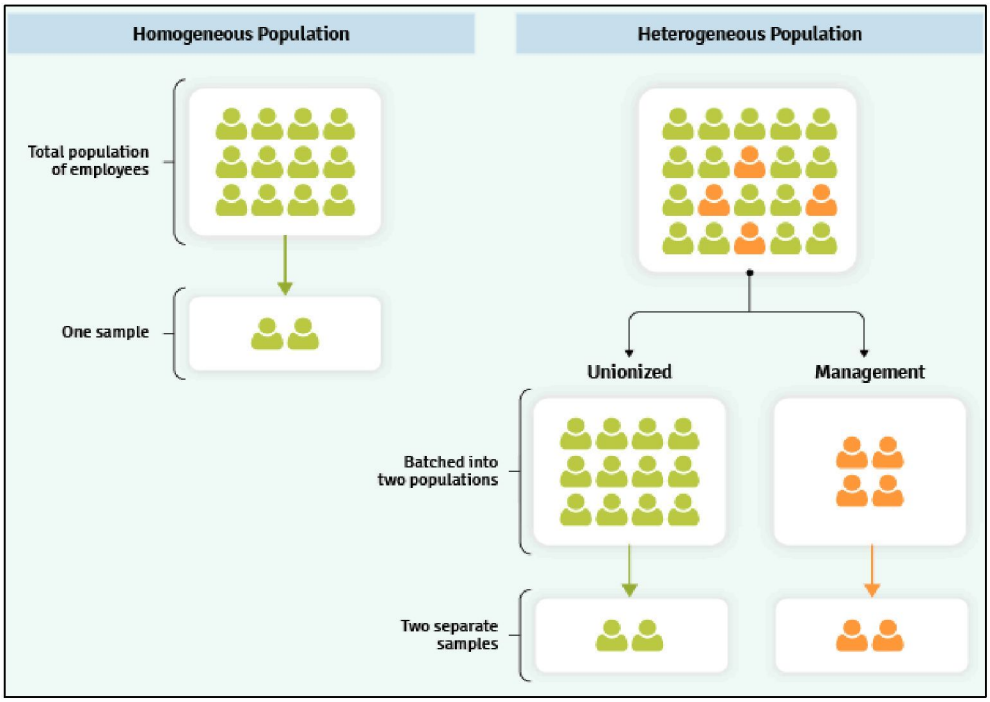


Figure 3.34 Homogeneity and Heterogeneity Populations

Source: CAAF (2021)

However, the justification for the number of students is taken from the minimum value within the availability source using the programme standards (PS) of degree/bachelor which is recognised by the MQA-MOHE. Programme standards[8],

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[8] Source from MOHE website https://www2.mqa.gov.my/qad/v2/types3new.cfm following,

"This document outlines sets of characteristics that describe and represent the minimum levels of acceptable practices that cover all the nine quality assurance areas: programme aims and learning outcomes; curriculum design and delivery; assessment of student learning; student selection; academic staff; educational resources; programme monitoring and review; leadership, governance and administration; and continual quality improvement."

"The programmed standards is developed by panel members in consultation with various public and private higher education providers (HEPs), relevant government and statutory agencies, professional bodies, related industries and students. The programmed standards is compulsory to be complied with, in conducting the respective programmes."

which span all educational levels, from certificate to doctoral degree, are created as a guide for the stakeholders to help with the establishment of programmes in a given field of study as the minimum level of PS requirements (MOHE, 2022). According to the MQA's education programme standards (2017), the significant subtopic of student selection is based on the recruitment of student quality following the individual programme of the study, which refers to:

> *"There are varying views on the best method of student selection. Whatever the methods used, the Higher Education Provider (HEP) must be able to justify and defend the coherence and consistency of its policies. The number of students to be admitted to the programme is determined by the capacity of the HEP and the number of qualified applicants. HEP admission and retention policies must not be compromised for the sole purpose of maintaining a desired enrolment. If an HEP operates geographically separated campuses or if the programme is a collaborative one, the selection and assignment of all students must be consistent with national policies" (COPPA, 2008, pp.17).*

Therefore, the above situation has covered the basic estimation of programs' capacity including two parties that have been identified with (1) the numbers of lecturers for whom teaching in the higher education provider (HEP) as academic staff and/or teaching staff and (2) the numbers of student for whom learning in a classroom intake of entry requirement as further Table 3.4. Besides, these two parties will pertain to the cohort programme which is related to the entire period of programme offered in every HEP of Malaysian public universities. The emphasising of teaching staff should be strictly guided by EPS (2014) as citations,

> *"The quality of the academic staff is one of the most important components in assuring the quality of higher education and thus every effort must be made to establish proper and effective recruitment, service, development and appraisal policies that are conducive to staff productivity" (COPPA, 2008, pp.21).*

To meet the criteria and characteristics of teaching staff, HEPs must make sure that the qualifications of academic staff are given courses based on their areas of expertise or pertinent industry experience in addition to having credentials in the

respective discipline. The specific listing of staff requirements is important in the study in that it can figure out the estimation of sampling design and enable to describe the justification of the population parameter concurrently. Here, there are three pinpoints of academic professionals, are to be qualified to teach at the various levels of education qualifications, the standardised requirements are provided with seven (7) people of subjects' lecturers (*s*) - the sum total of overall staff following,

i) Minimum qualification of academic staff: Master's Degree in relevant or related fields OR Bachelor's Degree in relevant or related fields with five years of related working experience, including teaching experience. (The programme should not employ more than 20% of the staff in this category).
ii) Overall staff - Student ratio – 1:15
iii) Full-time and Part-time teaching faculty – At least 60% full-time

As the above scenario explanation, let's count to seek the amount of student population from the second pinpoint highlighted, which is to use the minimum requirement and to begin with overall staff (*Os*) - student ratio (*Sr*) – 1:15, number of *Os value* to multiply *Sr value*, divided by six (6) semesters *Sem value* by the cohort programme (duration) describing to the equation below,

Where,

N is the target population from three different schools (heterogeneous),
Nc is an entire student semester in the whole cohort programme,
is the application of staff required to the cohort programme,

Os is the overall staff (lecturer) for the student ratio within the cohort programme and *Sr* is the number of students in the staffs' staff-student ratio by cohort programme,

$$Nc = \frac{\#\ \text{of}\ Os \times Sr}{6\ Sem} \tag{3.1}$$

To begin, *Nc* requires the ID students' to count the population of the minimum number of student enrolment in the cohort programme or, where, i.e.,

$$Nc = \frac{7\ (1) \times 15}{6} \tag{3.2}$$

$$Nc = \frac{7\ (1) \times 15}{6} \tag{3.3}$$

$$Nc = \frac{105}{6} \tag{3.4}$$

$$Nc = 17.5 \tag{3.5}$$

Therefore, a total of 17.5 students in the cohort programme that it's figured by seven (7) staff (each/per-lecturer) within three years into the estimation of value parameter which is rounded up with 18 students. But, to generate the students' population, 18 students of overall subjects' ratio resulted (value assumption) should be multiplied by the listed numbers of each institutional organisation in a geographical area referred to as an earlier Table 3.1. Next, to examine the population size (*N*) using the random cluster sampling study, simple multiple data have counted the numbers of value assumption (pertaining to the population in the sampling size delivery) following:

Σ is 17 total categorisations of three institutional organisations within the area of diploma/degree with ten (10) of industrial design (ID), three (3) of product design engineering (PDE) and four (4) of product design (PD), and multiply with 105 ID students (taken from the whole cohort program) according to the Table 3.1 have calculated with,

$$N = \Sigma\ (Nc) \tag{3.6}$$

For the *N* representing the target population of ID students as representatives of the whole Malaysian public universities or, where, i.e.,

$$N = 17 \times 105, \tag{3.7}$$

$$N = 1{,}785. \tag{3.8}$$

Hence, the entire subjects' population (N) resulted in 1,785 ID students population from the whole country based on the undergraduate programme representing the industrial design courses of Malaysian public universities, successfully estimated the population parameter through the random cluster sampling approach can be reviewed systematically. However, to determine the sampling method, it is required to validate an exact sample size using: (1) the criteria's availability; and (2) the application of rules of thumb in the geographical area of random cluster sampling.

Realistically, the total amount of 1785 ID students' subjects was invalid due to improper criteria selection which meant the specific degree bachelor programme is not compliance with the entire/whole three major criteria namely (1) nature of fundamental/basic research programme, (2) methodological triangulation of sample size under one research methodology programme and (3) the heterogeneous members characteristic as subjects' participant under the different orientation where it refers to the bachelor degree/level specialisation of industrial design course – bachelor of arts (BA) and/or bachelor of design (BDes) and/or bachelor of science (BSc). All these three have embodied together where the probability sampling should be generalised – every subject has an equal chance of being randomly chosen in the approach of a small-sized probability sampling design. Therefore, the study will specify the three institutions that can fulfil the criterion requirement and let's enable framing (sampling frame) of the appropriate probability sampling design. Thus, to calculate an exact population of ID students, the random cluster of probability sampling is required to conduct the heterogeneity populations of sample framing,

Where, i.e.,

R is random cluster sampling that is taken from the specific area of degree level only along the entire seven (7) of ID programme purposively and multiplied with 105 ID students (taken from the whole cohort program) as Table 3.5,

$$N = R\,(Nc) \tag{3.9}$$

$$N = 7 \times 105, \tag{3.10}$$

$$N = 735. \tag{3.11}$$

Hence, 735 ID students (*N*) population from seven (7) selected institutions (specific area of degree level/bachelor only is grey highlighted) is categorised under the smaller - small sample size that can be used and applied the 10% sampling per cent and it refers to the size of the population with 101 – 1000 people according to the rule of thumbs (Curry, 1984; Yount, 2006). This selection of sampling per cent is based on the confidence level and confidence interval under the statistically generalisable sample in the adapting attribute/variables sampling (CAAF, 2021).

Table 3.5
Categorisation of Industrial Design Course Level in Malaysian Public Universities

No.	Name of Qualification	Name of Institution & Website	National Education Code Field	Duration (Years)
	Degree Level (Industrial Design)			
1.	Bachelor of Engineering Technology (Industrial Design) with Honours Previously known as : Bachelor of Engineering Technology (Hons) in Industrial Design **MQA/FA11167**	Universiti Kuala Lumpur Kampus Cawangan Malaysia Italy Design Institute (UniKL MIDI) (Previously known as : Universiti Kuala Lumpur - Institute of Product Design and Manufacturing (UniKL IPROM)) midi.unikl.edu.my/	540 (Manufacturing and processing (broad programmes))	4
2.	Bachelor Of Art And Design (Hons) (Industrial Design) **10844**	Universiti Teknologi MARA (UiTM) (Shah Alam) www.uitm.edu.my	214 (Design)	6/3
3.	Bachelor of Science (Industrial Design) **10734**	Universiti Teknologi Malaysia (UTM) SPACE www.utm.my	214 (Design)	8/4
4.	Bachelor of Design	Universiti Putra Malaysia	214 (Design)	4

	(Industrial Design) **MQA/SWA0383**	(UPM) www.upm.edu.my		
5	Bachelor of Industrial Design (Honours) **12660**	Universiti Sultan Zainal Abidin (UniSZA) (Gong Badak Campus) www.unisza.edu.my	214 (Design)	3.5
6.	Bachelor of Mechanical Engineering Technology (Industrial Design) with Honours **MQA/FA7526**	DRB-HICOM University of Automotive Malaysia (Previously known as : International College of Automotive) www.dhu.edu.my	521 (Mechanics and Metal Work)	3
7.	Bachelor Of Arts (Hons) In Industrial Design **A6164**	Limkokwing University of Creative Technology (Previously known as : Limkokwing University College of Creative Technology) www.limkokwing.edu.my	214 (Design)	3
	Diploma Level (Industrial Design)			
8.	Diploma in Industrial Design **10349**	Universiti Sultan Zainal Abidin (UniSZA) (Gong Badak Campus) www.unisza.edu.my	214 (Design)	6/3
9.	Diploma in Industrial Design **MQA/FA3278**	Politeknik Ibrahim Sultan www.pis.edu.my	214 (Design)	3
10.	Diploma in Art and Design (Industrial Design) in collaboration with Universiti Teknologi MARA (UiTM) **A7777**	Widad College (Previously known as : Shahputra College Campus Pekan) www.widad.edu.my	214 (Design)	3
11.	Diploma in Art and Design (Industrial Design) **MQA/SWA11866**	Universiti Teknologi MARA (UiTM) Cawangan Melaka Kampus Alor Gajah melaka.uitm.edu.my	214 (Design)	3
12.	Diploma in Art and Design (Industrial Design) **MQA/SWA11867**	Universiti Teknologi MARA (UiTM) Cawangan Kedah Kampus Sungai Petani	214 (Design)	3
13.	Diploma in Industrial Design **MQA/FA1513**	Malaysian Institute of Art www.mia.edu.my	214 (Design)	2.5
14.	Diploma in Industrial Design **A6743**	Southern University College (Previously known as : Southern College) www.southern.edu.my	214 (Design)	2.5
15.	Diploma in Art and Design (Industrial	Universiti Teknologi MARA (UiTM) (Shah	214 (Design)	2.5

	Design) **MQA/SWA12269**	Alam) www.uitm.edu.my		
16.	Diploma in Engineering Technology (Industrial Design) **MQA/FA4785**	German Malaysian Institute (GMI) www.gmi.edu.my	521 (Mechanics and Metal Work)	3
		Degree Level (Product Design)		
17.	Bachelor of Manufacturing Engineering Technology (Product Design) with Honours **MQA/FA0701**	Universiti Teknikal Malaysia Melaka (UTeM) (Previously known as : Kolej Universiti Teknikal Kebangsaan Malaysia (KUTKM)) www.utem.edu.my	540 (Manufacturing and processing (broad programmes))	4
18.	Bachelor of Fine Arts (Honours) (Product Design) **10609**	Universiti Sains Malaysia (USM) (Minden) www.usm.my	214 (Design)	6/3
19.	B.Tech. (Hons) in Manufacturing Engineering Technology (Product Design) **MQA/FA3118**	Universiti Sultan Zainal Abidin (UniSZA) (Gong Badak Campus) www.unisza.edu.my	540 (Manufacturing and processing (broad programmes))	4
20.	Bachelor of Engineering (Honours) (Product Design Engineering) **MQA/FA5832**	Universiti Malaysia Perlis (UniMAP) (Previously known as : Kolej Universiti Kejuruteraan Utara Malaysia (KUKUM)) www.unimap.edu.my	521 (Mechanics and Metal Work)	4
21.	BA (Hons) Furniture and Product Design (3+0) in collaboration with Nottingham Trent University, UK **MQA/FA1455**	First City University College (Previously known as : KBU International College) www.firstcity.edu.my	214 (Design)	3
22.	Bachelor of Arts (Hons) Product Design Futures 3+0 in collaboration with University of East London, United Kingdom **A11012**	Linton University College (Previously known as : Kolej Linton) www.linton.edu.my	214 (Design)	3
23.	Bachelor of Engineering Technology (Hons) in Product Design **MQA/FA11166**	Universiti Kuala Lumpur Kampus Cawangan Malaysia Italy Design Institute (UniKL MIDI) (Previously known as : Universiti Kuala Lumpur - Institute of Product Design and Manufacturing (UniKL IPROM)) midi.unikl.edu.my	521 (Mechanics and Metal Work)	4

	Diploma Level (Product Design)			
24.	Diploma in Product Design **A10354**	Kuala Lumpur Metropolitan University College (KLMUC) (Previously known as : Kolej Universiti Antarabangsa Cosmopoint) www.klmuc.edu.my	214 (Design)	3
25.	Diploma in Product Design **A9928**	Linton University College (Previously known as : Kolej Linton) www.linton.edu.my	214 (Design)	3
26.	Diploma in Product Design **MQA/FA3073**	Limkokwing University of Creative Technology (Previously known as : Limkokwing University College of Creative Technology) www.limkokwing.edu.my	214 (Design)	3
27.	Diploma in Product Design **MQA/FA0405**	UNITI College	214 (Design)	3

Source: Malaysian Qualifications Register (MQR) - The Malaysian Qualifications Agency (2020)

Therefore, this sampling frame remains to use the formulation of 10% sampling per cent following 101-1000 size of population (grey highlighted) at the rule of thumbs in Table 3.6. The Abdul Latif Jameel Poverty Action Lab (J-PAL) (2018) has stated the purpose and main reason for using the rule of thumb as,

> *"... the manual offers six "rules of thumb" that have an impact on statistical power and sample size. Whether the treatment group and control group are the same size and whether randomisation is conducted at the level of individuals or larger units such as schools or villages are the two that specifically relate to random assignment, but the other four apply more generally to sampling in order to generate quantitative estimates. Six pinpoints are established to use the level of sampling per cent with rule of thumb #1: A larger sample increases the statistical power of the evaluation; (2) rule of thumb #2: If the effect size of a programme is small, the evaluation needs a larger sample to achieve a given level of power; (3) rule of thumb #3: An evaluation of a programme with low take-up needs a larger sample; (4) rule of thumb #4: If the underlying population has high variation in outcomes, the evaluation needs a larger sample; (5) rule of thumb #5: For a given sample size, power is maximised when the sample is equally split*

between the treatment and control group; and (6) rule of thumb #6: For a given sample size, randomising at the cluster level as opposed to the individual level reduces the power of the evaluation. The more similar the outcomes of individuals within clusters are, the larger the sample needs to be."

However, the taxonomy of sampling strategies from the mixed method sampling requirement is important so that there will be easily figured out an appropriate sampling frame process. It is part of the accessible target population for the study which means referred to the criterion particularly - the sample size of the actual unit selected for the study. In the further subtopic of sample size, the study will emphasise the justification of determining the appropriate sample size following an attribute sampling pattern (CAAF, 2021).

Besides, all three institutions deliver different levels of design expertise. This judgement of expert level shows the subjects' competency among the various participation of actual units selected for the study between two methods generated by purposive (qualitative method - QUAL) and probability sampling (quantitative method - QUAN) respectively (Teddlie & Yu, 2007). After the recognition of the target population, the study should apply the Practice Guide Sampling Methodology for Performing Audit from the Canadian Audit and Accountability Foundation (CAAF) that the application of factors to consider when determining the precision of a generalisable sample have occurred during the identifying the unit selected process.

Table 3.6
Sample Size Rules of Thumb

Size of Population	Sampling Percent
0-100	100%
101-1000	10%
1001-5000	5%
5001-10,000	3%
10,000+	1%

Source: Populations and sampling (Curry,1984; Yount, 2006, p7-4)

The suitable use of a practice guide is significant following the nature of research methodology and research topic upon the continuum direction of basic/fundamental research method under the one methodology program; an evidence statistical report refers to a confidence interval and percentages' level. Here, the practice

guide CAAF (2021) can facilitate the initial stage of the sampling frame through mixed methods sampling according to the report,

> *"In general, small samples (35-45 units) have a confidence interval of about 10% and a confidence of 90% depending on population size and observed error. Generalisable samples for performance audits should not have levels of precision any lower than this. Smaller sample sizes lower the confidence level and widen the confidence interval, which means, respectively, that there is less assurance in the results and less precision as well". (p.23)*

By right, the sequential mixed methods approach (in the research methodology context) as related to the expertise level participation is required. There is usually known with the heterogeneous members' characteristics as subjects' participants following:

$$N = 735 \times 10\%, \tag{3.12}$$

$$N = 73.5. \tag{3.13}$$

Thus, 73.5 rounded up with 74 small populations of 1785 students' subjects have been identified in the population overview study. In Table 3.2, the study found seven (7) institutions have offered the bachelor's degree/level specialisation of industrial design course. To meet the heterogeneous criteria requirement, the study decides to select and screen three (3) institutions namely (1) Universiti Teknologi MARA (UiTM) (Shah Alam) for the Bachelor of Arts (BA), (2) Universiti Putra Malaysia (UPM) for bachelor of design (BDes) and (3) Universiti Teknologi Malaysia (UTM) as well as UTMSPACE Kuala Lumpur for bachelor of science (BSc). There are three (3) schools' orientations specifically using the heterogeneous criterion referring to BA, BDes and BSc,

$$N = \frac{74}{3\ Institutions} \tag{3.14}$$

$$N = 24.6 \tag{3.15}$$

Therefore, 25 ID students (after rounded-up) from the classroom resulted in an appropriate number of sampling frames that answered the actual figure and evidenced in the sampling frame of the population overview study. Thus, the subjects' emphasis

on the sampling frame and expected numbers of sample size will be discussed in further subtopic sample size accordingly.

To visualise the sampling process stage, the study is ethically complied with to use the continuum of Akhouri's sampling process as Figure 3.35. The appropriate amount of 25 ID students from the classroom as a number of subjects' participants is mainly used the characteristic of heterogeneous members in three different schools' orientation. The study has observed the complimentary matters from the expertise level of subjects' participants are referred by the heterogeneous members characteristic that it possibly can bridge both probability and non-probability sampling.

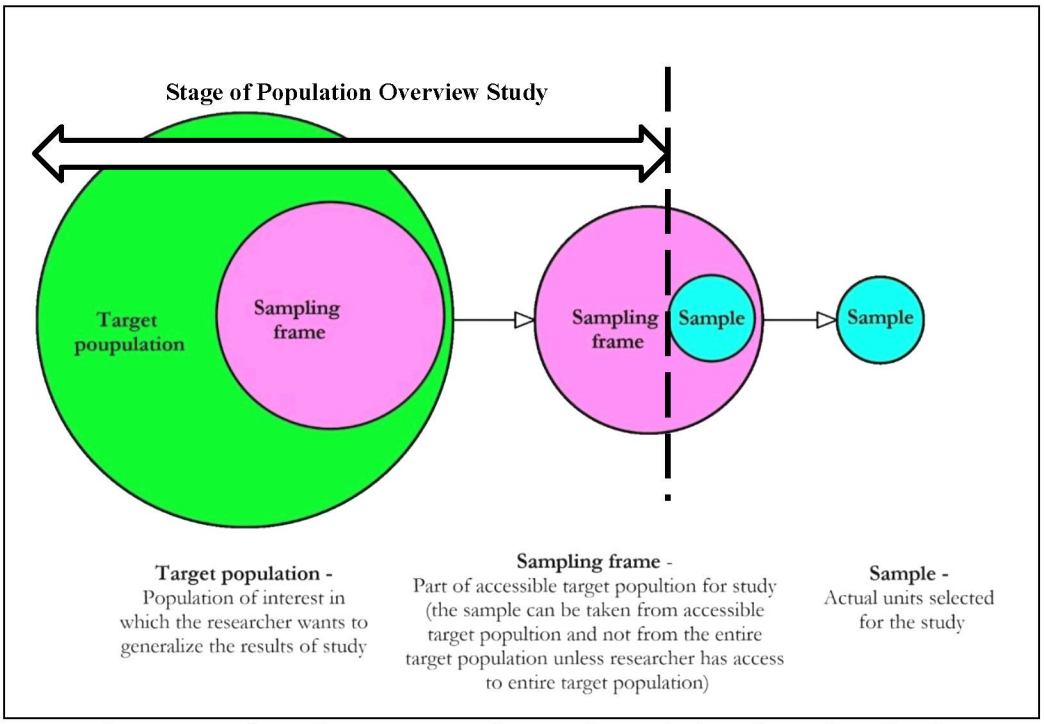


Figure 3.35 Sampling Process; Stage of Population Overview Study

Source: Akhouri (2022)

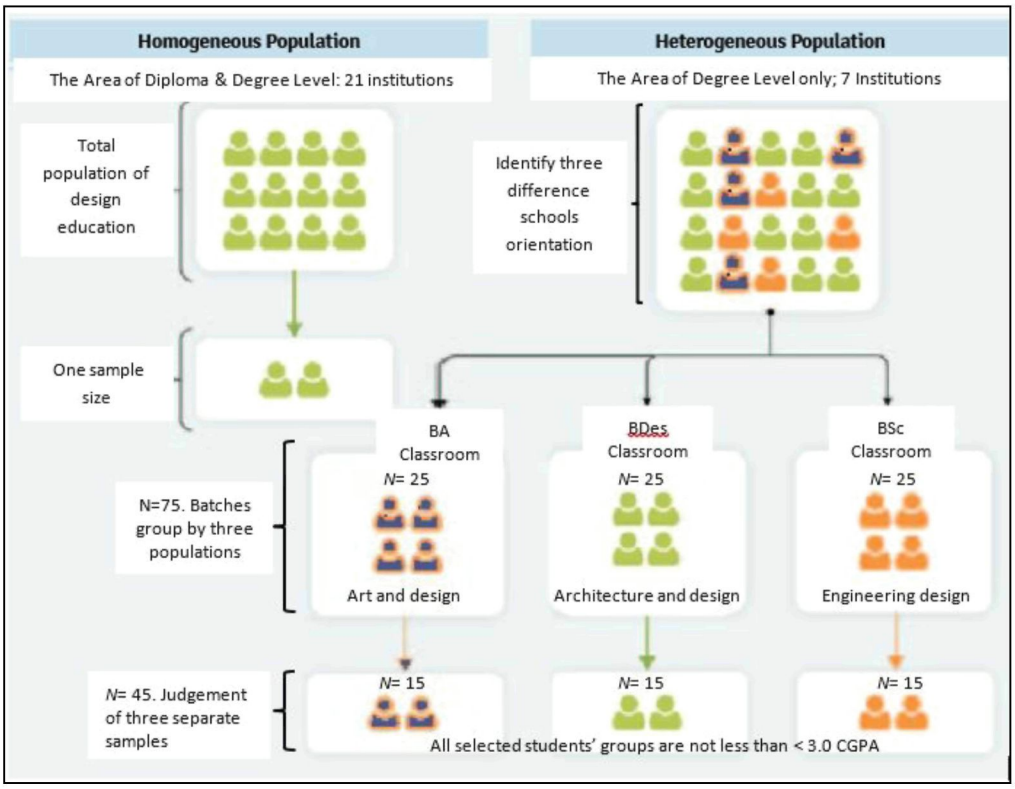


Figure 3.36 MMS Tree Topology of The Sampling Frame

However, the fundamentals of different sampling approaches are required that it enabling to screen the two roles between the conception of homogeneity and heterogeneity sampling populations concurrently. This comparison study reveals the population overview process and will be assisted by the MMS conception such as,

a) Firstly, identifying the roles and functions of the groups' sampling population patterned - refers to entire ID students containing 7 institutional organisations within the ID course as the target population,
b) Secondly, complementary used between the part of management and others are unionised (refers to the orientation of three different ID courses as purposive non-probability), and,
c) Thirdly, assessing a population's level via the sampling processes by both groups (to determine the sample size and let's enable to engage the justification of design sampling). All three pinpoints unite an appropriate further topological study as Figure 3.36.

In the above study, the lessoning practises on the population overview study discover the MMS tree topology of the sampling frame systematically. The tree topology describes the structure of a node is distributes branches to another node the connection of networking will be demonstrated by the linkage engagement based on the distinct levelling in the hierarchy. In other words, it is also familiarly known with hierarchical topology as well.

This study aims to investigate the conception of hierarchical topology refers to evidence of mutual correlation which means the bonding elements between homogeneity and heterogeneity sampling populations. By the distinct levelling in the hierarchy, the establishment of MMS sampling begins to spread two branches node (divided by homogeneity and heterogeneity sampling populations) that it reveals form the naturalistic pattern of sampling size judgement according to three different schools orientation as earlier mentioned before. Thus, the study has outlined the linkage direction of one to another node levelling. For the selection of seven (7) institutions in a programme offered, the study is strictly accepted to use the area of degree level purpose only. Due to an essential and/or requirement of three (3) schools orientation specifically using the heterogeneous criterion referring to BA, BDes and BSc classrooms.

Table 3.7
The MMS Reflection of Similar Characteristics Between the Probability and Non-probability Sampling

Types of sampling / **Desire Components**	**Probability sampling for random**	**Non-probability sampling for purposive**
	Mixed Methods Sampling (MMS)	
Demographics	Large sample size	Small sample size
Geographical area	Institutions by the state	Institutions from the state
Sampling approach	Homogeneity characteristic	Heterogeneity characteristic
Dataset patterns	Analyse by numerical	Visualise by categorical
Descriptive labels	Variables	Coding
Subject particular	Numbers of respondent	Amount of participant
Category indication	Performance by value	Quality by theme
Target population	Inclusion	Exclusion

Therefore, the understanding of MMS reflection emergent from the proper tree topology representative that it is purposely used to justify the further sample size

following Table 3.7. The number of desired components assists the comparison study between both samples that it enables the reflection of characteristic similarity obviously. However, a particular of type sampling is needed and it is crucial to know how to approach MMS in the fundamental and/or basic research study systematically. The identification of probability in the non-probability sampling determines an exact analysis or method delivering to the MMS dataset (purposes the conception of hierarchical topology) provisionally. It's reflected on the MMS dataset pattern of the sample unit that there must be engagement with the subjects' participants following the VPA method of grounded theory. A further discussion for this population study will be figured out in the next subtopic sample size accordingly.

3.9 Sample Size

In this sample size subtopic, the continuity of the population study is reflected in the target population as known as the sample size (Sekaran & Bougie, 2009). Due to the sampling frame approach the sample unit could be representing and seeking the heterogeneous population obviously. The study continues to discover the second stage of the sampling process to achieve the "actual unit selected (sample unit) for the study" as Figure 3.37. The illustration of the sampling process assists the flow concept in the interpretation of the sample size study systematically.

This understanding pattern of the heterogeneous population began from the sociology knowledge and research that the emergence of an accessibility concept has navigated the target population subsequently. Definitely, the initial identification of the MMS sampling frame is based on the simple sampling approach strategy following the observation of the population overview study and there will be easily specified sample size through the processes' comparison of two sampling approaches between homogeneity and heterogeneity characteristics. These two sampling approaches such as (1) generalisable sampling and (2) purposeful sampling have been categorised to define an actual principle of random selection – "samples must be selected in an unbiased manner" (CAAF, 2021).

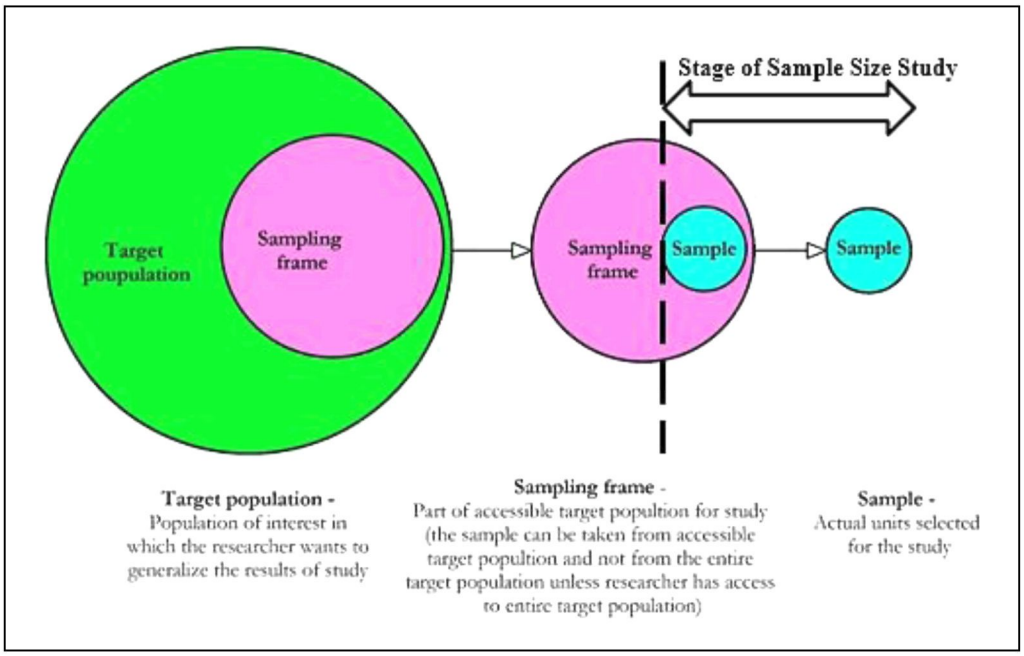


Figure 3.37 Sampling Process; Stage of Sample Size Study

Source: Akhouri (2022)

First, to proceed into the sample size stage, the essential requirements are used with the population overview via homogeneous characteristics and large sample size concurrently. The generalisable sampling occurs upon the application of two types of sampling approaches,

i) *Attribute sampling* - When data is sampled using an attribute-based method, the outcome is either consistent or inconsistent. It is a technique for gauging quality that involves noting whether a certain attribute's characteristic is present or absent in each unit being evaluated. There should be to determine if an item is defective or not, attribute sampling is used - yes or no response.
ii) *Variable sampling* - The degree of conformance is graded on a continuous scale using data that is in the "variable" form when using variable sampling. Checking "how much," "how good," or "how bad," respectively, is the goal of variable sampling.

Here, the research discovered that the target demographic (from the homogeneous characteristics) was reachable through design education networks, and the presence of numerous Malaysian public universities suggests that sizable sample

size was present. It is necessary to verify the MMS sample size with regard to the application of sampling procedures by performing hypothetical testing. The employment of a hypothetical form is crucial in bridging the knowledge gap, as illustrated by CAAF (2021), which provides a solution to this MMS identification. An example of the following hypothetical statement from the study is as follows,

> *"Having chosen a small sample size within Malaysia's public universities, some of the ID students were clearly lacking in understanding the product form in ecodesign identity development and ineffective use of design method practises into the combination of two elements required, such as the 3R's method and form follows function. As a result, the ID students could not understand how the SfPD programme was affected by the misinterpretation of the "visual elements study" and "principle solution study" sources of information."*

At this point, the description of a tangible source for the subjects' participant identifies "the level of performance and/or competency" that is present in the generalisable sampling. It may have dealt with an experience that occurred inside the homogeneous qualities into the homogeneous judgmental needs and it evidences.

Second, purposive sampling also known as judgmental, selective, or subjective sampling, is a form of non-probability sampling in which researchers rely on their own judgment when choosing members of the population to participate in their surveys. The definition of purposive sampling is very important, as it engages with the sample unit characteristic and the specific requirement as well. Sekaran and Bougie (2009) noticed:

> *"...Sampling for qualitative research is as important as sampling for quantitative research. Qualitative sampling begins with precisely defining the target population. As a sampling technique, qualitative research generally uses non-probability sampling as it does not aim to draw statistical inferences. Purposive sampling is one technique that is often employed in qualitative investigation: subjects are selected on the basis of expertise in the subject that is being investigated. It is important that the subjects are chosen in such a way that they reflect the diversity of the population." (p.297)*

However, the understanding of heterogeneous terminology is based on the same judgemental expertise level that the effective use of strategy namely purposive - mixed - probability sampling continuum[9] as Figure 3.38. This continuum strategy will be discussed in further sub-topic sample size accordingly.

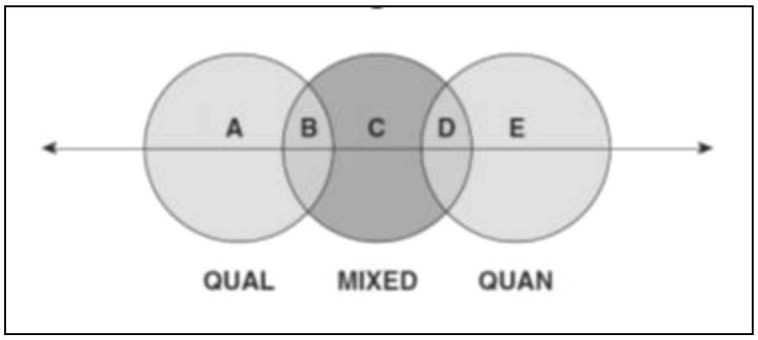


Figure 3.38 The MM Sampling Strategies; Purposive - Mixed - Probability Sampling Continuum

Sources: Teddlie (2005). (p. 85) and Teddlie and Yu (2007)

The researcher plans to apply the basic sampling design flow process to reveal and develop the mixed methods sampling specifically that it related to the nature of the research study along an ecological form of ecodesign identity into the fusion design context. Two components are developed by research/theoretical framework called (1) design perception as representing the probability and (2) design belief for non-probability consistently. Using the same subjects' involvement which meant the particular sampling design flow process requires mixed method sampling, is useful to interpret the both differentiate methodologies between probability and purposive sampling towards the probability-mixed-purposive sampling continuum.

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[9] "Zone A consists of totally qualitative (QUAL) research with purposive sampling, whereas Zone E consists of totally quantitative (QUAN) research with probability sampling. Zone B represents primarily QUAL research, with some QUAN components. Zone D represents primarily QUAN research, with some QUAL components. Zone C represents totally integrated mixed methods (MM) research and sampling. The arrow represents the purposive-mixed-probability sampling continuum. Movement toward the middle of the continuum indicates a greater integration of research methods and sampling. Movement away from the centre (and toward either end) indicates that research methods and sampling (QUAN and QUAL) are more separated or distinct." (Source: Teddlie, 2005. P. 85; Teddlie and Yu, 2007)

Table 3.8
Adapting Attribute Sampling Variables for Common Software Sampling Utilities

	Typical Input Variables for Attribute Sample Size Calculation				**Input Variables for IDEA Attribute Sample Size Calculator**			
Input Variables	Population Size	Confidence Limit	Confidence Interval	Expected Error	Population Size	Confidence Limit	Tolerable Error	Expected Error
Formula	N	CL	CI	EE	N	CL	CI+EE	EE
Ex 1	500	90%	5%	10%	500	90%	15%	10%
Ex 2	500	90%	5%	15%	500	90%	20%	15%
Ex 3	500	90%	10%	20%	500	90%	30%	20%

Source: CAAF (2021)

To begin the sample size, the study focused on undergraduate students from three selected particular levels of bachelor's degree programme following Table 3.8. The study found that the experts have similarly defined both definitions of the confidence interval and confidence level which could possibly enable the sample size study throughout via a common process of sampling frame procedural steps. Thus, both meaning contexts are described as:

a) The confidence interval, also known as the margin of error, is the range of values in which we may be relatively confident that the true population value exists, given the results of a sample. (Sekaran & Bougie, 2009; Teddlie & Yu, 2007; CAAF, 2021)
b) Confidence level is the degree of certainty that the estimated value produced from a sample fall within the sample's confidence interval. (Sekaran & Bougie, 2009; Teddlie & Yu, 2007; CAAF, 2021)

Based on the Report of CAAF (2021), the research study explicitly found a similar meaning to the experts the Teddlie (2005) that the accessibility concept recognised and coincided with the sampling approach strategies such as MM sampling strategies.

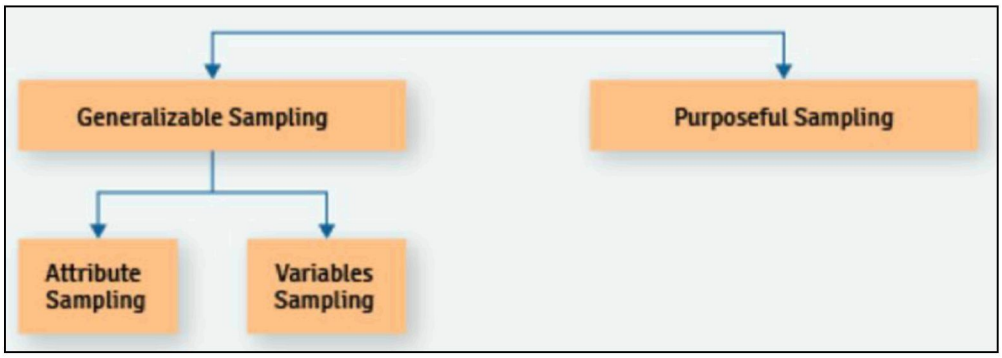


Figure 3.39 Sampling Approach Options

Source: CAAF (2021)

The recommended sampling approach is attribute/variable sampling, which allows for the unique process of sample saturation and engagement through MMS sampling. This approach continuum is linked from random sampling (probability) to purposeful sampling (non-probability). Here, the research study lesson about the accessibility concept of sampling approach in DRM research design such as (1) accessibility in generalisable sampling and (2) accessibility in purposeful sampling as Figure 3.39.

i) Accessibility in generalisation sampling ranges from modest to high, based on the availability of a thorough sampling frame and the resources required to reach and randomly sample individuals. Generalisation sampling can be reasonably simple to implement when the population is well-defined and accessible, such as through a thorough list or database.
ii) Accessibility in purposeful sampling varies greatly depending on the population and the selection criteria used. Purposeful sampling may be more accessible than generalisation sampling in some circumstances since researchers can target specific persons or groups who are easily accessible. However, deliberate sampling may face difficulties if the targeted participants are difficult to locate or if identifying acceptable applicants based on the research criteria is limited.

Table 3.9
Industrial Design Courses Orientation of Malaysian Public Universities

Undergraduate Programme Profile for Three Industrial Design Courses		
	(a) Orientation of Study	
Art and Design (Collage of Creative Arts)	Design and Architecture (Faculty of Design and Architecture)	Engineering Design (Razak Faculty of Technology and Informatics)
	(b) Public University	
Universiti Teknologi MARA (UiTM), Shah Alam, Selangor.	Universiti Putra Malaysia (UPM), Serdang, Selangor. Status: Research University	Universiti Teknologi Malaysia, UTMSPACE, Kuala Lumpur.
	(c) Type of University	
Comprehensive University (CU)	Research University (RU)	Research University (RU)
	(d) Bachelor's Degree Programme Offered	
Bachelor of Art and Design (Hons) in Industrial Design Year of Accreditation: 1999 Credit Hours: 120 Mode of Study: Full Time Duration: 6 Semesters (3 Years)	Bachelor of Design (Hons) in Industrial Design Year of Accreditation: 2013 Credit Hours: 130 Mode of Study: Full Time Duration: 8 Semesters (4 Years)	Bachelor of Science (Hons) in Industrial Design Year of Accreditation: 2007 Credit Hours: 120 Mode of Study: Full Time Duration: 8 Semesters (4 Years)
	(e) Intake Enrolment	
Domestic only	Domestic and International	Domestic and International
	(f) Admission Requirements	
	(f. i) Malaysian	
Academic Pass STPM or equivalent with a minimum grade of C (NGMP 2.00) in two (2) subjects; **OR** Pass STAM with a minimum grade of Jayyid Jiddan*; **OR** Pass Matriculation/Foundation/Asasi from Public or Private Higher Education Institutions with minimum CGPA of 2.00; **OR** Pass Diploma programme in relevant field with minimum CGPA of 2.00; **OR** Other equivalent qualification recognised by Government of Malaysia **AND** Malaysian University English Test (MUET) Band 2. Note: This is minimum entry requirement, please refer to the specific requirement for each programme. *Entry using STAM is only applicable for certain programme.		
	(f. ii) International	
Academic Senior High School/Senior Secondary School/Other Equivalent Pre-University Examinations from the Government School (12 Years). **OR** A-Level/Diploma in the related field; **OR** Other certificates recognised by the Malaysia Qualifications Agency (MQA) & senate of the university **English** Students must obtain: A band score of 5.5 and above in IELTS; **OR**		

A score of 500 and above in TOEFL or 59 and above in TOEFL IBT; **OR**
Completion of ELS Certified Intensive English Programme (CIEP) Level 107 or higher

Sources:
(1) UiTM Admission and e-Syarat UiTM (2022), https://pengambilan.uitm.edu.my/e-syarat/2019 and https://pengambilan.uitm.edu.my/e-syarat/2016;
(2) UPM Industrial design studies (2022), https://sgs.upm.edu.my/content/industrial_design_studies-26277;
(3) UTM Razak Admission (2022), /and https://space.utm.my/utmidp/local/

Generally, to define the number of sampling sizes, the researcher remained within the dual types of previously applied sampling selection (DS-1 sampling design), which means a similar characteristic is truly maintained due to the triangulation approach in dual methodologies. Because of respondent variation (number of subject units), two types of sampling design are applied, such as (1) probability; random sampling and (2) non-probability; while purposive sampling design will be used in further population study. Firstly, in random sampling point, Parmjit, Chan and Gurnam (2006) defined the Krejcie and Morgan (1970) in determining the sample size with "*the greater population size with minor percentages of population*" is a must to allow for the representative sampling findings. Because of the limitation, this researcher will use the minimum theory provided, which states: "*For smaller population, say N = 100 or fewer, there is little point in sampling; survey the entire population*". Secondly, purposive sampling refers to a select group of subjects from the representative of a given population (Parmjit, Chan & Gurnam, 2006). Thus, the researcher is supposed to define the best Malaysian university that the school of industrial design is compulsory followed with differently three different categories of ID background or orientation.

Table 3.10
The Classification of Design Experience for The Number of Practicing Designers

Levels	Categories	Working Experience	Total of Subjects
1.	Novice (student, educator or practitioner)	Less than 5 years	45*
2.	Intermediate (educator or practitioner)	5 – 10 years	Not applicable
3.	Senior (educator or practitioner)	8/10 - 15/18 years	
4.	Expert (educator or practitioner)	18 years and above	

Source: Abidin (2012)
*Note: $n = 45$

In Table 3.10, the study estimates the size of the sampling parameter requirement that will assist the respondent's classification (novice and/or young industrial designers) by the sampling strategy approach. Based on the specific public

universities selection, it would be interesting to present the kinds of demographics in different ID's orientation of school discipline respectively. In the mixed methods sampling (MMS), the study found an ambiguous strategy here had suitable use for the MMS namely the taxonomy analysis strategy following the sampling characteristics.

In Table 3.11, 45 participants will therefore be represented as novices/young designer community from studies' orientation (AD, DA and ED) throughout Malaysian public universities (UiTM, UPM and UTMSPACE) as the beginner level following the random-cluster sampling (Vasileiou, Barnett, Thorpe & Young, 2018). The researcher identified that the sample size for the statistical testing method should follow a normality test (frequency distribution) with at least 30 subjects and preferably in the appropriate size of 40 subjects (Delica, 2010). Consequently, in this calculation of the sample size study, an appropriate probability sampling within a small size sampling was complemented with the non-probability sampling (Saunders, et al., 2017).

Table 3.11
Taxonomy of Sequential Mixed Methods Sampling Represents the Respondents (Quantitative Method - QUAN) and Participants (Qualitative Method - QUAL)

Types of Sampling and Characteristics	**Sequential Mixed Methods Sampling (QUAN-QUAL and QUAL-QUAN)**		
Probability sampling. Characteristics; Generalisation and design perception	Random Cluster Sampling (Survey: Quantitative Method)		
	The whole Malaysian public university orientation of industrial design course		
	45 students*		
Non-probability sampling. Characteristics; Purposive and design belief	Focus Group – Purposive Sampling (VPA: Qualitative Method)		
	Arts and Design (AD)	Design and Architecture (DA)	Engineering Design (ED)
	15 students	15 students	15 students

Source: Malaysian Qualifications Register (MQR) - The Malaysian Qualifications Agency (2020)
*Total of Sample Size: $N = 45$

In Table 3.12, focus group sampling (n) = Participants (p) × # Institutions (Ni) [non-probability sampling],

where,

$$n = p\,(Ni\,)\ [4<45, \text{saturation}] \tag{3.16}$$

$$n = 15 \text{ participants} \times 3 \text{ institutions } [4<45, \text{focus group}] \tag{3.17}$$

$$n = 45 \text{ participants } [4<45, \text{small sample size}] \tag{3.18}$$

Table 3.12
Small Sample Size – Participants and Respondents for VPA and Designing Clinical Survey

No.	School/Department Orientation	Sequential Mixed Methods Sampling	
		Purposive - Focus Groups	Probability
		4 < 45 Saturation	10% Sampling Percent
1.	Arts and Design	15 students	
2.	Design and Architectural	15 students	45* students
3.	Engineering Design	15 students	

Source: Malaysian Qualifications Register (MQR) - The Malaysian Qualifications Agency (2020)
*Note: N = 45 (Schools of industrial design department from three selected Malaysian public universities).

3.10 Summary

The summary of the research methodology found the understanding of the research methods pattern within the research design selection itself; it could be developed together concurrently. Then, the research study executes to manage the appropriate methods' for the outcome expected. In the reflective practice, the dissertation of the study found the similarity and/or a similar research methodology concept between mixed methods research described by Creswell (2014) and the DRM framework handled by Blessing (2002). Also, these two concepts of research methodology look associated and compatible with the transdisciplinary design (TD) knowledge. Throughout on the reflection of TD study, the researcher explores how mixed methods sampling (MMS) strategically merges qualitative (QUAL) and quantitative (QUAN) approaches through a topological framework, enhancing methodological accessibility and integration. It emphasizes managing the continuum between heterogeneous and homogeneous populations to construct systematic, reflective sampling frames. Unioned and categorized subgroups guide process structure and data coherence. Importantly, this approach aligns with transdisciplinary design knowledge by fostering flexible, adaptive strategies that cut across disciplinary boundaries. By linking population dynamics to sampling design, the study supports more inclusive, context-sensitive research—advancing design methodologies that are capable of addressing complex, real-world problems through integrated knowledge systems.

As earlier evidence, there was begun from the DS-1 findings of data sources leads to fruitful the answering ecodesign identity concept. It is related to the design knowledge gap which is the solution needs to embody the sequential-directional

research methodologies between the prescriptive qualitative methodology and the descriptive quantitative methodology. Both research methodologies refer to the design experience and/or empirical ways to translate the understanding of TD knowledge to bridge the roles and job functions in all three related fields simultaneously:(1) industrial design (ID); (2) manufacturing technology (MT); (3) and industrial marketing (IM). Hence, the overall research activities decided to reach "Option 6" as the best type of selection of design research along this current mode of DRM framework. Based on the combination of qualitative and quantitative methods, there are naturally embedded and let's driven together within the explanatory (QUAN) and exploratory (QUAL) study of the research topic as Figure 3.40. On the other hand, the DRM research design approaches the use of a mixed method research strategy that there would be support for the further engagement of the onion approach strategy accordingly.

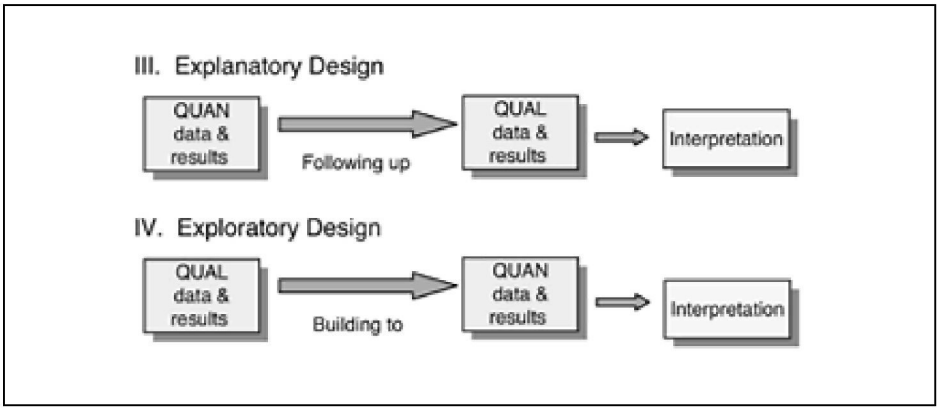


Figure 3.40 The Comparison Study Between The Essentials of an Explanatory and Exploratory Study

Source: Mackey (2020)

Again, both combinations are recommended for the research assumption study which means the entire process of research design must consistently deal with the several design approaches and/or methods development in the data analysis chapter. The major research assumption significantly supports to approach the of knowledge acquisition and inquiry in fundamental research methodology as it relates to the study's philosophical assumptions. These assumptions govern researchers' study design, data collection, findings analysis, and conclusions. Some of the key methodological assumptions include such as Ontological Assumptions → Epistemological Assumptions → Methodological Assumptions. First, these concern the nature of reality and existence.

Fundamental research frequently presupposes a realist ontology, which holds that there is an objective reality separate from human perception and experience analysis. This assumption underpins the concept that things exist and work according to specific principles that can be investigated and understood by systematic inquiry via think-aloud, allowing for the use of grounded theory. Second, there is the discussion of the nature of knowledge and how it might be obtained. Fundamental research often uses an objectivist or positivist epistemology, which holds that knowledge is objective, verifiable, and independent of the observer. This perspective of view emphasises the value of empirical data, careful observation, and rigorous techniques in developing accurate knowledge. Third, these concern the methodologies and procedures utilised to study research problems. Fundamental research frequently incorporates quantitative approaches, which are distinguished by systematic measurement, statistical analysis, and variable manipulation during the contextual or empirical stage. These techniques seek to find patterns, correlations, and generalisable concepts that aid in the understanding of phenomena.

Therefore, the expectation of research findings within it evidence in this study will solve three major contributions for the industrial design field specifically such as (1) ecological form theory, (2) design theory orientated by methodology and its scientific characteristics and (3) the readiness design information of new ecological form of ecodesign theory for the SfPD contribution. However, it must be used with a sustainable iterative process thinking approach (ecological form framework) such as *"Form is to form a formgiving to form an ecological form of ecodesign"*. Hence, the 3R's methodology awareness in the SfPD will fit into the role and responsibility of industrial designers in that it could support our resources, environment, society and ecosystem locally and/or internationally.

For sample size saturation and reduction, the study discovered that concurrent sampling entails collecting both qualitative and quantitative data from the same people or cases at the same time. This method enables researchers to integrate many forms of data in order to acquire a thorough knowledge of the issue under investigation while also capturing the population's variability. Concurrent sampling guarantees that both qualitative and quantitative data (QUAL and QUAN) are collected in parallel, allowing for a more comprehensive study and interpretation of the findings. In contrast, purposeful sampling is intentionally selecting participants or cases based on particular criteria related to the research aims. Purposeful sampling can be utilised in MMS

strategy to ensure diversity and representativeness across a range of interests. To capture population variability, researchers may use criteria such as demographic traits, level of experience, geographic location, or other relevant aspects.

However, depending on the study's unique objectives that emerged from the theoretical framework, both one-tailed and two-tailed predictions might be useful in the findings of quantitative research that it enables to describe qualitative grounded theory. There could be frequent emphasis on examining phenomena, comprehending context, and formulating hypotheses. To identify the best approach for their analysis, researchers should carefully analyse the research issue, theoretical framework, and available literature. Furthermore, accurate documentation of the selected approach and rationale is critical for maintaining the rigour and repeatability of qualitative research findings which means representing a basic / fundamental research study.

CHAPTER 4
DATA COLLECTION

4.1 Introduction

This chapter explains and explores the pattern of data collection using certain approach strategies to collect the dataset along the direction of procedural steps according to the methodology model. In the beginning, the sources of the dataset are articulated from the empirical data analysis in the DS1 study of the DRM framework. When the findings have resulted in the research study as a primary dataset, it should be delivered and entered into the main outcome section into the specific understanding needs at the same DS1 study level. The main outcome of understanding needs as a part of the primary data collection is it enables the research study to execute a few procedural steps of data collection properly. Based on the right appropriate design sampling, a proper procedural step can be applied to the specific focus group of non-probability sampling, namely, participants following observation of qualitative methodology – verbal protocol analysis (VPA) method. Meanwhile, the same subject of participants can be shifted into the cluster sampling of probability sampling as called with the respondents in the designing clinical survey (DCS) at the fieldwork study. This complement of subject terminology can be realistically found during the designing data collection as usually known with the sequential mixed methods (MM) sampling (Teddlie and Yu, 2007; Onwuegbuzie and Collins, 2007). Hence, the setting (location of geographic clusters) of the study is required to plan the fieldwork strategy. Even, if there are some research difficulties study/matter/situation (time constraints, expenses, source availability), such as the pandemic coronavirus (Covid-19), there can be stabilised the progression of data collection, flow processes and timeframe period due to the practical mode (the participants → the respondents; the strategy of mixed methods sampling) for the execution of fieldwork strategy in data collection development.

For the preparation of the research medium, the study is structured with the use of a product clinical adoption (PCA) concept refers to prescriptive qualitative methodology - inspired by the scientific research of clinical health or nursing programmes. The complexity of the challenging research study motivates the researcher to map and triangulate the design-based research into the CA concept understanding, it

consists of (1) evidence-based practice as EBP knowledge in plausibility study; and (2) practice-based evidence as PBE knowledge in feasibility study respectively. Thus, the aim of data collection is to identify, divide and present the two patterns of the dataset for (1) metaphor visualisation as the visual elements (VE) study that represents the design thinking knowledge in the industrial design field; and (2) bipolar digitisation refers to principal solution study from the system thinking in field of engineering design (ED).

Therefore, emphasising both prescriptive and descriptive datasets will lead to the methodological content of data collection in the PCA concept. It enables the exploration of design cognition using the levelling order (VPA method purpose) for the subjects' participants and semantics scale order (DCS purpose) within the mode of subjects (respondent) (Abidin, 2012; Chumiran and Abidin, 2019). Hence, to get the research roadmap where there could be framing the systematic methodology used following the mixed methods sampling to answer the research questions within the design belief itself.

4.2 Delimitation

This delimitation study refers to the product form of ecological form trending which is the priority of design identity scope exposure to the complexity area in the boundaries of fusion design interpretation. This fusion design is revealed from the triangulation method processed by design cognition between design thinking and system thinking concurrently. Using both a combination of design thinking and system thinking where it has embodied: (1) three components of transdisciplinary design (TD) following syntactic, pragmatic and semantic through design-based research formally sourced from human-centred design orientation; and (2) the movement of methodological assumption, namely, positivism, post-positivism and pragmatic in formgiving development (Jantsch, 1970; Abidin, 2012; Jeder, 2014). Thus, this explanation has described an appropriate delimitation meaning which is to the restriction of the research's scope within established limits and the management of the attributes into queries throughout the research methodology.

First, the study purposely highlighted the pragmatic component of TD lessoning that enables support and recognises the exploration of design belief which is purposefully targeted to the subjects' group of ID schools in Malaysian public

universities as purposive sampling. It is very suitable for the current industrial revolution era known as industry 4.0, the conception of ecodesign identity and its application of design technology addresses the designing tools (digitisation of pictograph imaging) in an intangible and/or tangible ecological form of ecodesign during the sustainable for product design (SfPD) development. Here, the delimitation is framing the practical of prescriptive study as reality design solution/problem solving compared to the theoretical understanding. Again, in transdisciplinary learning, there are some uncertain and/or certain an aesthetic value of the ecodesign identity which means under the digitisation of pictograph imaging following three components of TD mentioned earlier in Chapter 2.

Second, the wider knowledge of design-based research desires and derives a complexity study in the movement of methodological assumption via an ecological form of ecodesign identity. In the basic and/or practical design practice, many young industrial designers create product designs and services that must project an aesthetic value initiatively (Schwarzfischer, 2010 and Schwarzfischer, 2011). By the design belief, the ID field usually demonstrates an aesthetic keyword as value, is nearest to the Gestalt theory according to the shape and/or form of product creation via algorithm digitisation: algorithmic point of view (Guberman, 2015; Chumiran and Abidin, 2019). According to the experience of human-centred design (HCD), the aesthetics of product design are categorised under an object/the things (product) and meaning (communication) in the observing system that the Gestalt experience enabled the product designers interfaces the semiotic signs, terms, sense and emotion: an aesthetic experience creation on the understanding and simulating design called Gestalt Integration (GI). Hence, the methodological assumption covers and deals with an exploration of design cognition using the levelling order (VPA method purpose) and semantics scale order (DCS purpose) within the mode of subjects (participant and/or respondent) data collection following the fusion design parameter. By this scenario, the delimitation study demonstrates some a good example of the explanatory design experiences along the use of methodology boundaries - HCD, critical thinking – Gestalt, and complexity/beyond knowledge of methodological levels – philosophical assumption.

Therefore, the research study should control and manage the sources of the dataset throughout the literature review it must be aligned with the research methodology simultaneously. However, the research questions and the research

objective are suggested to guide the research significantly and enabling to reach a critical priority of study fundamentally. Thus, an irrelevant context and source will be screened in any research materials, and the filtering stage should apply an appropriate research methodology used as well as Chapter 3 previously.

4.3 Limitation

The study's limitations are those methodology-related aspects that affect its reflection into the interpretation of the research study's findings. In the conception of the ecological form of ecodesign identity, a wider ecodesign product process brings certain design considerations within the subjects' roles and responsibilities as the participants and/or the respondents that refer to the understanding of individual competency level. Here, the study found the significance of the young industrial designers, is to deliver and generate the designing dataset depending on the subjects' design belief and their practical designing skills. Due to the selection of sequential MM sampling being engaged within the data collection, the young industrial designers have a lack of and little design experience in the interpretation of fusion design. Because of the duration or period of the design experience is based on their learning and lessoning within the academic development – exercise, project assignment, practical design laboratory and designing skills tutorial in teaching or learning delivery method. Thus, the students as well as the research subjects' have had a little exploration of designing activities productively. Compared to the intermediate or expert level of practising industrial designers they comprehend the design concept, design process, designing methods, design development and embodiment of design research within it design principle holistically. Also, the competence level of industrial designers is always passionate about the design skills within two components for the understanding of design activities following: (1) "the knower – inquirer" focuses on practitioners' belief; and (2) "known - knowable" refers to human approach, behaviour, activity or productivity to existing or certain systems (design principle: design thinking and 3R's methodology: system thinking) in the common manufacturing environment that relate to business operations.

Further, it will take a long time to spend consistent days - weekly – and monthly periods of data collection. This situation increases a time constraint, research timeframe and research expenses when these entire situations should have aligned with the

subjects' availability. Due to the different three focus groups of subject sampling, will be led to some variety of inquiry needs in purposive sampling study – three types of ID school orientation/institutional according to the undergraduate programme as bachelor's degree/level specialisation of industrial design course – Bachelor of Arts (BA) or Bachelor of Design (BDes) or Bachelor of Science (BSc). Each total of three small focus groups refers to the number of subjects sampling as different types of ID school orientation/institutional. Thus, the number of subject sampling is represented by the sampling frame method to screen the subjects' sampling saturation within the specific population study consistently.

In addition, the global Covid-19 impacted the research activities since the pandemic disease has spread. Tan Sri Muhyidin Yassin, the prime minister, subsequently said that the first Movement Control Order (MCO) would go into effect on March 18, 2020. The MCO has a significant influence on Malaysia's educational system, forcing the majority of schools and colleges to shut down, affecting millions of students (Kamil and Sani, 2021). However, as education needs to be conducted during MCO, educators use online learning as a means to convey their knowledge utilising e-learning or other platforms virtually. Therefore, the limitations of the study leassoning are exposure to those characteristics of methodology during the data collection that influenced the interpretation of the results of the research study.

4.4 Ethics

The ethical responsibilities of the research study are very important to the data collection of discipline stages while conducting the research activities and methodology processes (See the Ethics Appendix 6 and 8). This study's research objective is to address the ecodesign identity method of distinguishing intangible ecological forms through the human emotions of young industrial designers in the SfPD identity concept phenomenally, as well as different ID orientations in ecodesign communication among various Malaysian public institutions.

Fundamentally, the justification of expected benefits should be focused on the designing research activities, that are carried out under: (1) an ethical behaviour preparation; and (2) the event's environmental observation of qualitative prescriptive methodology. These two points are vital to the VPA method in that it will empirical the

participants explore their emotional knowledge of human beings, namely, interaction, sensation and expression – called a think-aloud.

Next, the research study uses the observation method, and the study manages to use the in vitro study as the detailing context of the VPA approach referring to an ethical behaviour preparation. For the observation of the in vitro VPA method, the VPA session setup calls on-site mobility setting and no requirement for a permanent design laboratory. The observation of videotaping should be ready with an ergonomic workplace and chair seating in the classroom. The open table and sitting are common items regularly. The camera and the instrument will be used and set up during the observation process. It must be proposed the time estimation (to generate the VPA design scheme) with the videotaping record to produce a design manuscript. Also, there will be some mood board panels in front of the participants, to refer to the design references according to the design brief as required.

Lastly, the closing thoughts - For the consent form and the process, the study managed the administrative research plan to seek and address an ethics case study - the event's environmental observation of qualitative methodology. Ethics information is regularly used for the participating subject's volunteering to avoid and protect against harm, risks impacts or injuries, and what it means for human beings psychologically and physically. Due to the observation study based on the human-centred design orientation, it will advisably follow the design briefing instructions to reach the goal setting of the VPA method accordingly. During the consent enquiry, the consideration of acceptance from the participants must be understood from the following three points of justification evaluating their own: (1) study risk; (2) risk of harm; and (3) privacy with confidentiality. This is clearly stated in the procedure requirement before the participating subject makes a decision.

Therefore, from the above two components described, it should avoid and protect against something harm, risks and impacts along the participating subject involved. In particular, a proper ethical case study procedure could be simulated and used to conduct an approach design strategy.

4.5 Data Collection Process

The researcher initially discovered that the key findings of an articulated data case study might be further explored using a qualitative methodology known as a

fundamental and/or basic research study. The previous interview protocol results demonstrated the existence of a patterned design causal of thin description from the descriptive study – 1 (DS-1) stage, and it was appropriately attributed (re-think) into the prescriptive study (PS) stage in accordance with the design research methodology (DRM) framework as Figure 4.1. The research onion technique (longitudinal and cross-sectional) successfully resulted and engaged with the design criterion findings by using the pattern of thin description. It is necessary suggested to comprehend the end-to-end research paradigm. The hypothesis statement, which is an encoding of the prior interpretation of design criterion findings, was then constructed and evaluated.

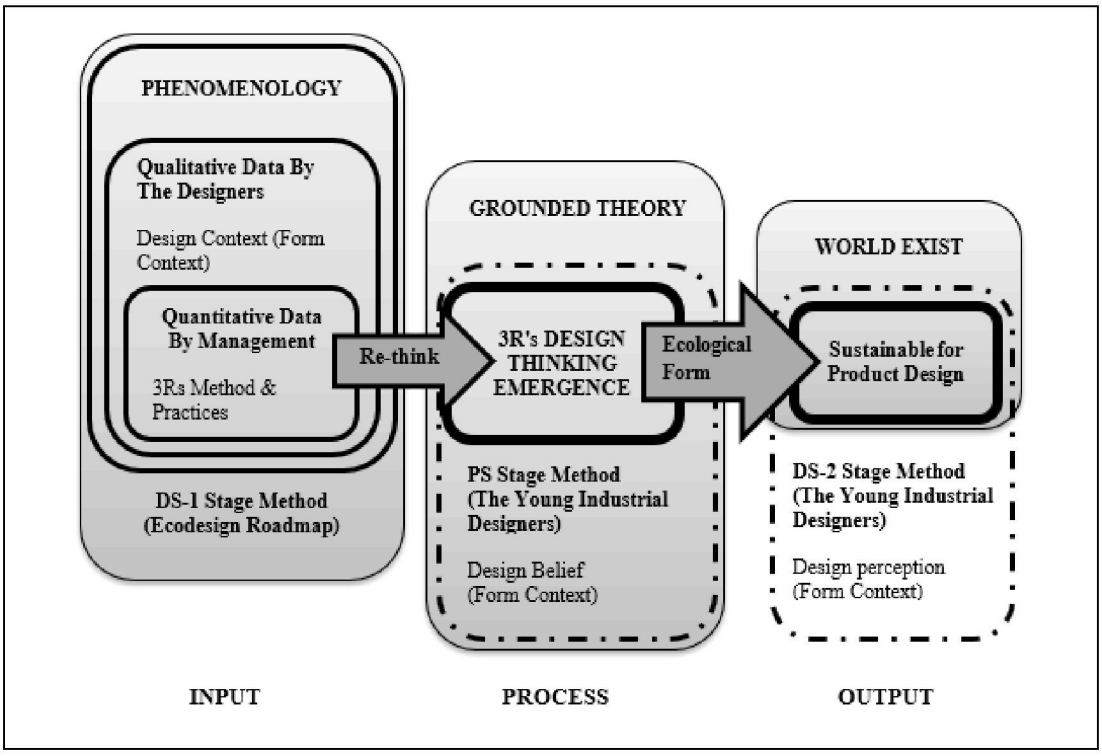
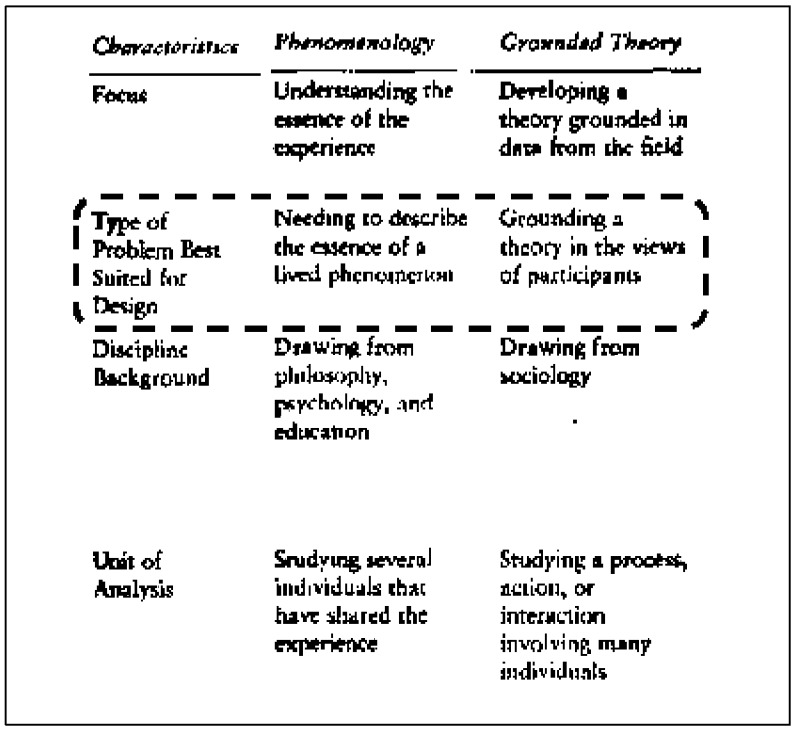


Figure 4.1 Data Collection Process Using the DRM Framework Flow

Realistically, there is a mysterious design thought based on the ecodesign identity that needs to be studied. A null hypothesis statement was thus rejected, and the study addressed the real-world phenomenon by using the VPA approach. To pinpoint the precise pattern of design experience, the think-aloud interpretation is now needed. This pattern will indicate how the transcribed design process should be addressed in the design document and administrative data collection.

Every design activity needs design phenomena, but industrial designers in particular depend on it for their perspectives on design concepts and for forecasting

their information needs. The two essential aspects of design phenomena, namely: (1) the qualities of the morphological design patterns; and (2) the visual elements components of the product form—are influenced by the design considerations and/or attributions for the interpretation of the form providing design context (Abidin, 2012; Chumiran, Abidin & Sirat, 2016). These essential aspects are connected to reveal the ecological form of ecodesign identity that is hermeneutically intangible and has a non-linear, non-uniform product form background. However, to screen both essential aspects in the data collection of the VPA method required, the study succeeded to identify the significance of the study that is similarly same or required from the interviewing qualitative method as traditionally best practices called "essence" significant (Creswell, 2003; Creswell and Clark, 2007).



Characteristics	*Phenomenology*	*Grounded Theory*
Focus	Understanding the essence of the experience	Developing a theory grounded in data from the field
Type of Problem Best Suited for Design	Needing to describe the essence of a lived phenomenon	Grounding a theory in the views of participants
Discipline Background	Drawing from philosophy, psychology, and education	Drawing from sociology
Unit of Analysis	Studying several individuals that have shared the experience	Studying a process, action, or interaction involving many individuals

Figure 4.2 Contrasting Characteristics Between Phenomenology (DS1) and Grounded Theory (PS) Revealed by The Use of The Research Onion Approach

The essence of significance will be applied upon the completion of the data analysis phase (drawings' conclusion) so that the interpretation of the finding might be the result. This conception of essence significance possibly coincides with the VPA method processes whereby it means an equivalent with the "consciousness" significant – attended purpose within phenomenology, and another "solution" significant – think

aloud purpose grounded theory during the further analysis study. In this research scenario, as Figure 4.2, the research studies have approached the engagement of phenomenology and grounded theory together. The combination of both qualitative paradigms occurs from the methodological nature of the study and its design activities called a fusion design (as the earlier chapter mentioned). By the characteristics of types of problems best suited for design, there are two different meanings of research goals' exploration. Thus, the research gaps of two qualitative paradigms are needed to bridge the two components together following the complex research study. Therefore, there are both different forms of significant studies (integration and adaptation processes - or vice-versa) that should be combined with the research onion approach concurrently as Figure 4.3.

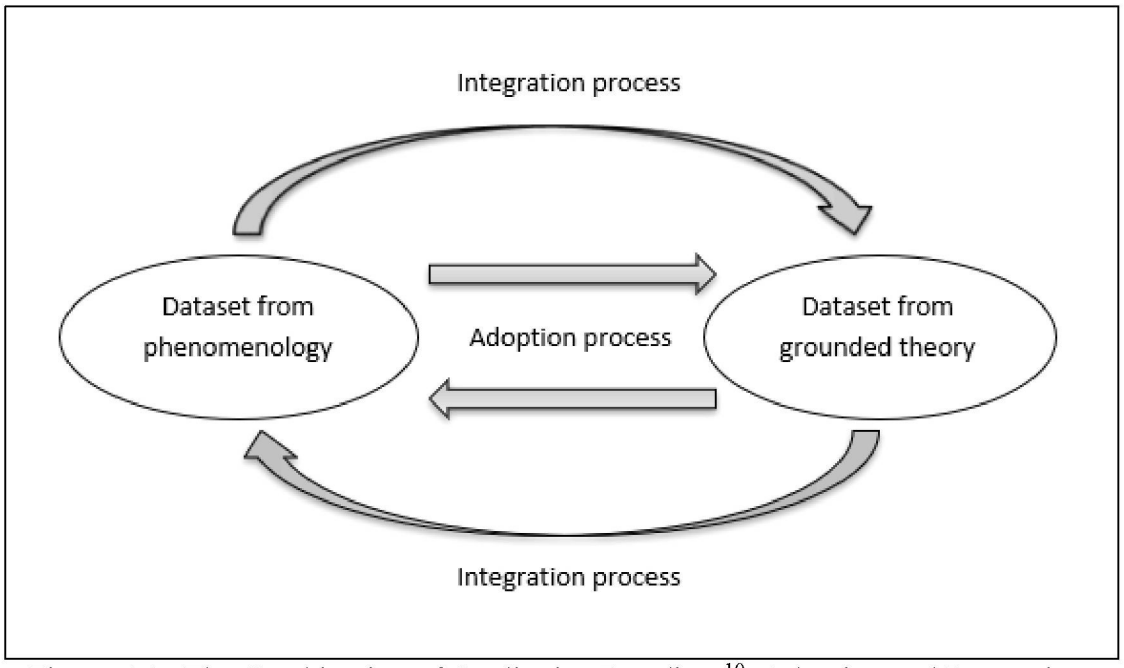


Figure 4.3 The Combination of Qualitative Paradigm[10]: Adoption and Integration Derive The Form of Attended And Think-Aloud Datasets

[10] The dataset knowledge gap navigates the types of qualitative paradigm following,
Use for Adoption - Phenomenology is a branch of philosophy that, in grounded theory specifically, realistically informs other kinds of qualitative approaches. According to the phenomenology method of thought, "consciousness" develops from experiences. If this assumption was made in the study, participants with a particular designing experience would be chosen in order to get their interpretations of their visual experiences. Since the study was not looking to develop any theories, phenomenology could also be used as a methodology and tool. Therefore, if phenomenology is the chosen approach, the

The research onion approach is the solution way of the research strategy that bridges the knowledge gap within both components' engagement as shown in Figure 4.4. These are mostly related to the time horizon during the data collection as previous Chapter 3. This research strategy enables the triangulation study which means the practice of cross-sectional and longitudinal research was implemented under one methodology programme, especially the design research methodology (DRM) (Saunders, Lewis, Thornhill, 2003; Blessing and Chakrabarti, 2009).

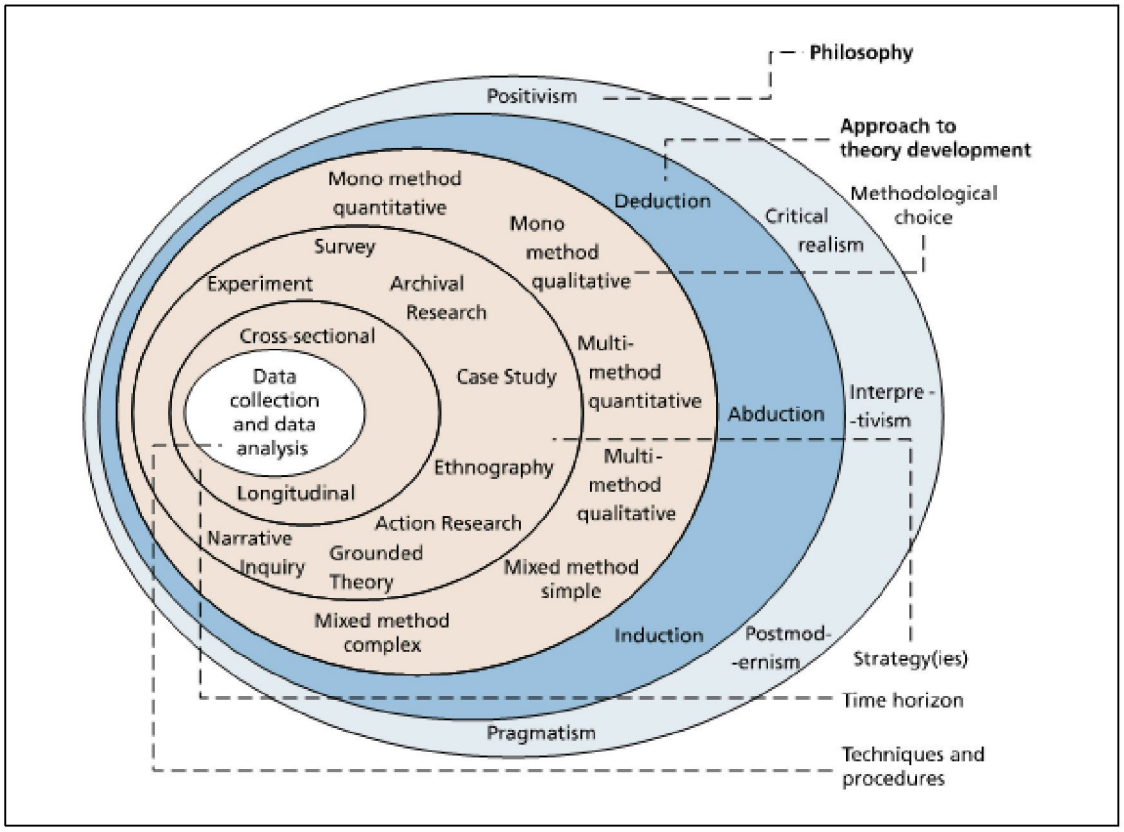


Figure 4.4 Research Onion Concept

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study must focus on "the essence of lived experiences" while utilising certain methods connected to the "attended" of VPA method.

Use for Integration - While the study can utilise grounded theory as a "think aloud" of the VPA method and phenomenology as the basis of current research, if it requires to construct a theory based on the interpretations of the participants from their lived experiences. The answer to the problem will be presented through the merging of phenomenological philosophy with grounded theory methodology.

For the study of literature review, there are three major components: (1) chronological order (CO); (2) evolution of design (EoD); and (3) thematic analysis method (TA). The CO of literature review focuses on the product form the narrative within the sequence of events, from earliest to last. Meanwhile, the EoD of the literature review discussing recycling knowledge – design for recycling (DfR) was derived from the evolution of cycle in accordance with design for X (DfX) globally. Lastly, the approach applied in this study is TA method content, which coincides with the research model of the prescriptive study (PS) stage in the design DRM – referring to the bubbling model. By the categorisation of design phenomena, the theme of the study indicates the primary source information that could emphasise the grounded theory within an orientation of basic/fundamental research. This will help the consistency of sources information that the recognition of dataset allowing the reliability and validity. On the other hand, the secondary source information was reviewed by the end-to-end research methodology (completion of DRM framework) following the design elements and/or criteria, which means the design attribution has a good validation of upcoming knowledge for future study into the PS research framework. It is related to the bubbling modelling structure and linkage annotation which can be enhanced immediately upon some actual attribution of articulated datasets that have been developed systematically.

4.5.1 Design Observation

Focusing on designing research activities, which are carried out under: (1) an ethical behaviour preparation; and (2) the event's environmental observation of qualitative prescriptive methodology, is how both projected benefits should be justified by the mental event in verbalisation ways. These two aspects of the think-aloud technique are crucial to the VPA approach because they allow participants to empirically examine their understanding of how emotions affect human interaction, experience, and expression in an in-depth manner as a grounded study referring to cognitive processes of designers (Ericsson and Simon, 1980; Ransdell, 1995; Austin and Delaney, 1998; Lundgrén-Laine and Salantera, 2010; Abidin, 2012). Abidin (2012) coincided with using the VPA method as the practical in-depth experimental design following "*…The pros and cons, as well as the techniques for VPA, are described in-depth in their work. In terms of the validity of the experiment the verbalisations in the VPA indicate the inputs and outputs to the processes rather than the processes*

themselves. This is parallel to the research technique for design by Cross, Christiaans, and Dorst where they discuss the validity of VPA: The purpose of observation is to see any interaction between the mind and the body".

For the use of medium observation, there are two approaches application of the design observation, such as: (1) digital observation by recording video - online and/or conventional camera; and (2) design manuscript by drawing or sketches - multimedia and/or drawing instruments. Both input-output of medium observation explains the designing behaviour moments within the design activities following the essential of a fundamental research study in qualitative methodology. Hence, the vital understanding of the input-output processes should be recognised concurrently due to the validity and reliability of qualitative data collection. However, the input-output processes depend on the purpose of the study and the supporting evaluation is required from the rubric assessment. Thus, this rubric assessment will be elaborated on the verbalisation ways in the further design thinking study.

In the design thinking study, the empirical VPA method study would explain the purpose of the drawing practice (design activities) into the specific semantics thinking for the design evolution of the design identity under the sustainable for product design (SfPD). Thus, a rigorous prescriptive study (PS) is very significant for the "think aloud" of design experience according to the ecodesign identity in the product form context (Blessing & Chakrabarti, 2009; Abidin, 2012; Cowan, 2017; IDEO, 2017). Currently, the subject's setting is defined by the observer for the participants (novice/young industrial designers) to achieve and validate a significant timeframe into the manual design scheme effectively as a goal with sufficient time for completion (Vasileiou, Barnett, Thorpe & Young, 2018). It will be evaluated by an analytic rubric evaluation (ARE) that the quality of the design manuscript requires. By using an ARE approach, the triangulation of the contents of the two factors is organised to level the score in the design manuscript, which is tied to a five-point Likert scale – the use of Cronbach's Alpha (CA) value will be recognised in the reliability study. The ARE approach performs functions that are known as a qualitative methodology tool for transmitting the articulated data (from the scales) into the quantitative approach reasoning methodically. Data from the participants in the focus groups conducted at the three institutions will be used to compile the data.

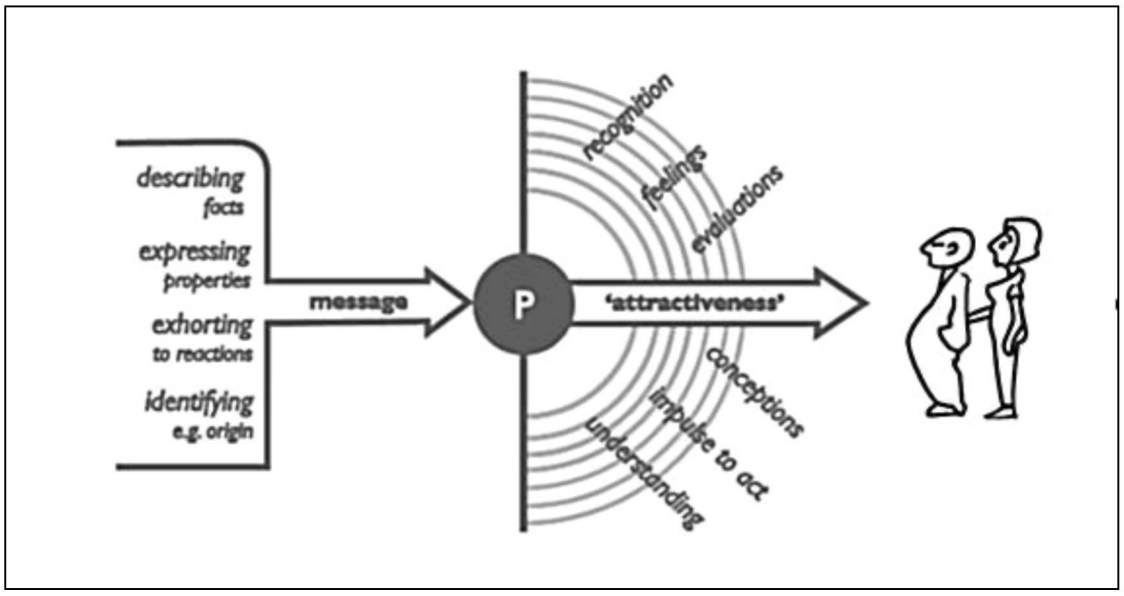


Figure 4.5 Monö Model Experience (1997) Reveals The Communication Process Phases

In design solutions, the design phenomenon can be traced by certain and/or uncertain reasoning of the designer's behaviour during design activities from the human-centred design concept, such as sketching and drawing (Abidin, 2012; Jonsson & Svingby, 2007). Hence, following the concept of ecodesign identity, the PS stage is significantly developing the product form imagery (representation) in design thinking among novice or young industrial designers. Then, the improvement in the quality of product form shifts concurrently.

Lastly, the understanding and supporting model of design observation are required so that it could establish the enrichment data collection. During the design thinking processes, the conception of model experience obviously needs to bring some a good pattern of design representation, namely, the product form imagery. The reason to use the specific model experience is to relate with an earlier design solution mentioned before, which is the nature of product experience having occurred to the product representations for the context of meaning's communication process between artefacts and consumers as Figure 4.5. Thus, the statement of the flow study in the concept of ecodesign identity will be formed and interpreted as an example with hypothetical form following "product form imagery → verbalisation ways (message) → design thinking (product) → product representations (attractiveness). A further explanation should be emphasised on how the physical approach can be demonstrated by using an appropriate kind implementation of the perceptual framework in data

collection as well. Evidence to approach the representation study should be taken an account for determining the specific and/or kind of design scheme (as design observation of qualitative assessment tool) and an objective of the VPA method purposely.

4.5.2 Design Survey

This design survey study employs a probability cluster sampling strategy in accordance with the nature of its queries. It took place as a result of the subject having studied for a department from a prestigious industrial design degree programme at three of the chosen public institutions in Malaysia. The respondent is aware of the specific item or location in the studying workplace and environment where crucial data collection and setting study events took place. On the subject of the preceding section, we shall get to this knowledge.

For the demographic, the final year students have participated to complete the data collection stage. The detailed information to the respondents, namely: (1) gender; (2) age; (3) academic qualification; (4) semester; and (5) course specialisation – is very significant in that it could explain and recognised the subject's availability upon and/or during the data collection processes. The appropriate types of respondents can assist in selecting the right sample size and enable to let for reach the justification of appropriate research findings as Chapter 3 described previously.

In the instrumentation, the study applies the general reliability coefficient rule of thumbs, a reliability test should be used to determine the quality of a design questionnaire and it should be backed by a Cronbach's Alpha (CA) value that is not less than 70. Next, the normality test - frequency distribution from the small sample size will be used for the specific statistical testing method in this study. Due to the kind of probability sampling having the same number of participants in non-probability sampling, particularly the focus group, it is now important to take a sufficient sample and number it so it may be included in the mixed methods sampling.

As an expected finding, the study's connection and association (from a few different factors) improve quantitative reasoning and help rookie and young industrial designers better grasp how people perceive design. The descriptive research that comes after the statistical analysis context is referred to so that the interpretation of the design article may be measured numerically and systematically. As a result, the complementary

dual approach has an impact on the accuracy of the results, particularly when it comes to the observation of exploratory research study to define in vitro meaning inside its problem identification.

4.6 Design Method Procedures

The observation of the design process study is very important in the design method procedures. Before execution, there are some administrative tasks which require the observer to acquire approval from the university faculty for permission to conduct data collection. Usually, the Department of Programme Studies will sanction the observation session and allow for the preparation of the classroom facility for the participating subjects as well as the sampling of student programmes.

From the above situation, the criteria for inclusion and exclusion must therefore be discussed. The population of study needs to be framed and uniformed into the design education area as well as the inclusion criteria. This participating subjects' study will explore a design method procedure referring to a think-aloud of the cognition of young industrial designers towards design thinking among Malaysian design education institutions. Interpretation of the subject develops the intuitiveness of the study of product form that could specifically create the verbalisation of ecodesign identity. Hence, the most significant subject population refers to final year students or later semester students, who have diploma and degree graduating student status. Both certifications will be represented by the ages group of students in the diploma and degree level background who studying industrial design programme – subjects ages of 18 until 30 from the demographics of three types of ID school orientation/institutional according to the undergraduate programme as bachelor's degree/level specialisation of industrial design course – Bachelor of Arts (BA) or Bachelor of Design (BDes) or Bachelor of Science (BSc). Meanwhile, the exclusion criteria refer to the characteristics of the subjects' population that will be not applied to the postgraduate students, such as Master's and PhD students. However, for the inclusion criteria, there is a similarity characteristic in the population of demographics of the subject due to the fact that a novice/young industrial designer (the beginner) should start a career in the industrial design field. On the other hand, the exclusion criteria are normally represented by the expertise and competency level of the demographic population that enable them to

present their design expertise and/or experience which is to deliver a design skill and knowledge demonstration from the actual field by working in a multi-industry sector.

For the administrative type of the observation of design method procedure, there are two courses observation engages with the design thinking contexts following: (1) tacit knowing in design; in vivo; and (2) problem-solving in design; in vitro. Here, the context of the in vivo study deals with the designing experience or familiarity things for design practice to identify the solution of finding (action) purposes that there is something intangible and/or implicit knowledge for the designing clinical concept upon approaching the method demonstration oriented by portable laboratory setting. It's very important that the details observation about how a specific substance or durability or condition progresses in a real, living thing (in daily use or/and practise application). In other words, the statement refers to what and how the method can be used/developed commonly. Therefore, the verbalising study of clinical concepts has engaged with the preliminary work of prescriptive study that the probing for the design activities referring to verbalisation of prescriptive procedures (the minds and human body interaction), will investigate the "specific" VPA process/phases/stage following the higher ranking and/or rating from the numbers of subjects frequently. Effects on the investigation, there will be a repetition of the probing stage (2^{nd} probing sequence). Hence, the result of the clinical concept context of the in vivo study should be bounced back to convey the area of parameter study (problem-solving in design; in vitro) in emphasising the further synthesisation of think think-aloud concept. This reflection is needed to make sure the administrative types of the observation of design method procedure are smoothly running well. On the other hand, this study is approached to focus the in vitro for the simulation of the VPA method (solve) that a study carried out in a portable and/or flexible laboratory setting or carefully monitored by the designing practice-based study on experimental of environment conditions, such as design pedagogy as an online room for seek the mimicry design solving. The goal of observation or/or simulation is to spot any instances of the hand sketches/drawings interacting revealed from the synthesisation of think aloud concept that it seeks the mimicry solution of tangible and/or explicit design environment produced an evidence of design manuscript, which refers to what the product form/ecological form of ecodesign identity actually is. The evidence goal observation or/simulation refers to the designing essence that it usually practises in the grounded theory. From the designing essence, an exact theme of coding will possibly produce the abstraction of questions' answers accordingly. By the

reflection of the two-course studies, both in vivo and in vitro approaches will be discussed in the data verbalisation in the next sub-topic together concurrently.

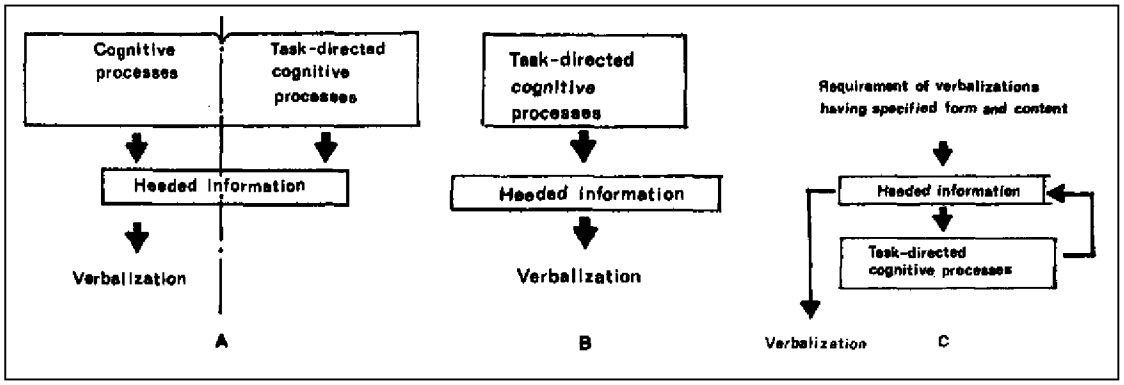


Figure 4.6 Three Types of Verbalising Procedures: A Procedure Concurrent Verbalisation - The Task and Heeded Information Categorised Under Panel A, Panel B and Panel C

Source: Ericsson and Simon (1980)

The data verbalisation of design method procedures must coincide with the research paradigm and methodological assumption as previous Chapters 1 and 3 in terms of verbalising procedure context. Realistically, the nature study of transdisciplinary design (TD) - syntactic, pragmatic and semantic in formgiving development; has navigated and related with the holistic verbalisation studies following the structure of the dataset in the current fundamental/basic research topic needs.

The verbalising study of data collection reveals the consistency of hypothetical states and/or forms in the research supply chain and its continuity research operation. The main opinion for induction reasoning on the procedure development is found using the experimental behaviour of grounded theory study that the combination of verbalising procedures has occurred. In Figure 4.6, Ericsson and Simon (1980) defined and identified the types of verbalising procedures discussion with "...three possible relations between task-directed cognitive processes and verbalisation. ([Panel A] Verbalisation and task-directed processes are separate and distinct. [Panel B] Verbalisation of heeded information is generated by task-directed processes. [Panel C] Requirements for verbalisation modify task-directed processes.)". From this research study, there have been two panels combination where it could reach and answer the research questions, design solution and the research objective as well. The reason to use the combination of two panels is that the essential research approach of mixed methods

deals with four pinpoints of pragmatic worldviews, namely: (1) consequences of actions; (2) problem-centred learning; (3) pluralistic; and (4) real-world practice-oriented (Creswell, 2003; Creswell and Clark, 2007). By right, a justification for the use of panels' combination is still engaged from the design belief (form context) using the DRM framework flow as an earlier Figure 4.1. These were related to the prescriptive study (PS) stage method which is an ethical and performance behaviour at the process level as system and design thinking emergence by Malaysians young industrial designers. However, the research design study is decided and identified the procedure flow of the VPA method approaching with the hypothetical form as [Panel A] → [Panel B] together following Figure 4.7. The panels' combination is revealed from the nature of the research study in the ecological form of ecodesign identity.

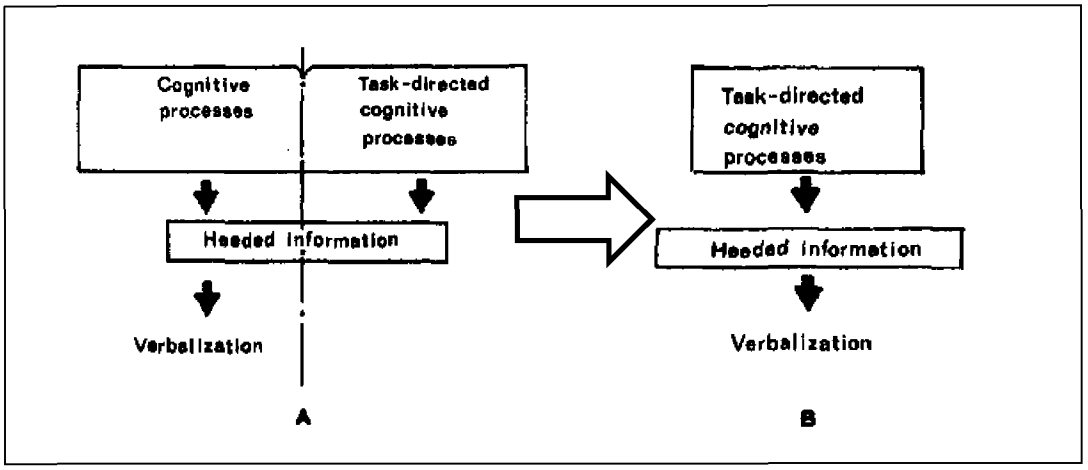


Figure 4.7 Panel A Refers to Tacit Knowing in Design; In Vivo Approach/Study and Panel B (2) Problem-Solving in Design; In Vitro Approach/Study

Therefore, the research study takes some initiative to illustrate the form of combination, namely, with the VPA capsule of the process model following Figure 4.8. To meet the whole conception of design method procedures according to VPA's preliminary study (VPAPS) method, the study has taken some initiative approaches to explore and identify the encoding dataset within Panel A of the VPA method as similarly same the roles and functions, namely, a pilot study (as quantitative methodology) – to examine and rehearse the coding of qualitative dataset – refer to why is the product form/ecological form of ecodesign identity. Further, Panel B of the VPA method will explore the clinical study for receiving coding and/or theme categorisation of dataset grounded theory that emphasising a think-aloud to recognise the form of

convergent use dataset – refer to what is the plan execution for the method process? and how method process can be used/developed into the essential research. In this situation of second last step of the hypothetical form, is to seek ideal evidence that enables us to pinpoint the finding dataset in comprehensive analysis.

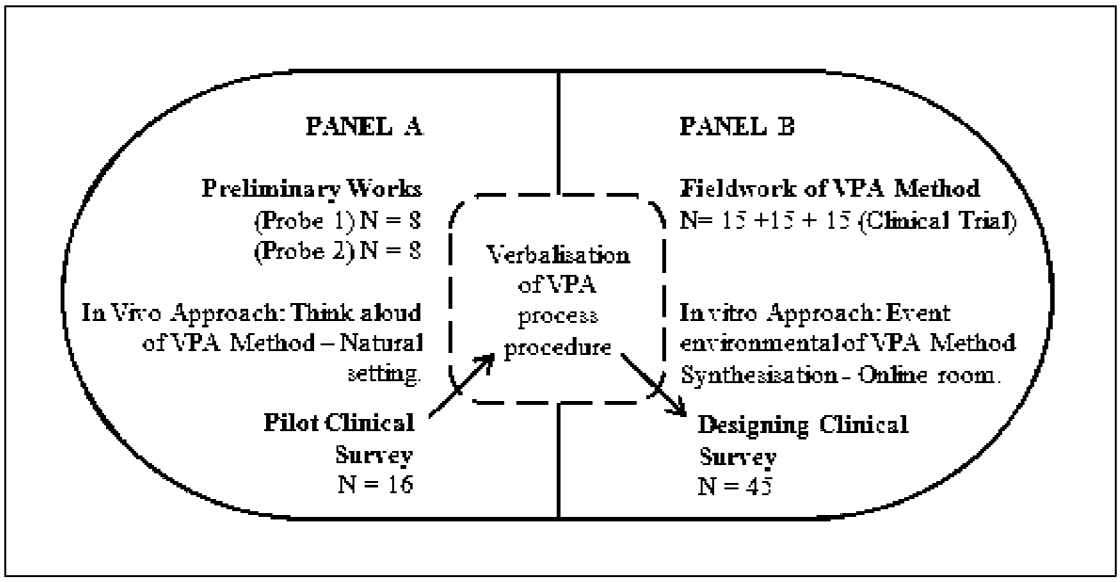


Figure 4.8 VPA Capsule of Process Model (Introduction To Embedded System Model)

Both in vivo and in vitro VPA methods must be embedded together so that a natural characteristic has occurred according to the current use of the mixed methods approach. Due to the nature of mixed methods study, there has been a continuity movement to provide the research goal or research direction specifically by using the experimental of analogy thinking needs. The experts Ericsson and Simon; (1980) explained the significance of analogical with "…the analogy to performance behaviour, whose veridically is commonly accepted without question, is clear. It would never cross a researcher's mind simply to ask subjects to raise their hands when they had solved a problem, without reporting the solution, no matter how much the experimenter thought he or she could trust them. The best evidence that they have actually reached a solution is their ability to report it."

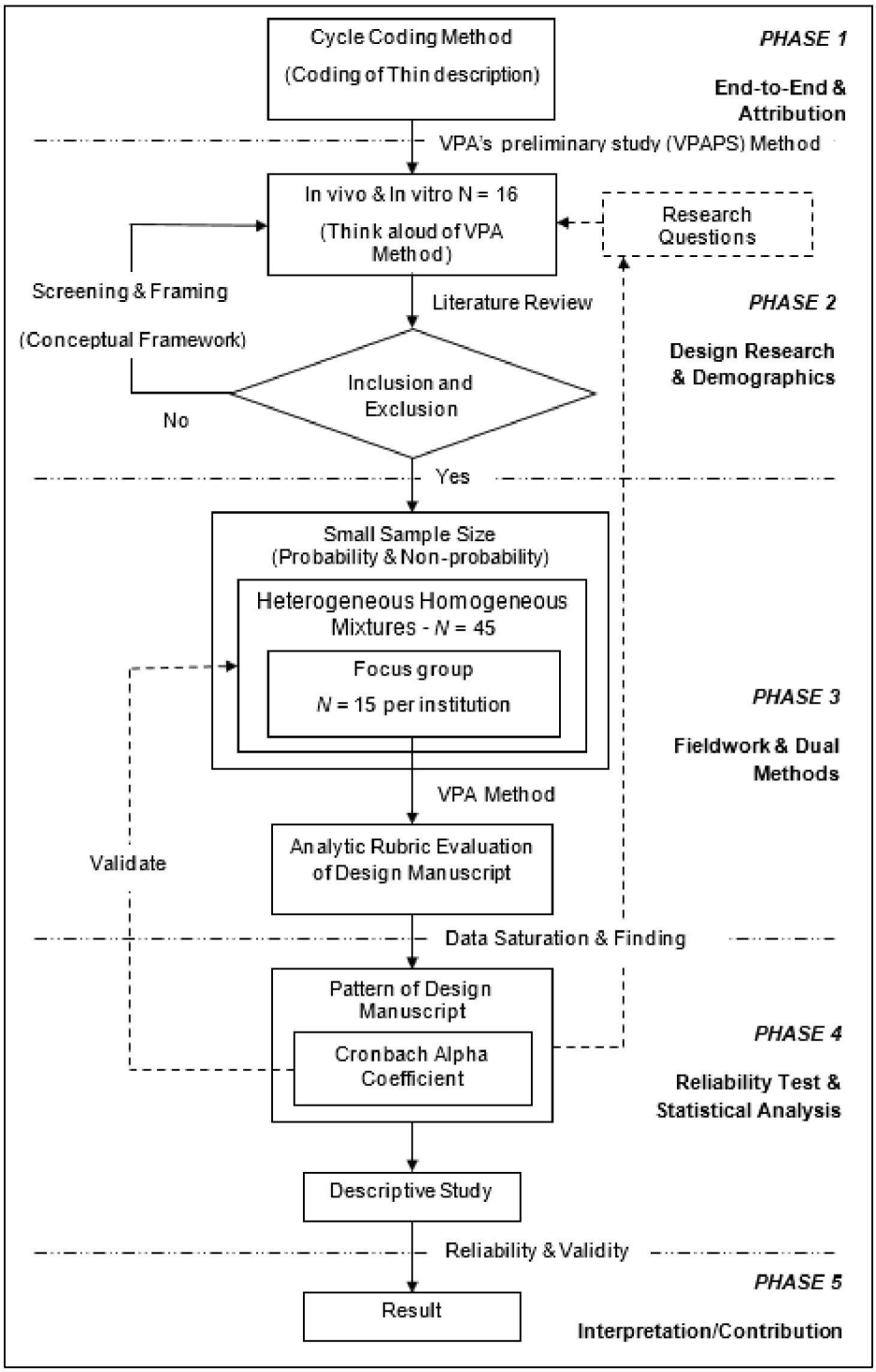


Figure 4.9 Five Phases in The Verbalisation of The VPA Process Procedure

Hence, to demonstrate the designing method process procedures, the study displays Figure 4.9 following five phases of flow levelling activities from the beginning with: (1) end-to-end and attribution; (2) design research and demographics; (3) fieldworks and dual method; (4) reliability test and statistical analysis; and (5) interpretation/contribution. It is prominent to the study in developing the grounded

research activities that it could develop the embodiment of mixed methods along the prescriptive research activities/study.

Also, the flow processes have shown the direction of convergent thinking that the notion of study is systematically delivered with the continuity pathway from the coding of thin description until the result is needed. In other words, an appropriate design method procedure can be formed in the direction of a real picture and/or perspective view that enables research study in a comprehensive manner.

4.7 Verbal Protocol Analysis Method

The VPA method was systematically developed in 1980 by Ericson and Simon it started with a research article titled "The Verbal Reports as Data" in the verbalisation study. At this moment, the observer will notice and declare to the participating subjects what kind of verbalisation method will be used. For the number of students, a period session, the observation briefing, and the recording instrument are the essential preparations of the VPA method. The subjects' information sheets and consent forms are needed, therefore require distribution to every participant categorised and/or selected. Once the permission to collect data has been obtained, the observer will proceed with the six steps of the experimental design preparation of the VPA procedure so that it can systematically address a rigorous PS method: (1) demographic information; (2) design theme briefing and VPA information; (3) imagery interactions: mood board (visual aid) and reading material; (4) on/off-site mode and camera layout setup; (5) drawing media and instrument; and (6) proposed estimated time. However, to define the verbalisation of the participating subject, a student in the early and middle semesters should not be advisably involved in the population of this subject as a sampling of the research study. Empirically, on reflection of the data collection, biased and erroneous results will emerge. Additionally, novice/young industrial designer skills are not fit enough and too immature to present their design skills and design practice.

Further, two input consumptions are required in the post-observation, namely: (1) design manuscript; and (2) videotaping: HD 1080p, 1920 × 1080 resolution formatted. For the output lesson, the VPA strategy analysis will use the form of manual scheme transcription called VPA design scheme (VPADS) – this will be discussed in a further subtopic. Thus, the ethics case study emphasises the code of ethics practised

which would naturally shape the reality of grounded research. Also, these scenarios can define the in vitro meaning in the design research context.

For the strategy use of Mono' model experience (1997) within the VPA method, the development of design observation is based on the product communication interactions with consumers. Referring to Abidin (2012) and Crilly (2005) as a citation noticed the Monö's model with "… messages are encoded into the product by the designer (the sender). These messages are carried by the physical product gestalt (the combination of form, colour, texture, structure, etc.), and eventually decoded by the user (the receiver of the message)" (p. 13). Thus, evidence and the consistency of the model experience have enabled the specialisation of representation areas together within the design solution.

For the implementation of the VPA method, the study coincided with Warrel (2008); and Abidin (2012) in that the application of a basic framework of perceptual product experience (PPE framework), with core modes (centre), the two dimensions of presentation (left) and representation (right), within the engagement of three submodes – are delivered the specific expected finding in participants of design belief following Figure 4.10.

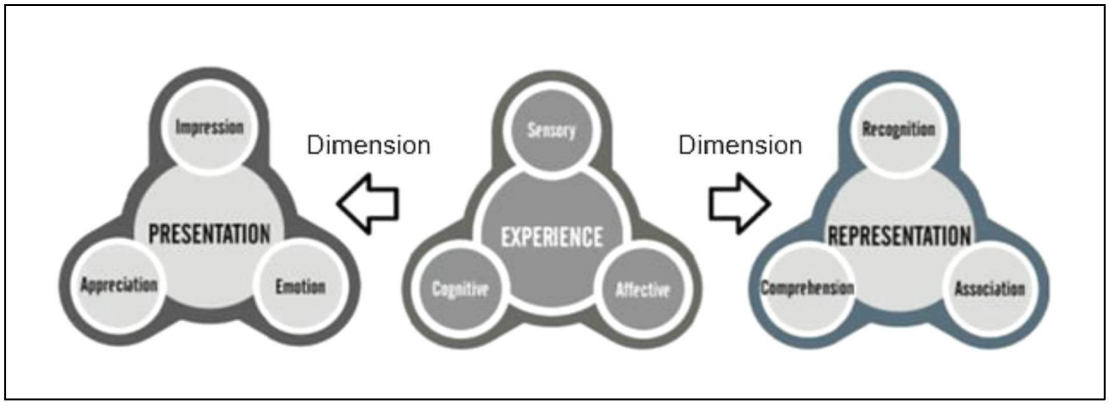


Figure 4.10 The Framework of Perceptual Product Experience

Source: Warell (2008)

However, the research study is related to the priority use of the basic and/or fundamental research study that the core modes of experience processes engaged to three submodes of dimensions' representation at first – emphasising and choosing the significance of "vital signs representation" (VsR) following to the: (1) recognition; (2) comprehension; and (3) association. This supporting representation of data sources is

actually developed by the quality of the pattern/form/symbol of the representation ways. Afterwards, the data sources of representation have to be delivered and processed into the dimensions' presentation simultaneously. At the transitional process stage, one of the specific vital signs representation (chosen) will be derived into the right path of "vital signs presentation" (VsP) according to the: (1) impression; (2) emotion; and (3) appreciation. The description of vital signs presentation refers to an event or performance that deals with the effectiveness / perception / professional / competent level of the presentation approach. Due to the nature of the research study in the specific semantics thinking, there have PPE highlighted the design evolution of the design identity experience under the sustainable for product design (SfPD). In addition, a similar pattern of verbalisation ways in the data collection process has indicated the same conception along the think-aloud of the VPA method.

4.7.1 Preliminary Works and Fieldwork of VPA Method

Based on the primary data source and information on VPA procedures earlier, the preliminary works and fieldwork of the VPA method had been established under the VPA capsule of the process model. The understanding of the VPA method from the prescriptive activities is divided by two courses of VPA methods developments, namely: (1) In vivo observation study which focuses on the area of preliminary works as probing stage; and (2) In vitro observation study refers to the fieldwork of VPA method with an examining/clinical trial stage. These two courses of VPA method developments address the continuum of research convergent that the continuity of encoding dataset is transmitted from the in vivo (Panel A) into in vitro (Panel B) of observation study subsequently (in vivo → in vitro). Based on the course of cognition, these two courses were performed and revealed by attended information through the designers' behaviours to build the greater dataset information during the midst of processing phases. Ericsson and Simon (1980) noticed that "…Increasingly, investigators record the direction of the subject's gaze (eye movements) and the intermediate behaviour (making moves or other physical manipulations of stimulus material) that precedes the solution or criterion performance. Since data on intermediate processing are costly to gather and analyse, it is important to carefully consider how such data can be interpreted validly and what contribution they can make to our understanding of the phenomena under study." Here, both courses describe short-term

memory (STM) within the verbalising principle, such as "…the subject's primary task, or only incidental to the "real" task that he or she is addressing. The verbalisation may either be concurrent with task performance or retrospective" (Ericsson and Simon (1980). Thus, the actual roles and functions following,

a) *In vivo approach as prescriptive works stage* - the basic mental cognition of task performance via the primary natural setting (verbalisation of Panel A as a probing stage) in "a new idea creation"; it can be observed the tacit knowledge as a pattern of design skills context, is expected from the information of attended process development. This in vivo approach study deals with a natural setting through the mind and human body interaction to probe a think-aloud reveals "a new idea creation" by the portable laboratory setting. In other words, this rehearsal approach's function is to probe the natural behaviour within designing experience utilising the short-term memory (STM) fundamentally.
b) *In vitro approach as fieldwork of VPA method stage* - the logical cognition of retrospective through the memorable accomplishment (previous time/things) in "a new way condition" (verbalisation of Panel B as examining/clinical trial stage); it can result in the problem-solving method is derived from the "pattern of STM contents/meanings" from the design manuscript. Normally, this refers to the kind of collected data generated by a demonstration, about their history to explain their present condition in designing activities in fieldwork study. It explains the artificially intelligent ways to simulate the mimicry process (morphing metaphor) on what design representation appears during the events' programme in the design manuscript intentionally.

To understand the comparison of in vivo–in vitro context, the research study advisably prefers the Merriam Webster (2023) that it enables to express an actual meaning of the word following, in vivo defined under the medical definition with "in a real-life situation: observing a patient's behaviour in vivo". The meaning of real-life situations from the industrial design context exposes the "knowing how" of the subjects' proficiency (expertise) in the prescriptive study. Meanwhile, in vitro describes "outside the living body and in an artificial environment". It is very close to engaging with the certain and/or surrounding environment where the event or programme situation is a

common practice-based participation of live experience as "knowing that". By right, the benefit of the two approaches facilitates the suitable prescriptive study in the DRM framework. Thus, a research journey for the data collection can be managed easily where the possibilities of qualitative testing method – choosing the verbalisation of Panel A and/or Panel B in VPA method for the suitable research objective, agenda of product clinical adoption and topic orientation.

Table 4.1
Differentiation of In Vivo–In Vitro Study

Roles & functions	**Short-term memory (STM) of think-aloud in two courses VPA methods**		**Meaning**
	In vivo study (Preliminary works)	**In vitro study (Fieldwork of VPA Method)**	
1. Aim	Tacit knowledge in design	Problem-solving/solution method in design	Stimulus or simulation analysis
2. Purposing	Why is the product form/ecological form of ecodesign identity?	What and how method can be used/developed?	Research questions
3. Exploring	Any instances of the body and mind interaction	Something implicit knowledge for the clinical trial	Probing or retrospective characteristic
4. Verbalising	Informing behaviour - attended	Logical thinking – concurrent STM	Probing or authentic context
5. Transcriptioning	Consistency of verbalisation – heuristic scheme	Consistency of empiricalisation – theory propostion	Comprehensive or extensive evidence
6. Complementary	Verbalisation of perceptual-motor process	Verbalisation of visual encoding	Weighing or context decision

Abidin, Christoforidou and Liem (2009) agreed to explain the combination of two courses in an in vivo–in vitro context were adopted together following the statement "…the VPA method has been developed for well-defined, linear problems and there has been little adaptation of VPA for the field of design research; the method has often been adopted as it is. The "in vivo" research methodology suggested by Christensen could be a possible way of successfully adapting the method of VPA to suit the nature of design activities as the method relies on the natural dialogue between designers. In vivo studies are carried out within a natural setting. In contrast, the in vitro studies are conducted in a laboratory or a controlled experimental environment and thus allow the

researcher to study expert thinking and reasoning "online" in the real world. It may therefore prove to be very fruitful to combine aspects of the in vivo approach with VPA, especially in contexts where the technical content is low, and the focus of the studies lies within the sphere of the humanities."

Therefore, the development of the VPA method identifies six roles and functions, namely: (1) aiming; (2) purposing; (3) exploring; (4) verbalising; (5) transcriptioning; and (6) complementary that these contents enable to select an appropriate VPA testing method since the attribution of research title have established earlier. To make sense of the two courses' cognition, the comparison of the research study is prepared in Table 4.1. However, the visual aid is required to deliver appropriate figure boundaries for the VPA method of research study as Figure 4.11. Due to the combination of STM of think aloud in the two-course studies (In vivo study: preliminary works and in vitro study: fieldwork) are concurrently displayed together even the actual approaches went consequently. Then, the study takes some initiative to place numbers of the participants (N= subjects) for both course studies so that it can describe a comprehensive and better understanding of the comparison strategy. Also, there are good contexts for the sample size study and it possibly reduces the knowledge gap between pilot and fieldwork study. By the number of subjects, the subjects' amounts represent the data collection activities obviously.

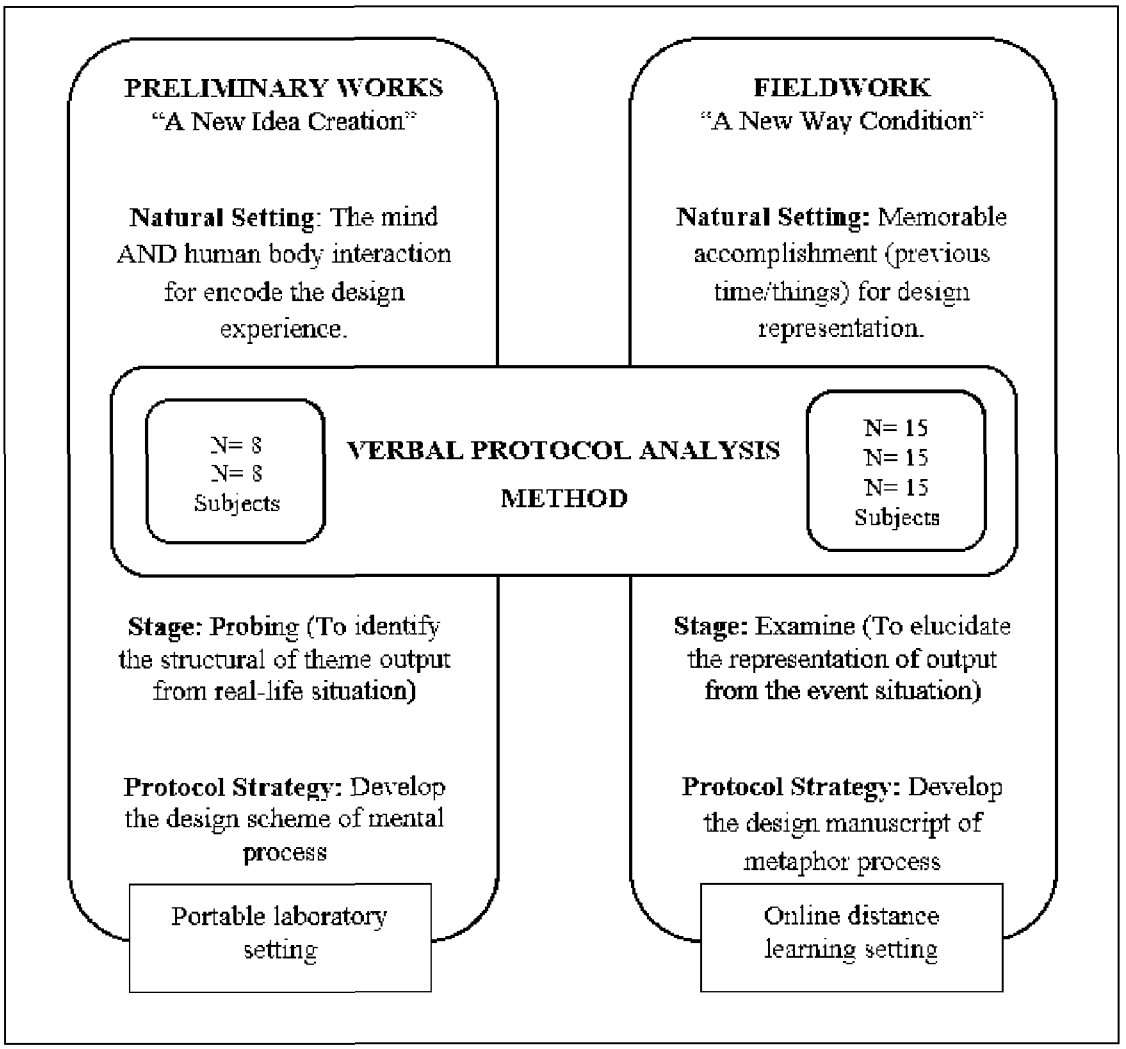


Figure 4.11 A Portion of VPA Boundaries Approach for Accessibility Research Between In- Vivo Study: Preliminary Works and In-Vitro Study: Fieldworks

4.7.2 Video Recording Method

The observation of the video recording method is a research tool to screen the visualisation of data set frequency that will be validated and engaged with the selection of research topic from Panel A → Panel B systematically. When the research activities are related to the designerly way of thinking activity, the accurate information of qualitative protocol which is produced by the audiovisual recording, can be managed the dataset material with the pre and post-observation. Based on the dataset of pre and post-observation, the administrative folder requires that the content of the video recording be assigned and categorised under the qualitative grounded study. Because of the qualitative protocol platform, the roles of the VPA method screening the several

elementary works of ethnographic discipline that a few subjects' participants will be derived by the common living activities in the practice of designers' action (consciousness context) and reflective practice of designers' behaviour (solution context) simultaneously.

From the type of situation of experimental/events' environment in the context of laboratory activity, there are two modes of laboratory activity settings, such as: (1) on-site; and (2) off-site modes. Further, this research study aimed to focus on on-site mode, and it extensively divided another two types of settings for the video recording method, namely: (1) on-site mobility (natural) setting – portable laboratory; and (2) on-site online room setting – online distance learning (ODL) as Figure 4.11 stated. In the current setting of experimental/events environment, this research study is very suitable with the on-site mobility setting for probing purposes and the on-site online room setting for examining purposes. This setting's opinion was selected due to no requirement for a permanent design laboratory.

For the use of audio-visual devices, there is a common electronic device/tool that will facilitate the transcription of dataset processes into the data analysis activities. The digital manuscript of dataset recording is usually created by the transcription of video recording method using several digital file types formatting, namely, MPEG-4 Part 14 (MP4), Quick Time Movie (MOV), Windows Media Viewer (WMV), Audio Video Interleave (AVI) and others equivalent. Also, the precise timeframe or duration of the audio-visual device can possibly assist the researcher in seeking the significant value and/or the frequent moment recorded situation justified by the frequency of the timing scheme as well. Hence, the significance of digital manuscripts should be used especially to generate the signs evidence and/or a greater dataset of design manuscripts along the transitional concept period.

Lastly, the material dataset should have the administrative task in digital editing mode. Thus, the research study is suggested to use the tradition of qualitative methods procedures following the summaries, including: (1) pre-post observation: the protocol study that generates observational notes, descriptive notes to reflective notes, and builds the demographic information; and (2) design scheme observation: the observation protocol that follows the recording components.

4.7.2.1 Pre-post Observation

Pre-post observation may take a different shape from the standard pre-post observation used in experimental research when utilised in the context of the VPA approach in qualitative prescriptive research. The VPA method is a qualitative prescriptive research method that is used to observe and comprehend people's mental processes, verbal expressions, and decision-making when they perform particular designing tasks or designer behaviour or skill activities. The flow procedure for the VPA's preliminary study (VPAPS) is used to structure how pre-post observation might be used for the probing stage (Panel A) in this think-aloud scenario.

First, pre-observation is the process of identifying specific design thinking for the product form's design evolution towards the development of a coding scheme known as the VPA design scheme (VPADS), prior to performing the primary think-aloud analysis. The following can be included in this pre-observation phase: the equipment and procedure setting for the VPA;

a) *Participant selection* – Using the purposive sampling study – three types of ID school orientation/institutional according to the undergraduate programme as bachelor's degree/level specialisation of industrial design course – Bachelor of Arts (BA) or Bachelor of Design (BDes) or Bachelor of Science (BSc).
b) *Task description* - Clearly defining the task or activity that participants will perform to use and follow the order of task description sequence provided accordingly, such as: (1) demographic information; (2) design theme briefing and VPA information; (3) visual imagery interactions i.e.: mood board (visual aid) and reading material; (4) on/off-site mode and camera layout setup; (5) drawing media and instrument, and a (6) proposed estimated time - to achieve an approximate timeframe.
c) *Ethical considerations* - securing informed consent from participants and ensuring that the person is aware of and able to adhere to the ethical rules. This ethics case study used the designer's methods of design thinking to observe the design phenomena that were disclosed by the participants' essence as Appendix 8, 9 and 10.

Second, the VPA outlines the primary findings of the study. In this stage, participants participate in the task or activity of interest using the suggested estimated time, while researchers watch and document their verbalisations (think-aloud protocols or retrospective interviews, for example). Data about participants' ideas, justifications, and verbalisations pertinent to the research issue are gathered for the study.

Thirdly, post-observation refers to the process whereby a research study evaluates the quality of verbal protocol analysis through a variety of activities. These activities are crucial for qualitative prescriptive research because they establish the validity of the datasets' quality through the assessment of design tools and output materials;

a) *Data analysis* – The recording and design manuscript indicator denotes transcription of work and encoding of the activities through coding or design scheme of the spoken data obtained, searching for trends, themes, or revelations associated with the study subject.
b) *Interpretation* - The interpretation of think-aloud describes the verbal data to draw meaningful conclusions or insights based on the analysis according to: (1) the basic instruments used; (2) provides a pattern of design process demonstration; and (3) is encouraged to do reflective practice approach to encode a think-aloud of the drawing content within the participant's behavioural capability. The method interpretation of the rubric is required – the analytic rubric evaluation (ARE) method.
c) *Validation* - The research study allows them to triangulate the data with other sources, confer with experts, or include several researchers in the analysis to identify the best design technique for their findings or interpretations.

Pre-post observation is therefore used in this context to enable an organised framework inside the flow process for applying the VPA approach, as shown in Figure 4.12. It can efficiently evaluate the think-aloud data gathered during the primary study, adhere to ethical work practice, and aid the research study in following a defined plan for data collection and analysis.

This method is frequently applied in qualitative prescriptive research, particularly in domains where comprehension of participants' decision-making and thought processes is crucial, such as industrial design, design education, engineering

design, and design thinking. These fields use the design artefact as a medium for research studies. It is actively utilised to validate that the dual method triangulation—that is, the VPADS (pre-observation) and ARE technique (post-observation)—allows for the production of a high-quality design manuscript.

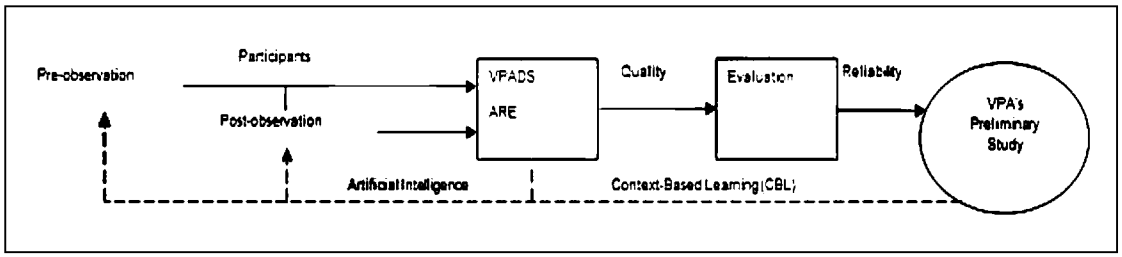


Figure 4.12 The Flow Process for VPA's Preliminary Study

Source: Chumiran, Abidin and Kamil (2020)

Nonetheless, to address context-based learning and artificial intelligence in the design process, a supporting system is needed for the exploratory study conducted by VPA. To memorise the sign and/or signal of the pattern dataset gathered as a cycle flow solution, the dashed line will be reflected upon the boundary stage of the flow process through a backward direction. Thus, after the cycle is finished, let's be ready to provide an appropriate ethical case study approach as a whole.

4.7.2.2 Design Scheme Observation

Within the framework of the VPA approach, "design scheme observation" refers to a particular method of collecting information on an individual's decision-making and mental processes throughout a design or problem-solving activity. The verbalisations people make while working on a task are recorded and analysed as part of the VPA technique, a qualitative methodology that provides insights into people's cognitive processes – the coding scheme working is to recognise the datasets of designing skill competency and/or pattern of psychomotor study. The verbal protocol experts Dixon and Bucknor (2019) have consistently agreed with the verbal protocol researchers who have claimed that "the purpose of segmenting is to break the transcribed verbal protocol text into units (or segments) representing discrete thoughts that can be coded with a predefined coding scheme. Each segment was coded manually using the following

predefined constructs: local heuristic, transitional heuristic, process heuristic, local and transitional heuristic, problem space, solution space, and overlapping space (Daly, Yilmaz, Seifert, & Gonzalez, 2010; Dorst & Cross, 2001; Yilmaz et al., 2011). Each heuristic was further coded for function or form."

To begin the coding scheme and/or segment, the VPA method study uses the taxonomy of design definition activities to synthesise a diagonal continuum structure, as shown in Figure 4.13. The direction of continuum synthesising begins with "abstract to concrete" according to this taxonomy model matrix, with the X-axis plane direction and the Y-axis plane representing the "undetailed to detailed artefact's attributes" from the synthesising process in turn. The topic categories of psychomotor activity—abstraction, composition, and standardisation—have been recognised and described by the blue colour highlighted (synthesisation of diagonal continuum organised). Three themes also need to be used to frame the design definition activities under the stage process, using the reflective practice of the study. The study thus took the initiative to introduce the "emerging stage" as the starting stage of the four-theme category of psychomotor activity and allowed for the continuation of the subsequent stages with the remaining abstracting, composing, and standardising. This helped to frame the establishment of the design scheme observation.

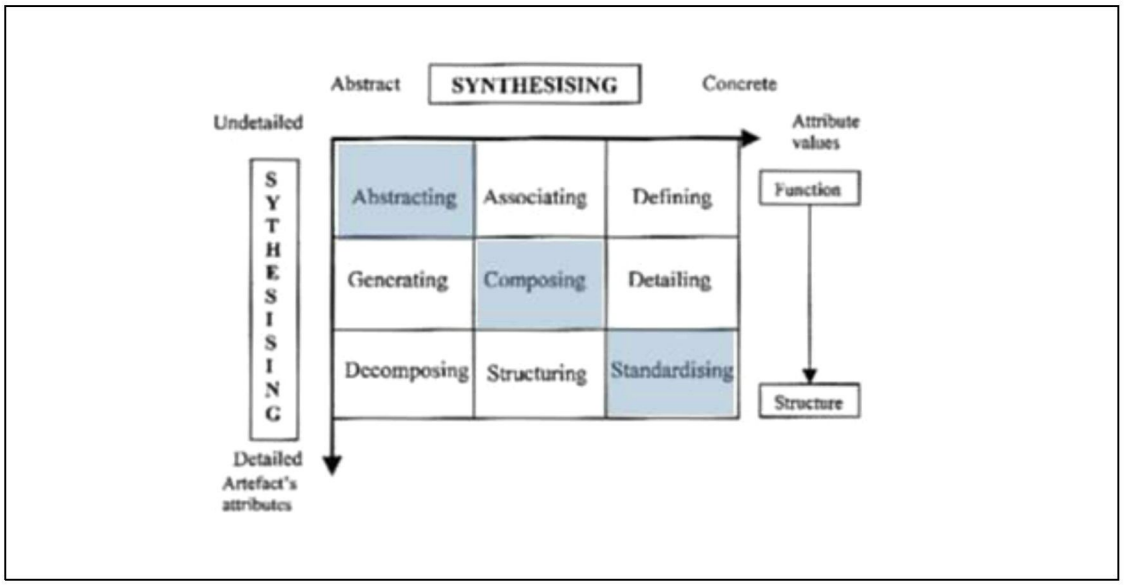


Figure 4.13 Taxonomy of Design Definition Activities

Sources: Hassen and Andreasen (2002) and Abidin, et al (2009)

Apart from that as Figure 4.14, this qualitative analysis of the coding scheme method is valuable in design-related research and usability studies because it provides insights into the thought processes and strategies employed by designers or individuals working on design tasks – the common question in verbal protocol, such as how many minutes (times) is frequently approach the design pattern around 20 minutes provided. It can help identify both successful and unsuccessful design strategies, leading to a better understanding of how people think and make design decisions. For instance, the study has used two design insight strategies, such as: (1) the extrapolative strategy; and (2) the interpolative strategy together. An analysis of each five-minute segment will be necessary. The extrapolative and interpolative strategies are based on the four (4) stages of design scheme observation, and they are potentially placed between the total twenty minutes along a timeframe in accordance with each segmented representative. It is necessary to leave free spaces at the top and bottom so that they can be used to indicate design references (eyesight for the mood board panel) for participants who are following the picture or visual aid orientation.

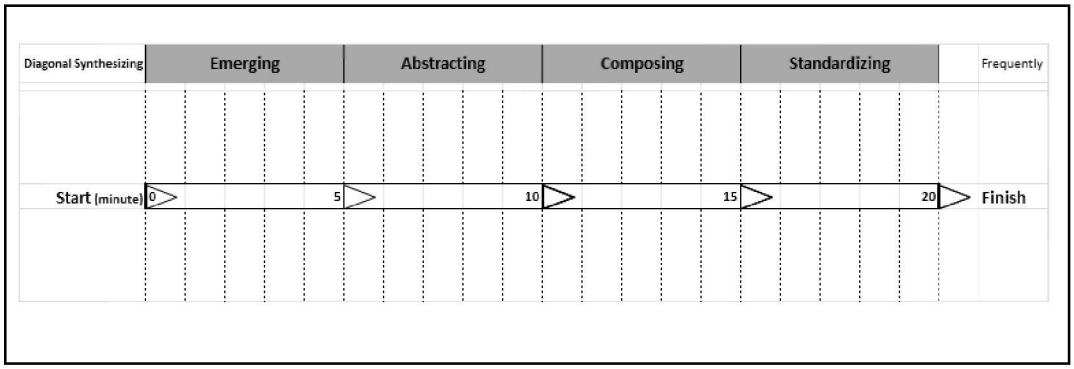


Figure 4.14 Four Theme Categories of Psychomotor Activity "Without" Design Insight Strategies

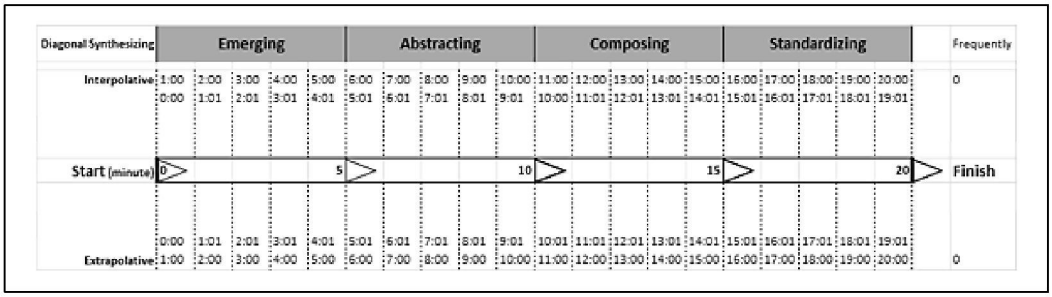


Figure 4.15 Four Theme Categories of Psychomotor Activity "With" Design Insight Strategies

During the think-aloud phase of the VPA method study, the images from the extrapolative and interpolative strategies should be positioned and made easier to mark using the prescriptive study's coding scheme, which allows for the recording of skill movement design as shown in Figure 4.15. The results will fundamentally indicate the moments to validate the datasets' signs and/or contents by prescribing a video recording approach for the psychomotor study's justification. Thus, evidence of qualitative prescriptive methodology will be looked at precise and more comprehensive strategies. Generally, observing the design scheme, coding scheme, or segment within the think-aloud protocol is a way to combine the qualitative strategy (design insight - extrapolative and interpolative) of verbal protocol analysis with an emphasis on design-related thinking and problem-solving.

4.7.3 VPA Events' Environments

An "event" is a specific occasion, episode, or piece of evidence contained in a participant's think-aloud and/or verbal protocol report in a qualitative prescriptive method study. VPA entails gathering and analysing individuals' verbal, written, or drawn expressions as participants undertake a task-directed cognitive process or solve a problem - to be related to novice/young industrial designers. In the context of design pedagogy and online distance learning (ODL) inside the verbal protocol analysis approach, the prescriptive study is a well-recognised term with an "environment" setting.

Table 4.2
First Instruction - Briefing and Timetable of Clinical Survey Activity

Task / Session(s)	Description	Time	Outcome
Session 1	To develop design thinking through the heuristic method intuitively.	3:00 – 3:30 pm	We expose the practice of design experience that enables us to approach the design concept into the new product development.
Design Thinking Presentation (Knowledge & Sharing session)			
Session 2	To explore the intangible ecological form using the Evolution of Form theory.	3:30 – 4:10 pm	We are reaching an understanding of the semantics of design thinking in the design process.
Verbal Protocol Analysis Method (VPA)			

Session 3 Survey – 45 Items of Questionnaires	To measure intangible ecological form through the design's perception from ecodesign identity.	4:10 – 4:40 pm	To address the intangible ecological form of ecodesign identity in new product development.
Closing Submission	Clearance	4:40 – 5:00 pm	-

Thus, the combination of words between event and environmental setting might provide some design insights techniques into how VPA can be utilised in the context of design pedagogy and/or ODL concept. The VPA of design insight strategies can be utilised to study the cognitive processes of design students while they engage in task-directed cognitive processes or design projects within ODL within event environments. This can include examining how students generate ideas, make design decisions, and solve design issues. The instructional branches of VPA event environments are divided into four (4) components, namely: (1) briefing and timetable of clinical survey; (2) theme of drawing evolution; (3) design thinking; and (4) drawing strategy.

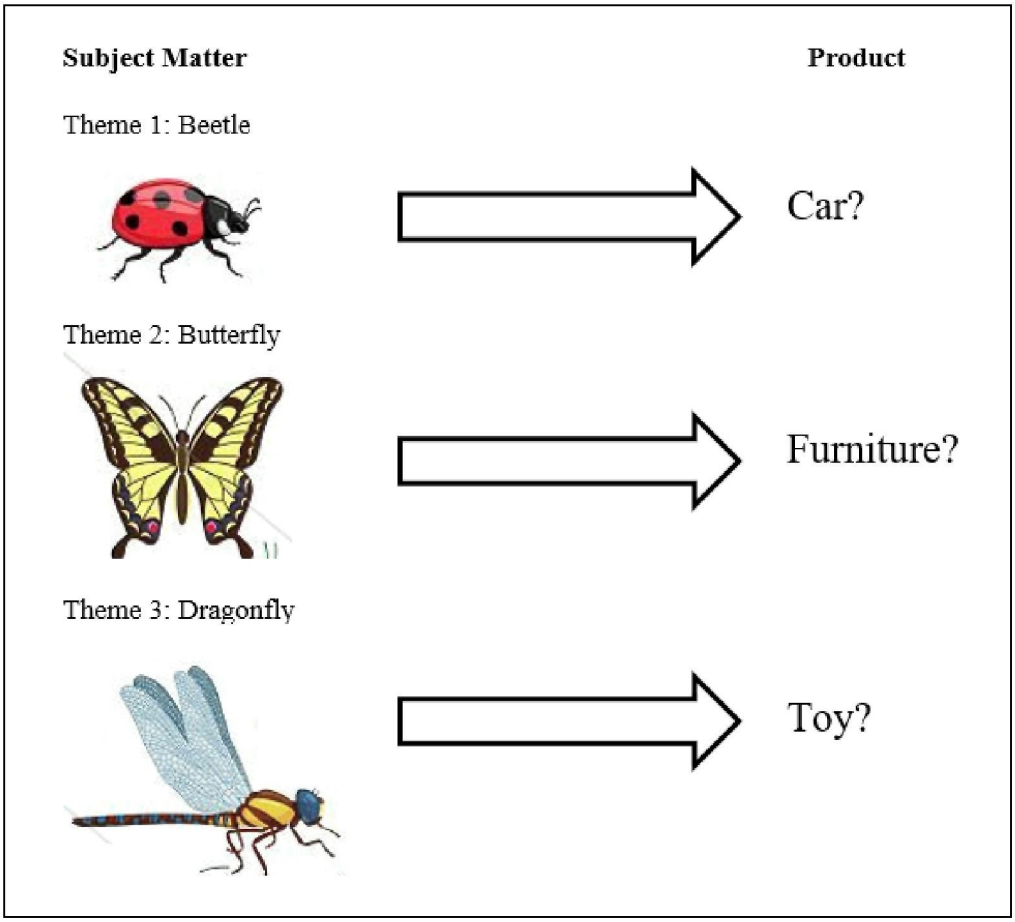


Figure 4.16 Second Instruction – Selection of Three Themes of Drawing Evolution

In Table 4.2, the ODL creates collaborative design projects among the number of session engagement that often involves product clinical adoption of VPA study under the first instruction. They can be used to examine how novice/young industrial designers work together in virtual teams, communicate their design ideas, and jointly make design decisions. The number of sessions including the hours duration are provided. Each description has notified the purpose of the particular session study together with the expectation of outcome needs.

Next, the usability of human-centred design using the VPA method can be employed to assess the novice/young industrial designers' experience of online design tools and platforms used in the concept of ODL. Based on the selection of three themes as Figure 4.16, the subjects' participants must choose or select one: (1) subject matter (insects – animal species) for the design evolution drawing in the VPA method session – following the second instruction. They can provide verbal feedback while interacting with these tools, helping to identify usability issues and areas for improvement.

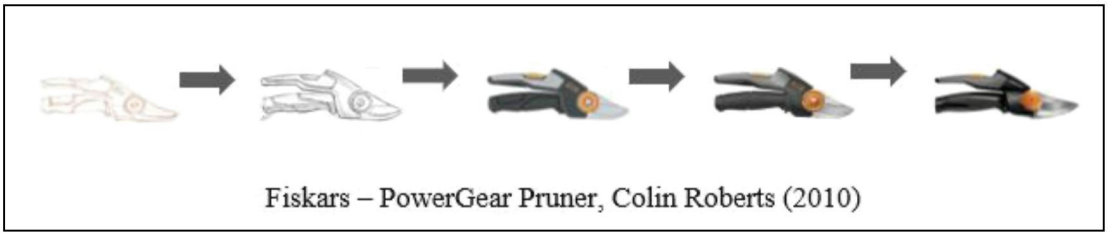


Figure 4.17 Third Instruction (A) - Semantics Design Thinking – An Interpolative Strategy

Source: Chumiran et al. (2018)

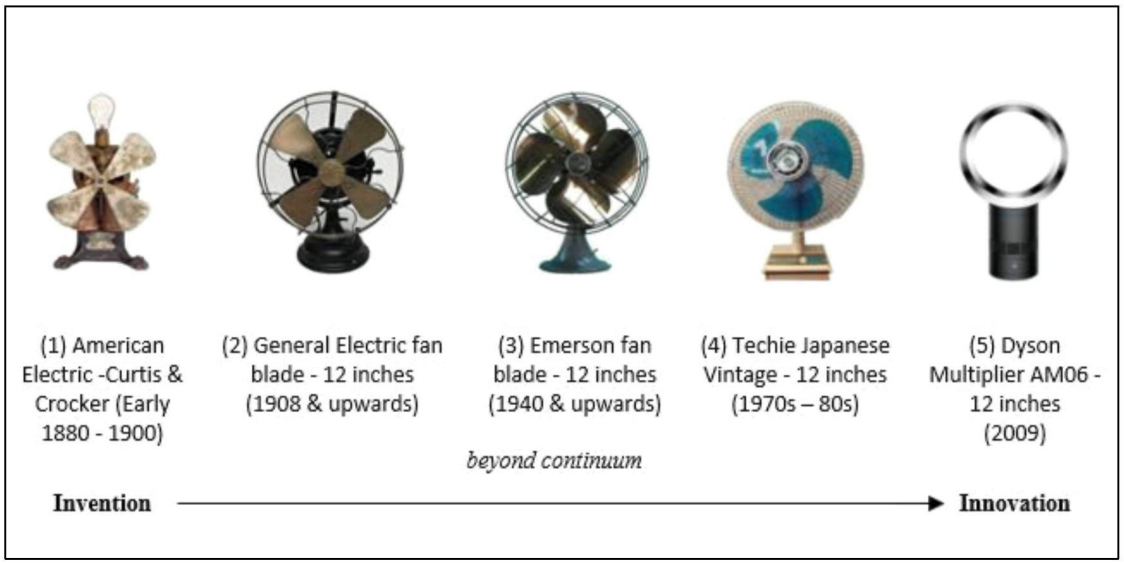


Figure 4.18 Third Instruction (B) - Semantics Design Thinking - An Extrapolative Strategy

Source:Chumiran et al. (2018)

For the fourth instruction as in both Figure 4.17 and 4.18 for the theme of semantics design thinking, an interpolative strategy refers to the explicit semantics of design development from the product form's foundation by "direct" visual and/or mass production physically.

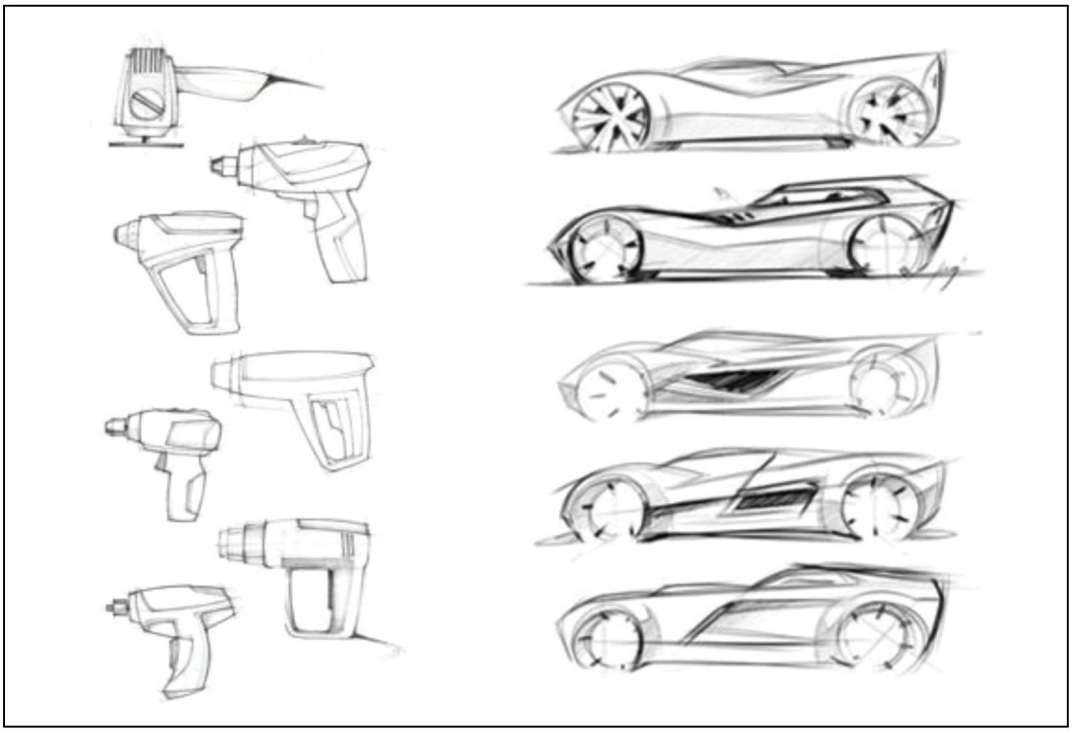


Figure 4.19 Fourth Instruction (A) - 2D Drawing Mode

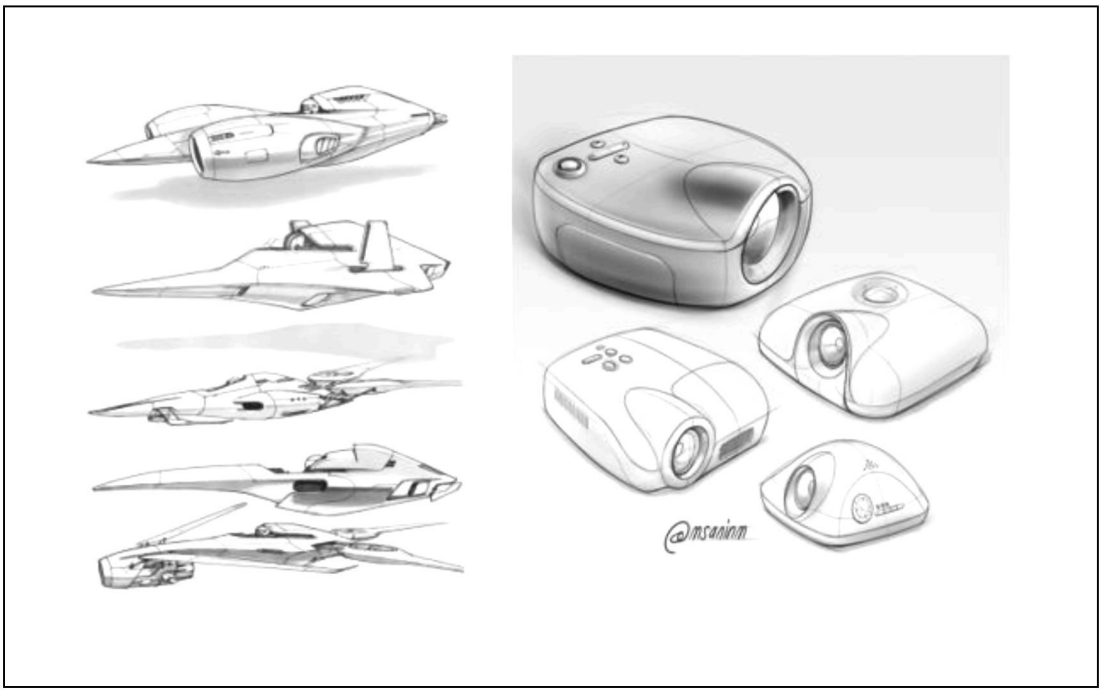


Figure 4.20 Fourth Instruction (B) - 3D Drawing Mode

Meanwhile, the intangible form represents the implicit semantics designs development from the product form's fusion by the "indirect" ecological system of the artefact timeline environmentally and 'beyond continuum' from one of the control images.

Finally, Figures 4.19 and 4.20 depict the fourth instruction. These two design insight strategies aid the beginner/young industrial designer in memorising the imagination of the product upon completion in which one digitally decides to interact with two kinds of drawing methods. Then, for the design evolution drawing, choose one: (1) style of drawing method (2D or 3D drawing mode) using within five (5) points of semantic differential scale (equilibrium to five times of design evolution – mimicry process). This semantic scale will facilitate the prescriptive measurement and provide a systematic way the use the application of SPSS software digitally as the statistics datasets. So, the subjects' participant is actually can choose another rate/number of semantic scales independently. However, the rate/number of the semantic scale should be preferred to count the semantic scale with an odd total ranking number of 7, 9, 11, and so on, to enable the placement of the same value for the SPSS software application. In this case, the VPA can be used to evaluate the success of various instructional strategies in online design pedagogy.

The research study can examine how novice/young industrial designers respond to various teaching approaches and adapt to design processes accordingly. While 2D drawings are more simplistic and flat plane representation – X and Y coordination, 3D drawings add dimension, providing a more realistic and detailed representation of objects and scenes – X, Y, and Z coordination. The choice between 2D and 3D drawing depends on the specific requirements of the task and the level of detail and realism needed. This includes how students respond to personalised design challenges and adapt their design strategies based on system feedback.

Although the term "event environment setting" may refer to a specific concept or methodology in a specific qualitative prescriptive research context, the broader application of the VPA method in online design pedagogy involves understanding and analysing the cognitive processes and experiences of design students in a distance learning environment. The research study can adjust and customise the use of VPA think-aloud to answer specific research questions and educational goals in the realm of industrial design.

In summary, the main distinction between 2D and 3D drawing modes lies in the dimensionality of the graphical representation. 2D drawing focuses on two dimensions, while 3D drawing adds a third dimension to create a more realistic and immersive representation of objects and scenes. The choice between 2D and 3D drawing depends on the specific requirements of the task or application.

4.7.3.1 Online Distance Learning

The notion of the online distance learning (ODL) approach has had a considerable impact on the task-directed cognitive process in the VPA method, particularly during the fieldwork stage – Panel B. The advantage strategies can see: (1) an increase in accessibility; (2) allowing subjects' participation recruitment to spread; and (3) enabling the application of student-centred learning (SCL) comprehensively. Even if the data collection is far away, it is easy to attract participants from various geographical places (Ghassan and Bohemia, 2019). This increased accessibility enables research studies to collect think-aloud verbal protocols from a more diverse and presumably bigger pool of participants, increasing the generalisation of findings. With SCL support, the task activities will be easier and more richness of datasets.

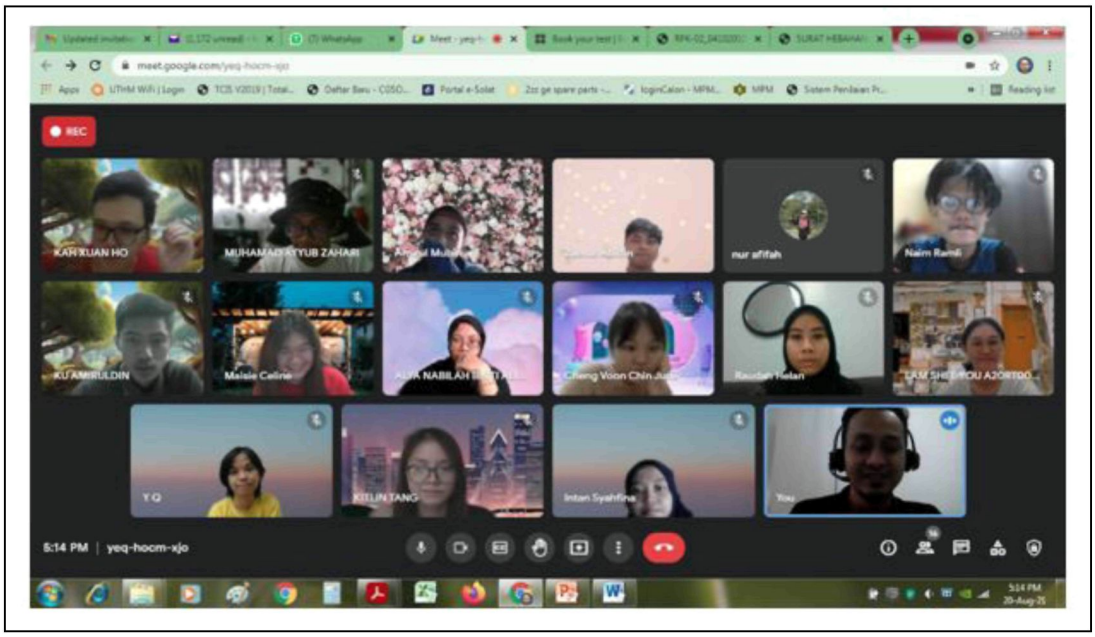


Plate 4.1 Step 1- ODL Method for Gathering Think-Aloud of VPA Method in an Online Setting.

Note: The ODL session begins with (i) on-site mobility setting with webcams/laptop camera online networking and link address provided, (ii) participants information)

In keeping with the current technology movement of Industrial Revolution 4.0 (IR 4.0), ODL frequently takes place in real-world contexts, such as virtual classrooms, online room learning and digital learning environments. The transformation of traditional classroom settings to online platforms (Google Meet/Outlook Microsoft Team/Zoom Meeting/Cisco Webex) has enabled changes in the think-aloud processes involved, resulting in the creation of problem-based learning, which introduces an easier way of real-world systematic study under the problem solution along the research study activity.

In the data collection of the qualitative prescriptive research study, the VPA method executes six (6) disciplines of the ODL approach with: (1) on-site mobility setting with webcams/laptop camera online networking and link address provided; (2) participants' information; (3) design theme briefing and VPA monitoring session; (4) imagery interactions of design insights – interpolative and extrapolative strategies; (5) drawing media and instrument; and (6) design manuscript and/or designing survey.

Following that, ODL's improvement of technology interactions is dependent on technology for communication and collaboration. The research study may be interested in understanding how the use of technology influences cognitive processes, such as how

participants navigate online interfaces, make decisions about digital resources, and interact with peers or instructors in virtual spaces - it can help the study uncover how participants in online settings engage in collaborative tasks, share ideas, and make joint decisions (Tovey, 2015; Ghassan and Bohemia, 2019). Thus, the research study must consider how to approach a new technique for collecting think-aloud of the VPA method in online settings, such as video conferencing, screen recording, chat transcripts, or online discussion boards - most of the task-directed cognitive process from Panel B in examining/clinical trial stage processes as shown Plate 4.1.

In Plate 4.2, in both the drawing session monitoring and activity phases of the ODL method session, there was an analysis of digital artefacts based on the design drawings/sketches development in front of the camera concurrently. Using the ODL for a VPA event atmosphere shows the design influence and/or mood board of digital artefacts, such as digital product design, digital sketching, video sharing websites (social media: YouTube, Facebook, Instagram, and so on), blogger website, and design tutorial websites. The research study can combine this artefact networking into their database analysis alongside the usual VPA approach to acquire a more thorough knowledge of cognitive processes digitally.

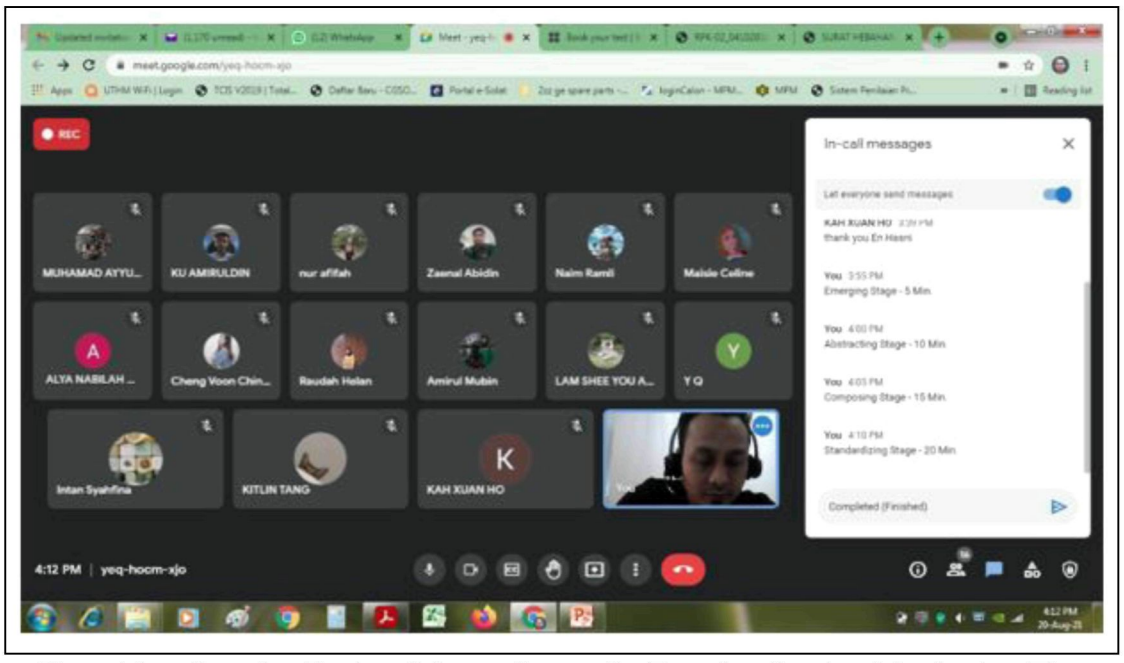


Plate 4.2 Step 2 – Design Scheme Stages for Drawing Session Monitoring The Participants.

Note: After the completion of the information session, the next phase refers to (iii) design theme briefing and VPA monitoring session (iv) imagery interactions of design

insights– interpolative and extrapolative strategies)

For the administrative task of the ODL concept, the online session must be guided by the design scheme stages. Four (4) design scheme stages, such as: (1) emerging; (2) abstracting; (3) composing; and (4) standardising were repeatedly used by the previous mental model - taxonomy of design (refer to Figure 4.13). These four labelling of design scheme stages is very significant, due to the engagement of 20 minutes lead time provided for the task completing the drawing/sketches development as times' punctuality. The spending of time punctuality, therefore, delivery on the five (5) points of semantics differential scale as VPA method settings' requirement. Midst of the ODL activity, the interviewer facilitated asking and informing the subject's participant using the: (1) in-call message; and (2) microphone/audio setting together according to the timetable arrangement as shown in Figure 4.21. An ideal of time provided had been defined and monitored that it is sufficient time for each subject participant to complete the tasks of thinking aloud using the ODL method. The reason of ODL research study has intentionally planned approaches to the instructional context is that it refers to the main concept of the protocol representativeness meaning the design of the experimental study in the problem-centred/based learning concept.

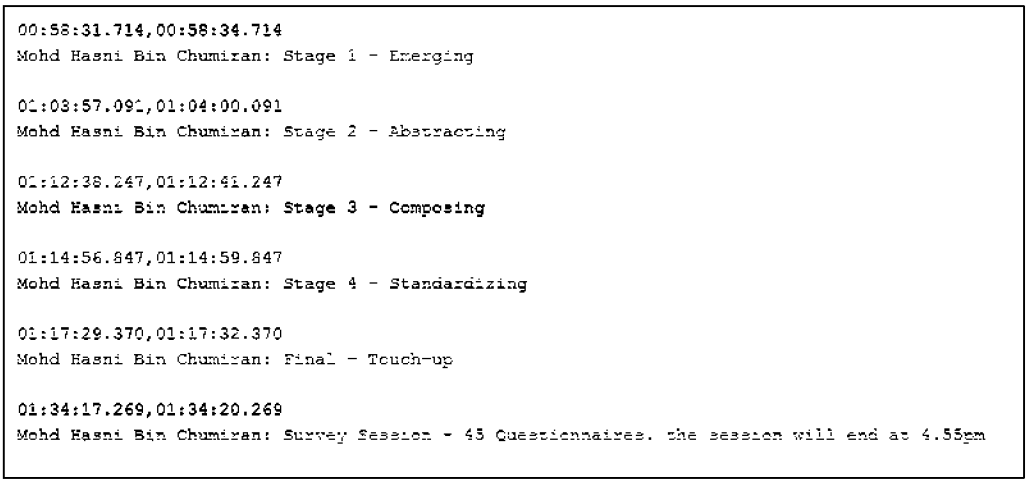


Plate 4.3 Drawing Session Monitoring The Participants'.

Note: The end of monitoring the phase following the (v) drawing media and instrument, there must readily prepared the quick questionnaire session as (vi) design manuscript and/or designing survey

Overall, the conception of online distance learning has opened up new avenues for qualitative prescriptive research in the field of VPA study. It allows the research study to investigate how the subjects' participants adapt to and engage with digital environments, collaborative online spaces, and technology-mediated learning experiences. An industrial design expert Tovey (2015) described distant learning as important according to the technological movement and it coincided with the case study of Global Studio (Ghassan and Bohemia, 2019) referring the transformative learning introduces the solution of problem-centred learning to enable the development in design pedagogy. For instance, the abstraction of research topic finding found an affirmative statement of transformative learning with "…is the key to gaining entry to the various practitioner communities. Each has its signature pedagogy and tutors support their students to become designers in ways specific to particular disciplines. They approach their teaching in qualitatively different ways and engage with the social practices and visual codes which constitute the particular design practice, illustrating them through case studies. This can be approached by strengthening studio culture to provide safe spaces for creative and problem-centred learning and 'gateway' strategies of assessment."

Hence, this evolution in the field contributes to a better understanding of the cognitive processes involved in modern educational settings. Due to digital technology, the attribution of development in design pedagogy networks many different avenues – institutions or organisations. Ghassan and Bohemia (2019) describe an exciting case study of The Global Studio under the global networks with "… utilises a blended learning approach – a combination of face-to-face teaching and online learning – to enable cross-institutional collaboration between universities located in international locations. Though hundreds of students around the world take part in a Global Studio project, at a microscopic scale assignments are conducted in the following manner: a small group of students in one institution utilises web 2.0 technologies to collaborate with a small group of peers at a partner university."

4.7.4 Transcription of Design Manuscript

The process of transforming spoken or handwritten material into a written, electronic, or digital representation is called transcription. When transcription is applied to a design manuscript, there are two components involved: (1) conversion of the VPA

capsule of process model at preliminary works (Panel A portion) into the fieldwork (Panel B portion); and (2) goal purpose. Any handwritten notes, audio recordings of conversations, or other types of data pertaining to the design project should be referred to for the conversion work and typed down into a structured document. This focuses on precisely collecting the material without changing or interpreting it; there have been no modifications made to anything. The aim of transcribing, on the other hand, is to produce a written record of the original information in an easily examined manner that accurately describes the basic data sources. For the transcription of the subjects' participation in drawing process activities, the qualitative prescriptive methodology approaches the audio-visual records, and the keeping of document and visual material records, enabling the creation of notes (Creswell, 2003; Creswell and Clark, 2007).

In the context of research or data analysis from the preliminary works (Panel A), a coding scheme is a set of predetermined codes or categories used to identify and categorise specific data points within the design manuscript for the design representative. This is necessary for the dataset management of data gathering. The preceding subtopic, which pertains to the creation of the VPA design scheme (VPADS), describes the essential transcribing process. The research investigation developed the three VPADS pinpoints as follows:

i) Coding scheme activities are often used following transcription. There must be assistance in organising the categorisation of information inside the article for later assessment.
ii) The strategy of having a coder analyse the material and give pertinent codes to distinct parts or content pieces based on a predetermined set of categories. These codes could be related to themes, topics, or any other significant characteristics of the content.
iii) The coding scheme assists research studies in indicating topic categorisation and displaying evidence-structured data in a way that aids the analysis and discovery of patterns or themes within the design content.

Next, the potential numbers of datasets focus on how the process transcription of transforming the design representation, namely, VsR under the Panel B portion of the VPA capsule as earlier mentioned. In the study, the continuous capsule programme

is consistently required for the data analysis that elements or characteristic datasets can be traced upon the application of design manuscript analysis. The further chapters emphasising (Chapter 5) will cover the three stages of design analysis parameter: (1) data reduction stage – using perceptual mapping in product positioning canvas and Ansoff Matrix for the patterns' themes and tabulation analysis; (2) data display stage – heuristic of quality review analysis for seeking the frequent and/or consistency datasets in interpreting of design manuscripts' goal; and (3) drawing conclusion – to use the kinds of taxonomy chart to show the findings or result reasoning in the outcome of data analysis.

Therefore, the think-aloud from the design manuscript will be expected to show the representative of the vital signs (VsR). The supporting representation of data sources is actually developed by the quality of the pattern/form/symbol of the representation ways. Thus, the outcome of the transcription of the design manuscript can support and reach the appropriate research answers within the research goals' of the DRM framework methodology.

4.7.4.1 Analytic Rubric Evaluation

In the research study, the rubric analysis is required to evaluate the quality of the design manuscript. A rubric evaluation is a tool assessment method that is purposed to assess and grade a task, project, or performance by providing clear criteria and levels of achievement. It helps ensure consistency, transparency, and fairness in evaluation. In formal education, rubrics assessment serves several important purposes in the classroom, helping both educators and students in various ways (Mertler, 2001; Jonsson and Svingby, 2007; Reeves and Stanford, 2009).

According to research studies, the four components of an evaluation rubric are as follows: (1) criteria, which is the fundamental requirement; (2) level of achievement, which is a numerical scale or rating; (3) descriptors, which explain the numerical level achievement; and (4) scoring, which is the value or quantity of points needed to justify a grade. When assessing student performances or products that come from a performance task, Mertler (2001) defines the start of rubric development as based on the scoring instrument. The two possibilities for the scoring instrument - a checklist and rating scales are shown in Figure 4.21. According to Mertler (2001), there are two branches that go beyond the basic rubric for evaluating scale numerical scores: (1)

analytic rubrics; and (2) holistic rubrics. The purpose and areas of interest of these two rubrics are distinct. The analytic rubrics refer to the educators assigning a score to each distinct component of the work or performance first, adding up the individual results to get the final result. Meanwhile, the holistic rubrics show that educators should grade the entire process or output without evaluating its individual components.

However, the research study begins to build the rubric assessment so that it may meet the requirements of the VPA method, also known as the performance task, as previously stated. The outcome of the VPA method provides a design manuscript pattern based on think-aloud processes and participants' living experiences during the mental drawing activity. There are various qualities and requirements for rubric assessment that connect to design education, prescriptive study and pragmatist thinking (Karkehabadi, 2013; Jescovitch et al., 2019).

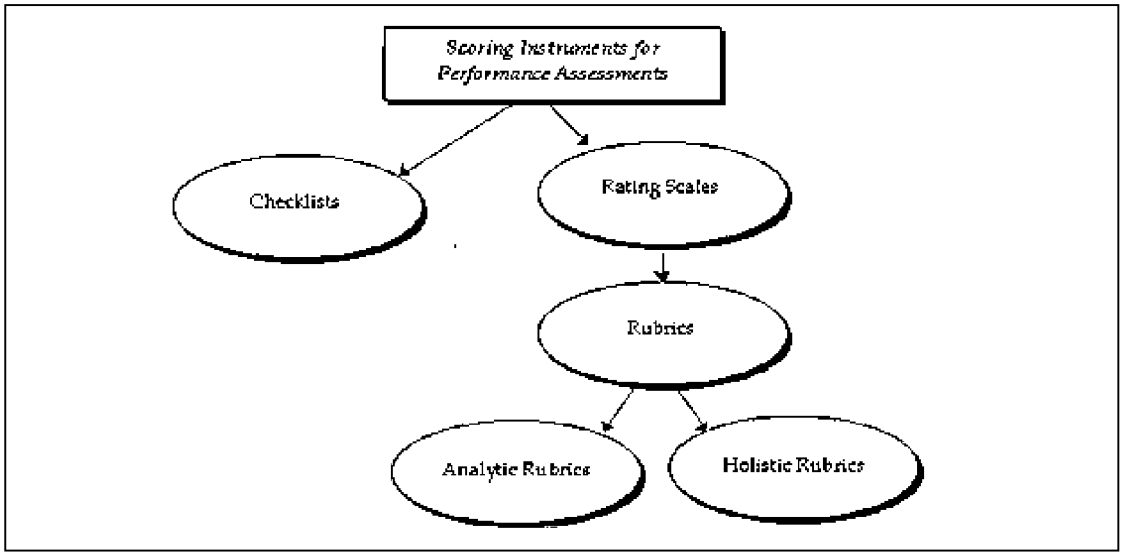


Figure 4.21 Scoring Instrument Develops Types of Rubric Assessment

Thus, the research study decides to emphasise the analytic rubric evaluation (ARE). ARE is a systematic method used to assess the quality of a design manuscript in Plan A – the stage of the preliminary work for In-Vivo study, typically in the context of academic or professional settings following the prescriptive study of the DRM framework. The ARE technique divides the review process into particular criteria and provides a more precise assessment of the manuscript's quality. Professional recommendations for the assessment quality of a design manuscript could be from a variety of design professions, such as industrial design, graphic design, engineering,

architecture, or any other discipline where design plays an important part. In order to produce a proper rating scale concurrently, the research study has selected the industrial design experts Francis D.K. Ching and Steven P. Juroszek (2010) and Jorge Paricio (2014) as a proficiency referral. The usual duties and functions of the ARE created for evaluating a design article in the VPA method requirement are shown in Table 4.3, which contains the assessment study's rubrics following,

i) *Criterion* - The rubric defines particular criteria or aspects to be evaluated in the design manuscript. These characteristics are typically associated with aspects, such as creativity, clarity, technical proficiency, originality, adherence to design principles, and problem-solving skills.
ii) *Objective assessment* - ARE intends to promote objective assessment by dividing the evaluation into different components. This lowers subjectivity and allows assessors to focus on specific parts of the design.
iii) *Scoring guidelines* - ARE gives specific scoring rules for each criterion. It may assign scores using a numerical scale, descriptive adjectives (such as inadequate to excellent), or a combination of the two. This provides consistent grading.
iv) *Feedback and comments* - Evaluators and/or educators can comment on each criterion, highlighting strengths and places for growth, which is useful for designers to better understand their work and improve their abilities.
v) *Comparison analysis and benchmarking* – Rubrics assessment allows evaluators and/or educators to compare multiple design materials in a systematic manner. This is very valuable in academic settings to establish relative performance among students, as well as in professional environments to compare different design proposals.
vi) *Accountability* – Transparency and accountability are provided in the review process by ARE analysis. The rubric helps both designers and assessors understand why a particular score was assigned, which helps to avoid disagreements or miscommunications.

In an educational context, analytic rubrics can be used as a teaching tool. They help students understand the specific expectations for their design work and can guide them in improving their skills and meeting the desired standards. The ARE assessment

should be aligned with the learning or project objectives so that the evaluation process is consistent with the goals of the design project, course, or assignment. For continuous improvement, this reasoning is to ensure that the evaluation process remains relevant. Therefore, ARE evaluations for evaluating design manuscripts give a structured and objective assessment of several areas of a design effort. It assists educators and designers in understanding the strengths and shortcomings of their work, promotes improvement, and consistency in the evaluation process. Thus, further data analysis will be exhibited, along with the specific essential discoveries that might support the beyond Plan B - the fieldwork stage for the in vitro study into the direction of continuum VPA capsule of process model systematically.

Table 4.3
Analytic Rubrics Assessment Sheet for the Preliminary Studies of the VPA Method in the Prescriptive Study Stage

	Criterion(s)/Scale Level	1	2	3	4	5	Score (Multiple 4)
1.	**Duration of drawing practices** – To observe the goal of the preliminary studies.	Insufficient time for the theme design	The development of time for design ideation	Acceptable time for design development	The effective time for emphasising the design concepts	High level of pacing for the final design concept	/20
2.	**Drawing Quality** – To identify the subject's competency in drawing and designing practices.	The line drawing was not an artefact's shape	Contour line drawing produces an object shape layout process	Gesture line drawing produces a continuous rhythmic line in pre-sketch	Corsshatch line drawing has powered the elements of light and shadow (value)	Multiple line drawing emphasises the value of product form and proportion of design	/20
3.	**Visual elements** – To understand the lining characteristics, namely, dot, line, plane and volume of the product form creation.	No perceived heuristic method hermeneutically.	An emerging heuristic continuum for the design artefact/form principle	Acceptable to view the VE spectrum for the design artifact/form composition	Understand the development of the VE continuum for the product form categorisation	Master the VE level hermeneutically through the structure and composition of form development	/20
4.	**Design pattern** – To observe the implicit and explicit design concept for the product form identity.	The product form pattern cannot be specified	Define the type of product shape pattern outlined	Clearly interpret the brand type identity development theme	Conceive the design feature of the design concept entity	Perceive differentiations within the design body with the tangible and intangible identity	/20
5.	**Design semantics** – To identify the semiotic sign in the manual morphing system.	No semantic design and semiotic sign for product morphing	Define the design semantics semiotic sign of design morphing	Clearly interpret the product's semiotic symbol and design morphing	Understand the product evolution of the design morphing	Master the semiotics with the concept of product timeline	/20
Total Score:		0–40	41–55	56–70	71–85	86–100	/100
Proficient:		Very Poor	Poor	Good	Very Good	Excellent	
Comments:							

4.8 Survey Method of Product Clinical Adoption

Initially, a qualitative research technique called the VPA capsule approach is used to get detailed insights into beginner and/or young designers' thought processes and decision-making standards when they engage with a product. With this approach, participants' verbal data is recorded while they use the device and think aloud. This is an explanation of the VPA capsule approach to the survey method of product clinical adoption. The VPA method for preliminary works must be completed in order to start the designing clinical survey in scenario 1. The design scheme of the mental process that emerged from the portable laboratory setting's probing stage will aid in the pilot survey's preparation. It allows the appropriate variables for numerical datasets to be defined and screened. As an outcome, the theory-building process stresses the relevant datasets for product clinical uptake in two directions at once.

Next, the emphasising on the procedure of product clinical adoption refers to the boundaries for the VPA method of research study. When analysing user interactions with a product form, the VPA capsule technique offers a comprehensive, qualitative picture. Through the process of recording articulated ideas and decision-making, researchers can get a profound understanding of usability problems, cognitive difficulties, and adoption-influencing variables. In order to create more efficient and user-friendly treatments, this approach is very helpful for enhancing clinical adoption and product design concepts. Consequently, the stage of examination involves searching for the metaphor process design manuscript and spending the appropriate amount of time on the design representation under scenario 2.

4.8.1 Designing Clinical Survey Method

Significant knowledge of the VPA capsule approach framework is required while studying how to build clinical survey methods. The VPA capsule technique offers a formal framework for evaluating clinical uptake of product form and/or formgiving items using thorough questionnaires. Manufacturing organisations can gather significant information by concentrating on the value proposition, perceived performance, and adoption factors in order to drive product enhancements and promote the product's clinical adoption.

In two scenarios 1 and 2, each study organises the research activities with different aims and protocol strategies. They have to complete the scenario 1 session and then move forward to the next scenario 2 session systematically. However, each session has to commit to the planning categorisation, which is as follows:

a) *Scenario 1* – A product designer evaluates a novice's think-aloud patterns utilising less of a sample in a portable laboratory setting as a diagnostic tool.
b) *Scenario 2* – A young designer and/or novice uses an updated platform online system to document pattern information as an online distance learning setting for design representation with a tiny sample size.

For the questionnaire development, the research study develops a comprehensive questionnaire that covers all aspects of the VPA capsule approach. Starting from the value proposition of design studies, the questions should focus on how the product form is perceived in terms of benefits, efficacy, and overall value to product clinical adoption practice. It should assess product designer satisfaction, product reliability, and outcomes referring to the perceived performance. This respondent's response reflectively delivers the research questions' answers and enables us to reach the solution for the problem-solving. Thus, there should be identified both internal and external factors affecting adoption, such as ease of use, integration with existing methodological systems, data triangulation, data saturation, and philosophical assumption support. In order to illustrate the appropriate research methodology in the data collection process within the categorisation of two relationships between the pilot survey (qualitative preliminary works) and fieldwork survey (qualitative fieldwork) using the combination of scenarios 1 and 2, another sub-topic will be displayed.

4.8.1.1 Pilot Survey and Fieldwork

The relationship activities of two research methodology observations such pilot survey and fieldwork survey have a vital research methodology of the DRM framework. It is a mandatory stage that the study should consider the differentiation of the roles and responsibilities together. On the other hand, the mandatory stage reasoning is developed by the VPA capsule of the process model discussed previously which means the

combination of Panel A and Panel B delivers the benefit of relationship methodological study concurrently. The benefit of these two relationship activities is to develop the validity and reliability of the framework procedure. Using the existing formulation of the research framework, it must be tested properly and it enables the consistent outcome of the DRM framework.

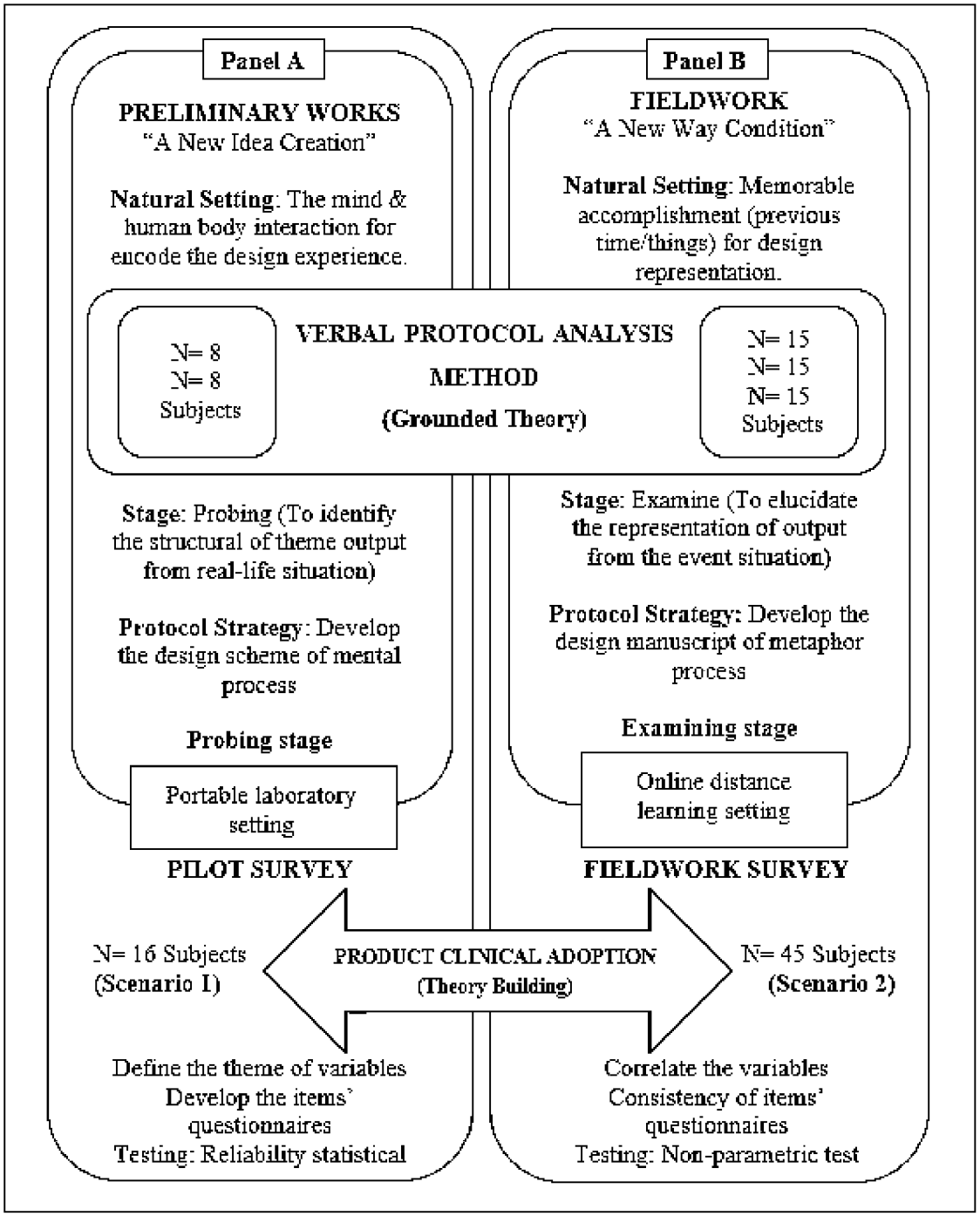


Figure 4.22 A Detailing for VPA Boundaries Approach of Accessibility Research Between In Vivo Study: Preliminary Works and In Vitro Study: Fieldworks

In Figure 4.22, there are actual boundaries between the in vivo study: preliminary works as Panel A and the in vitro study: fieldwork following the VPA method process as the Panel B. The separation of the VPA method process is very significant in that it can convey the context of the combination of Plans A and B.

4.8.2 Scales Instrumentation

The instrumentation of items in questionnaires for clinical survey research plays a crucial role in collecting reliable and valid data. This process involves designing and structuring the questionnaire to gather specific information effectively and accurately. The content of the clinical survey is usually used with the visual aid and/or image as an artefact product form that can demonstrate the meaning of the type of question together with the items' scale as Table 4.4. The main reason to apply the visual aid and/or image is to present the content validity in the context of the industrial design field. This content validity ensures that the questionnaire adequately covers all relevant aspects of the construct being studied. Instrumentation involves selecting and phrasing items that cover a broad spectrum of the construct to ensure comprehensive measurement. Scale instrumentation helps establish the construct validity of the questionnaire according to four (4) types of measurement scale, namely: (1) nominal; (2) ordinal; (3) interval; and (4) ratio.

First, the nominal scale is the simplest level of measurement that categorises data into distinct, non-overlapping categories or groups. Usually, categories are typically named or labelled without any inherent order or ranking – the dichotomous scale uses "Yes" and "No" and the category scale uses multiple items to elicit a single response. Also, the study cannot perform mathematical operations.

Second, the ordinal scale involves categories or groups that have a natural order or ranking or rating. It indicates the relative position or rank of items in a particular characteristic but does not provide information about the magnitude of differences between them. In this ordinal scale, there are several forms of scale ranking or rating, and it should be related to the nominal scale as the same used for the context of visual aid before. Sekaran and Bougie (2016) prepared five (5) types of ranking or rating scales, such as,

i) *Semantic differential scale* – "Several bipolar attributes are identified at the extremes of the scale, and respondents are asked to indicate their attitudes, on what may be called a semantic space, toward a particular individual, object, or event on each of the attributes. The bipolar adjectives used might employ such terms as Good–Bad; Strong–Weak; Hot–Cold. The semantic differential scale is used to assess respondents' attitudes toward a particular brand, advertisement, object, or individual" (Sekaran and Bougie, 2016).

ii) *Numerical scale* – "The numerical scale is similar to the semantic differential scale, with the difference that numbers on a five-point or seven-point scale are provided, with bipolar adjectives at both ends" (Sekaran and Bougie, 2016).

iii) *Itemised rating scale* – "A five-point or seven-point scale with anchors, as needed, is provided for each item and the respondent states the appropriate number on the side of each item, or circles the relevant number against each item, as per the examples that follow" (Sekaran and Bougie, 2016).

iv) *Likert scale* – "The Likert scale is designed to examine how strongly subjects agree or disagree with statements on a five-point scale. The responses over a number of items tapping a particular concept or variable can be analysed item by item, but it is also possible to calculate a total or summated score for each respondent by summing across items" (Sekaran and Bougie, 2016).

v) *Graphic rating scale* – "A graphical representation helps the respondents to indicate on this scale their answers to a particular question by placing a mark at the appropriate point on the line" (Sekaran and Bougie, 2016).

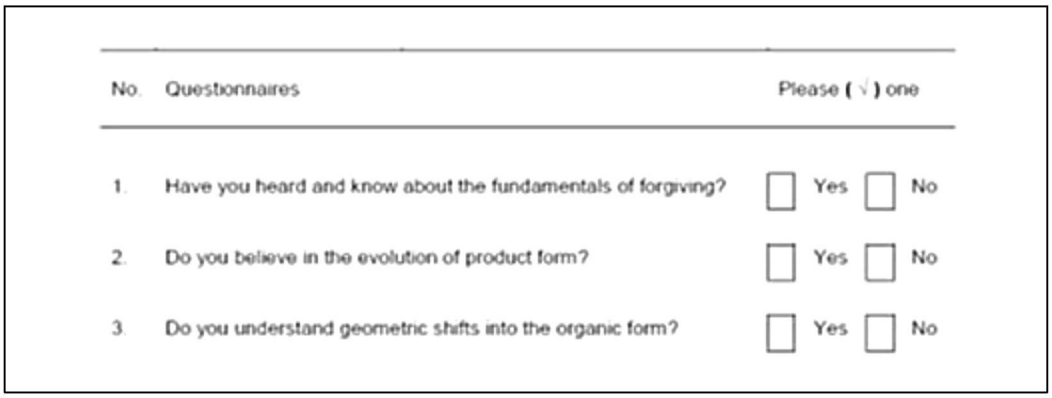
Third, the interval scale includes ordered categories with equal intervals between them. It provides information about the magnitude of differences between values but lacks a true zero point. For example, temperature in Celsius or Fahrenheit is a common example of an interval scale - 30°C is 10°C warmer than 20°C, the study cannot say that 30°C represents zero temperature.

Fourth, the ratio scale is the most advanced level of measurement and has all the properties of the other three scales (nominal, ordinal, and interval), plus it has a true zero point. A true zero point means that a value of zero indicates the complete absence of the measured attribute. Examples of ratio scales include age, height, weight, income, and time. In these scales, a value of zero signifies the absence of the attribute (e.g., zero age, zero weight).

Table 4.4
Construct Validity of Items' Scales Instrumentation for CA Survey

Part(s)	Section(s)	Purpose(s)	Application of Scale(s)	Questions
A	A Short Design Brief	To describe and explain the design thought of participants.	Not applicable	Not applicable
B	Demographics	To show the participation of respondents invalidating the answers and sources of data collection.	Multiple Choice	Not applicable
C	C1	To label the variables of product category towards an intangible ecological form identity.	Nominal	Q1 – Q5
	C2 & C3	To recognise some visual elements of product design following the design thinking.	Semantic Differential Scale	Q6 – Q15
	C4 & C5	To measure the perception of design belief (axis X&Y), using a 5 point Likert scale design to validate the intangible ecological form of ecodesign.	Likert Scale	Q16 – Q25
	C6 & C7	To seek the emotion of a product's form quality (axis X&Y), using a 7 point numerical scale design in the heuristic procedural step.	Numerical Scale	Q26 – Q35
	C8 & C9	To elaborate an intangible ecological form for ecodesign using the level of ratio scales following on the product's form and its functional unit.	Ratio Scale - Multiple Choice for "Duration/Series" as Time Contex	Q36 – Q45

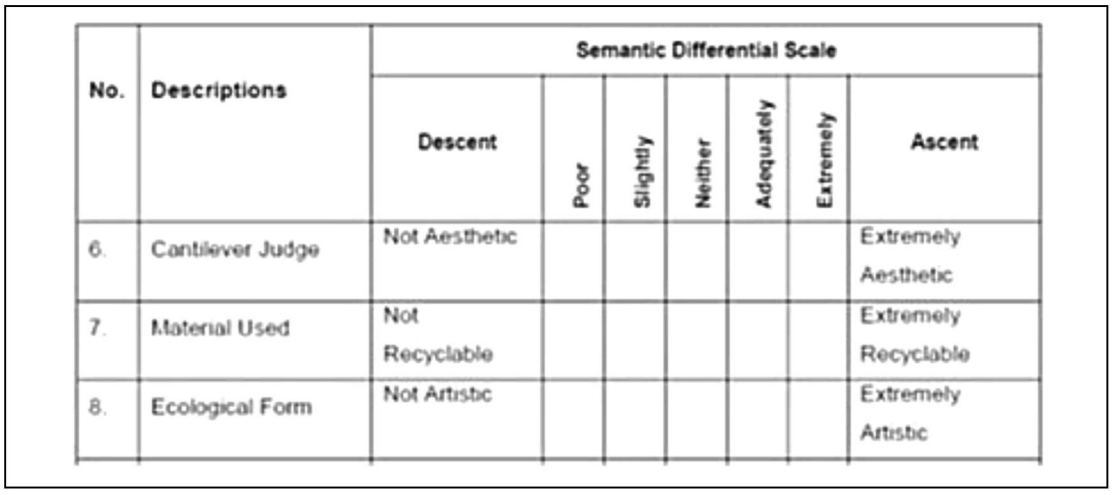
In Figure 4.23, using Yes/No replies in surveys and questionnaires is a frequent technique in nominal studies to establish construct validity. The goal is to assign a name to the product category's variables in order to represent an intangible ecological form identity. Respondents have clear, unambiguous options thanks to the nominal scale with Yes and No options, sometimes known as binary choices - provide accurate responses. The scale pattern appears to be a direct measurement of the inherent dichotomy of many social science and medicinal categories.



No.	Questionnaires	Please (√) one
1.	Have you heard and know about the fundamentals of forgiving?	☐ Yes ☐ No
2.	Do you believe in the evolution of product form?	☐ Yes ☐ No
3.	Do you understand geometric shifts into the organic form?	☐ Yes ☐ No

Figure 4.23 Nominal Scale for Items Q1 – Q5; Labelling "Yes" and "No"

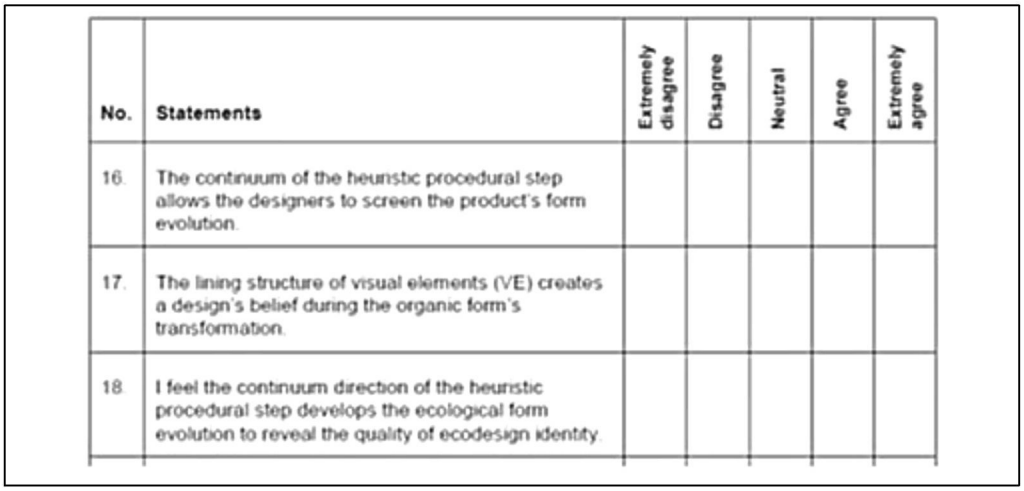
In Figure 4.24, a kind of rating scale used to gauge the connotative significance of things, occasions, or ideas is the semantic differential scale. This scale, when used in conjunction with construct validity, helps guarantee that an instrument or survey assesses the notion it is supposed to measure. It becomes easier to identify some visual components of product design when design thinking is applied. concept validity is increased by using a semantic differential scale with labels like: (1) Poor; (2) Slightly; (3) Neither; (4) Adequately; and (5) Extremely. This is because the scale captures complex answers, measures subjective impressions, and offers an in-depth understanding of the concept under study. This method not only increases the instrument's reliability and validity but also allows for more advanced statistical analysis, guaranteeing that the survey or tool truly represents the desired construct.



No.	Descriptions	Semantic Differential Scale						
		Descent	Poor	Slightly	Neither	Adequately	Extremely	Ascent
6.	Cantilever Judge	Not Aesthetic						Extremely Aesthetic
7.	Material Used	Not Recyclable						Extremely Recyclable
8.	Ecological Form	Not Artistic						Extremely Artistic

Figure 4.24 Semantic Differential Scale for Items Q6 – Q15; Labelling: (1) Poor; (2) Slightly; (3) Neither; (4) Adequately; and (5) Extremely

In Figure 4.25, a typical sort of Likert scale found in surveys and questionnaires is a numerical scale labelled with: (1) Extremely Disagree; (2) Disagree; (3) Neutral; (4) Agree; and (5) Extremely Agree. The purpose of this scale is to gauge respondents' views, beliefs, or perceptions regarding a specific concept. Its goal is to validate the intangible ecological form of ecodesign by measuring the perception of design belief (axis X&Y) using a 5-point Likert scale. This measure improves data dependability and precision, allows for thorough statistical analysis, and measures a broad variety of attitudes and views. This Likert scale contributes to ensuring that the survey or instrument measures the desired construct effectively by offering a comprehensive and nuanced grasp of respondents' perspectives.



No.	Statements	Extremely disagree	Disagree	Neutral	Agree	Extremely agree
16.	The continuum of the heuristic procedural step allows the designers to screen the product's form evolution.					
17.	The lining structure of visual elements (VE) creates a design's belief during the organic form's transformation.					
18.	I feel the continuum direction of the heuristic procedural step develops the ecological form evolution to reveal the quality of ecodesign identity.					

Figure 4.25 Likert Scale for Items Q16 – Q25; Labelling: (1) Extremely Disagree; (2) Disagree; (3) Neutral; (4) Agree; and (5) Extremely Agree

In Figure 4.26, a numerical scale labelled with adjectives that range from a positive extreme (7) to an antithesis: (1). This scale is designed to assess the connotative meaning of concepts, objects, or experiences by measuring the strength of respondents' attitudes along a continuum. In the heuristic procedural phase, it seeks the emotion associated with a product's form quality (axis X&Y) using a 7-point numerical scale. For pattern detection, analysing the scale data can assist in identifying patterns and correlations that support construct validity, providing empirical proof that the instrument accurately measures the desired construct. The precision, in-depth analysis, and thorough evaluation of the construct offered by this scale add to the measurement device's accuracy and dependability.

No.	Questionnaire	7 points of Numerical Scale							
		Adjectives	7	6	5	4	3	2	1	Antithesis
26.	How is the continuum's quality of the heuristic procedural step?	Convergent								Divergent
27.	How is the product's form transformation through the VE?	Organic								Geometric
28.	Did the quality of design development deliver an ecodesign identity?	Beauty								Ugly

Figure 4.26 Numerical Scale for Items Q26 – Q35; Labelling Adjectives 7 Score Until Antithesis 1 Score

In Figure 4.27, for multiple choice questions, a ratio scale In surveys and evaluations, calculating "Duration or Series" within a temporal framework is an effective tool. This kind of scale gives absolute numbers with a genuine zero point in addition to capturing the frequency or duration of an event. Its goals are to develop an intangible ecological form for ecodesign by applying ratio scales at varying levels based on the form and function of the product. Ratio scales are useful for identifying absolute values because they have a real zero point, which denotes the total absence of the quantity being measured (zero minutes, zero occurrences, etc.). This enables accurate comparisons and absolute measurements. For example, there is a research study to treat health clinical that measures the frequency of drug adherence. Hence, the natural query to the patient is "How many times did you take your medication as prescribed in the last week?". The predicted answer should then be listed as 0, 1-2, 3-4, 5-6, and 7 or more times. The construct validity of multiple-choice questions measuring "Duration or Series" in a temporal context is greatly improved by the use of a ratio scale. An in-depth and comprehensive examination of the construct is made possible by this method's precise, absolute measurements with a real zero point. Ratio scales guarantee that a survey or assessment instrument measures the desired variable precisely by capturing the entire range of temporal data. This allows for thorough and meaningful comparisons, trend analysis, and insights into the construct.

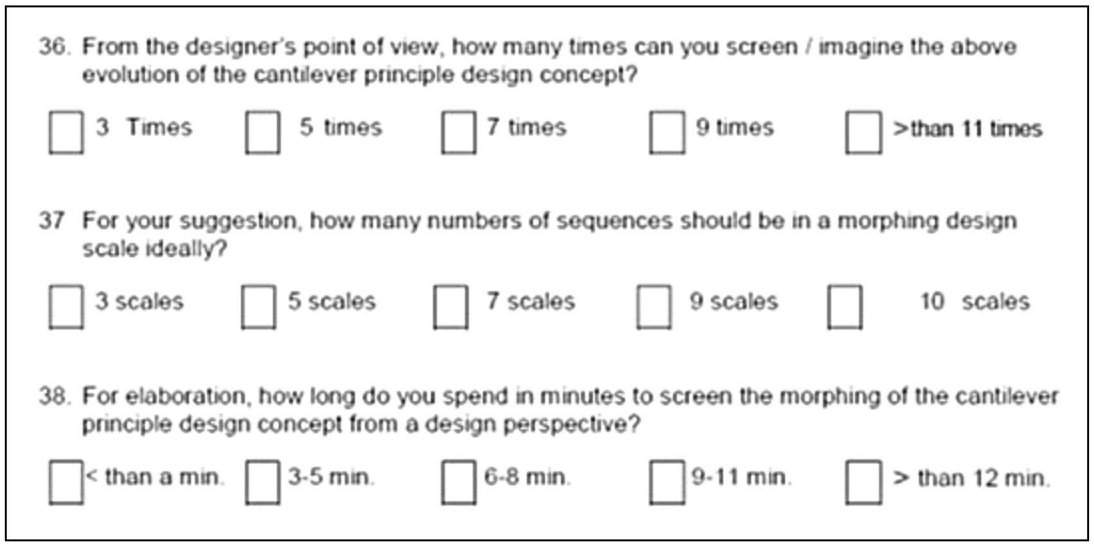


Figure 4.27 Ratio Scale - Multiple Choice for Items Q36 – Q45; Multiple Choice for "Duration/Series" as Time Context

However, understanding the type of scale used is important in research and data analysis because it dictates the appropriate statistical and mathematical operations that can be performed on the data and influence the level of detail, suitable statistical testing method and interpretation. Hence, that can be derived from the measurements. Thus, this means that the items should accurately represent the underlying psychological or clinical constructs being investigated especially in the industrial design field context.

4.8.2.1 Questionnaire Items

Individual questions or statements included in a survey or questionnaire with the purpose of gathering certain data from respondents are known as questionnaire items. Each item's objective is to collect data on a specific facet of the study topic or hypothesis. Opinions, actions, expertise, demographic data, and other things can all be evaluated by the research project. Generally, a research study will use one of two question kinds to collect data: closed-ended questions or open-ended questions. In a quantitative approach, closed-ended questions are those that use numerical or countable phrasing to provide predetermined possibilities for responses (such as multiple-choice, Yes/No, or rating scales). As for the open-ended questions, they are designed to let respondents respond in their own words, which results in deeper, qualitative data utilising a qualitative technique that uses non-numerical or uncountable phrasing.

In the study, introduce the research title, purpose, interviewer status or background, and provide a brief introduction at the outset of each questionnaire topic. The dataset should then be organised by section and/or component that can handle it and apply statistical testing methods or data analysis tools like the statistical package for the social sciences (SPSS) software. The first content question must be followed by three fundamental elements under the section and/or part: The following questions are asked: (1) about demographic refers to age, gender, and education level in Appendix 12 and 13; (2) about behaviour displays to the food habits and exercise frequency; and (3) about attitudes towards politics and service satisfaction as earlier mentioned via construct validity of items' scales instrumentation for CA study survey in Table 4.4. The research study ideally used to rehearse the survey structure methodically in order to construct the questionnaire item to develop the structural validity and reliability datasets concurrently, it is necessary to practise the survey format. For the survey structure, which is related to time or duration referring to the total number of question items is essential. The survey must first be piloted by the research study with the appropriate respondents, chosen correctly.

Table 4.5
Questionnaire Items Distribution in Pilot Survey - Scenario 1

Part(s)	Section(s)	Application of Scale(s)	Items	Estimate Percentage (%)
C	C1 & C2	Nominal – dichotomous scale	10 Items	20%
	C3 & C4	Likert scale	10 Items	20%
	C5 & C6	Numerical scale	10 Items	20%
	C7 & C8	Ratio Scale - Multiple Choice for "Duration/Series" as Time Context	10 Items	20%
	C9	Ordinal scale - Multiple Choice for general items	10 Items	20%
		Total	50 Items	100%

In Table 4.5, the entire set of 50 items for the questionnaires in the pilot survey has been prepared. The VPA technique assessment is followed by a face-to-face instrument distribution. The respondent is the same candidate who took part in the clinical assessment using the VPA approach. The research study promotes the same

subject to sit and complete the survey's task completion because of short-term memory issues in the design studies. The practice from Scenario 1 of the VPA capsule approach is continuously influenced by the DRM framework strategies.

According to Sharma (2022), a well-crafted questionnaire should consist of no more than 25 to 30 questions and be completed in less than 30 minutes in order to maintain participants' interest and focus clinically. There is a propensity for participants to speed through or satisfice through the questions as the number of questions grows, which has a negative impact on answer rates, quality, and dependability. In order to provide respondents enough time to interact with the survey instrument, future survey instruments must limit the number of question items. Nonetheless, they have an outstanding procedure to take into account, which is the method or plan to enhance the instrumentation of the survey questions. In order to accomplish a maximum as well as appropriate consistency and reliability study, the research study endeavours to produce the additional medium.

Here, the process of designing questionnaires throughout the data-gathering phase heavily relies on item analysis for improvement. These two elements enhance the medium's or tool's validity's credibility in order to guarantee internal consistency and dependability throughout the survey's instrumentation. Item analysis helps to guarantee consistency by ensuring that every item on a scale measures the same underlying construct. Increased internal consistency, as determined by Cronbach's alpha, indicates a strong correlation between the items and their ability to measure the construct as a whole. On the other hand, trustworthy questionnaires yield consistent findings for many samples and scenarios. Removing or changing items that decrease reliability increases the likelihood that the questionnaire will produce reliable results. As a consequence, the datasets that should be produced by the internal scale of reliability analysis testing method's results will be exposed by the SPSS program through the assessment of Cronbach's alpha value following,

a) *Item-total correlation* – Below 0.3 indicates that the item may not be adding much to the scale overall and should be reevaluated or possibly deleted.

b) *Alpha if Item Deleted* - Items that have a negative impact on the overall reliability can be found by looking at the value of Cronbach's alpha if an item is removed. It may be worthwhile to take an item out of the scale if its removal raises the alpha.

The research study tested the instrument survey so that it could expose the specific error data entry as 50 items obviously as Figure 4.28. By following these simple guidelines, the research study can ensure accurate data entry and carry out a comprehensive scale reliability analysis in SPSS software. Research study findings will be more reliable and high-quality overall if you ensure precise data entry and carefully evaluate the outcomes. This reduction in question items is required for the evidence and confidence level requirement, which pertains to the trustworthiness of consistency and reliability recognition. Table 4.6 clearly shows that the case processing summaries were computed using 100% genuine cases. However, a "Poor" Cronbach's alpha finding (0.565) valued for the reliability statistics suggests that the recognition of N items is accepted with just 49 as in Table 4.7. Again, the data entry (Figure 4.28) was then affected by the removal of question items from the scale as a warning notification, namely: (1) C2. Design Pattern Evolution - refer to Appendix 14.

```
RELIABILITY
/VARIABLES=C1 C2 C3 C4 C5 C6 C7 C8 C9 C10 C11 C12 C13 C14 C15 C16
C17 C18 C19 C20 C21 C22 C23 C24 C25 C26 C27 C28 C29 C30 C31 C32
C33 C34 C35 C36 C37 C38 C39 C40 C41 C42 C43 C44 C45 C46 C47 C48
C49 C50
/SCALE('16 students') ALL
/MODEL=ALPHA
/STATISTICS=DESCRIPTIVE SCALE
/SUMMARY=TOTAL CORR.
```

Warnings

Each of the following component variables has zero variance and is removed from the scale: C2. Design Pattern Evolution

Figure 4.28 SPSS Data Input Presented The Whole 50 Questionnaire Items Included "with" The Warning Notification as One Missing Items with Zero Variance

Table 4.6
Case Processing Summary – Scenario 1

		N	%
Cases	Valid	16	100.0
	Excluded	0	.0
	Total	16	100.0

a. Listwise deletion based on all variables in the procedure.

Table 4.7
Reliability Statistics – Scenario 1

Cronbach's Alpha	Cronbach's Alpha Based on Standardised Items	N of Items
.565	.527	49

In Table 4.8, a total of 45 items were employed in the clinical fieldwork survey (Scenario 2) due to the reduction of questionnaire items. Practically speaking, the research study purposefully kept the survey item Q2-Evolution of product shape. Because it is related to the literature review's synthesised contents, design knowledge has emerged to support the context of design beliefs. Only a few minor adjustments were made: (1) the original 10 question items on the Nominal scale were reduced to 5; (2) a new semantic differential scale was added to boost confidence and reliability; and (3) the question items no longer included the Ordinal Multiple Choice scale. This small adjustment action can be seen in the SPSS testing method's findings under "Alpha if Item Deleted."

In Table 4.9, the case processing summary indicates that 100% of the cases are clearly valid. The N items are computed in each section of the question items, and a new labelling data entry including the Q1 through Q45 questionnaire items is produced.

In Table 4.10, 45 questionnaire items were completed; and the warning notification for missing items with zero variance. Missing items with zero variance in the warning notification are the reason for the deduction of N of the 50 items that are displayed before as Figure 4.29. With "Very Good Reliability" computed at 0.812, the Cronbach's Alpha value expectation increases. Therefore, under the general guidelines for reliability statistic value, changing the questionnaire items affected the value performance of Coefficient Alpha (α) – refer to Appendix 15. These rules of thumb will be discussed in a further sub-topic.

Table 4.8
Questionnaire Items Distribution in Clinical Fieldwork Survey – Scenario 2

Part(s)	Section(s)	Application of Scale(s)	Items Questions	Estimate Percentage (%)
C	C1	Nominal - dichotomous scale	5 Items	11.11%
	C2 & C3	Semantic Differential Scale	10 Items	22.22%
	C4 & C5	Likert Scale	10 Items	22.22%
	C6 & C7	Numerical Scale	10 Items	22.22%
	C8 & C9	Ratio Scale - Multiple Choice for "Duration/Series" as Time Contex	10 Items	22.22%
		Total	45 Items	100%

```
RELIABILITY
/VARIABLES=Q1 Q2 Q3 Q4 Q5 Q6 Q7 Q8 Q9 Q10 Q11 Q12 Q13 Q14 Q15 Q16
Q17 Q18 Q19 Q20 Q21 Q22 Q23 Q24 Q25 Q26 Q27 Q28 Q29 Q30 Q31 Q32
Q33 Q34 Q35 Q36 Q37 Q38 Q39 Q40 Q41 Q42 Q43 Q44 Q45
/SCALE('45 students') ALL
/MODEL=ALPHA
/STATISTICS=DESCRIPTIVE SCALE
/SUMMARY=TOTAL CORR.
```

Figure 4.29 SPSS Data Input Presented The Whole 45 Questionnaire Items Included "without" The Warning Notification for Missing Items with Zero Variance

Table 4.9
Case Processing Summary – Scenario 2

		N	%
Cases	Valid	45	100.0
	Excluded[a]	0	.0
	Total	45	100.0

a. Listwise deletion based on all variables in the procedure.

Table 4.10
Reliability Statistics – Scenario 2

Cronbach's Alpha	Cronbach's Alpha Based on Standardised Items	N of Items
.812	.792	45

4.8.3 Rules of Thumbs - Reliability Statistic Value

Internal consistency is measured by Cronbach's alpha, which is frequently used to evaluate a scale or test's dependability. Rules of thumb offer helpful suggestions for interpreting the reliability of the scale and selecting possible ways to enhance it in the context of Cronbach's alpha data analysis. The following are a few widely used guidelines for interpreting Cronbach's alpha,

Table 4.11
The Rules of Thumb For Reliability Statistic Value

Category	Coefficient Alpha (α)
Very Good Reliability	> 0.8
Good Reliability	0.7 – 0.8
Fair Reliability	0.6 – 0.7
Poor	< 0.6

Source: Zikmund et al. (2009)

The general guidelines for reliability statistic values in Table 4.11 are quite important for understanding the design survey activities, particularly with regard to the instrument performance evidence that systematically examines the improvement progression between datasets of Scenario 1 and Scenario 2. These general guidelines can be used to rapidly evaluate and decipher a scale's dependability using Cronbach's alpha. But, especially when making crucial decisions based on the scale's reliability, it is crucial to supplement these heuristic recommendations with more thorough statistical analysis and theoretical considerations. Thus, the emphasis on SPSS analysis will be explained in more depth in Chapter 5, specifically in relation to the descriptive research that is in line with the requirements of the DRM framework.

4.9 Critical Literature Review

The literature review is a synthesis of scientific writing from the existing scholarly literature conducted by the researcher and/or specialist in the domains or disciplines. A literature review places what is being studied within the existing body of knowledge, offering a foundation and context for the study. It assists in identifying gaps or places where extra research is required, directing scholars to give new insights or answer outstanding issues. The research study might propose research questions or hypotheses based on current literature that build on prior findings or fill knowledge gaps.

A literature study examines methods used in prior studies and identifies best practices, influencing the selection of research methodology and design. It helps to establish a theoretical framework by reviewing the important theories and concepts that underpin the research. As a result, the research study conducts a literature review to identify essential ideas, themes, variables, codings, and constructs pertinent to their study, ensuring that their findings are clear and precise. Existing research must be thoroughly evaluated, including techniques, conclusions, and limits, to identify strengths and flaws and shape the study's path.

At the time, five key forms of literature reviews should be considered and categorised, such as: (1) narrative literature review; (2) systematic literature review; (3) meta-analysis literature review; (4) scope literature review; and (5) critical literature review. In the current research topic, the research study selects an appropriate for conducting a critical literature review (CLR), which should include evaluating and analysing existing literature in depth (a grounded theory heuristically), frequently with a special theoretical or methodological focus. It may entail evaluating the quality of research, investigating underlying assumptions, and challenging accepted interpretations or paradigms. All of these components are discussed in the previous Chapter 3. Therefore, the further literature review analysis focuses on the similar contents of CLR that it must refer to the theoretical development for the PS stage of DRM framework and let's uniform sequences together within the current research assumption following ontology, epistemology and methodology.

In the PS stage of the DRM framework, the selection of the thematic analysis method is decided for the research topic so that the qualitative methods reasoning reaches the research objectives and research questions accordingly. Due to the

attribution of the articulated dataset in both TD knowledge and methodological assumptions are driven by the PS stage of the DRM framework, both sources supplied from the VPA method which is the development of design observation based on the product communication interacts with consumers called pragmatism. Again, there was following the concept of ecodesign identity the PS stage is significantly developing the product form imagery (representation) in design thinking among novice or young industrial designers. Then, the improvement in the quality of product form shifts concurrently. The study subjects will explore a design method procedure referring to a think-aloud of the cognition of young industrial designers towards design thinking among Malaysian design education institutions. The meaning of a think-aloud of cognition describes the verbalisation of designing patterns and/or themes that could be possibly delivered in the context of ecodesign identity systematically. In simple terms, the research study of the literature review clearly demonstrates pragmatism and/or pragmatic characteristics. Only the heuristic technique allows for CLR extraction and the ability to screen and oversee the interpretation of philosophical pragmatism.

The development of a CLR is highly important in the early stages of preparing and maintaining article sources. The term "preparation" refers to the database's justification for conducting acceptable literature research on secondary source issues. The datasets are typically derived from well-known web online databases, such as: (1) Google Scholar; (2) Web of Science; and (3) Scopus. Other database sources for literature reviews are recognised using Publon Clarivate and/or the Open Researcher and Contributor Identifier (ORCID). While managing a literature review should be counted in broad terms of decade or years, as well as the issue within the topic. Thus, the following sub-topic will clarify what types of method strategies can be used to purposefully traverse theoretical development during the conceptual framework, which was previously stated in Chapter 4.

According to the scenario of the research study, a literature review strategy (LRS) is required, and it is suggested to use the keywords' articles for three thematic analyses (3T's) Coding Scheme for LRS, such as: (1) thematic cycle coding: categorisation of keywords; (2) thematic co-occurrence analysis: abstraction of key groups; and (3) thematic cluster: conclusion of key findings. The LRS function of CLR probes the manuscript of wording statement by applying highlighted and/or underlined wording statements encompassing keywords for the wording paragraph and sentences of articles in the coding scheme manuscript. The manuscript probing will help to display

and offer supporting evidence (contextual finding of VPA method purpose) by ensuring the consistency of dataset findings. The 3T's Coding Scheme Strategy study focuses on the wording accessibility features for keywords during the coding scheme phases, which suggest the causal statement and patterns' explanation as significant statements for the field or domain representation in the qualitative methodology. The validation of the memoing step will then be mirrored in the theoretical framework, as required by induction reasoning. The impact of language accessibility qualities can be enriched by using inductive reasoning principles in qualitative methodology. As a consequence, the coding can be simply determined from the highlighted and/or emphasised phrase statement without prejudice.

Coding Options and Cycles

Source	Proponent (s)	Initial coding	Intermediate coding	Advanced coding		Theory
(Birks & Mills, 2011)	Glasser & Strauss (1967)	Coding & comparing incidents	Integrating categories and properties	Delimiting the theory		Emerges (Classic)
(Birks & Mills, 2011)	Glasser (1978)	Open coding	Selective coding	Theoretical coding		Emerges (Classic)
(Böhm, 2004)	Böhm, (2004)	Open	Axial	Selective		Emerges *(Classic)*
(Saldana, 2016)	Saldana (2016)	Initial, process, in vivo	Focused, axial,	Theoretical		Emerges *(Classic)*
(Kenny & Fourie, (2015)	Holton (2010; 2017)	Substantive coding (open coding; selective)		Theoretical coding		Emerges *(Classic)*
(Birks & Mills, 2011)	Strauss & Corbin 1990; 1998)	Open coding	Axial coding	Selective coding		Created (Straussian)
(Kenny & Fourie, 2015)	Strauss & Corbin (1990)	Open coding	Axial coding	Selective coding	Conditional matrix	Created (Straussian)

Figure 4.30 Variations of Three Cycles of Coding

Figure 4.30 shows that the research study identified three cycles of coding based on Birks and Mills (2011) – ranking sixth out of seven, which is consistent with the present LRS technique of CLR. The acceptance of both experts must be obtained at an early stage, followed by open coding, axial coding, and selective coding. Thus, the research study captures theory generation along the Straussian path, which represents theoretical advancement. As a result, the appropriate methodologies of 3T's Coding Scheme Strategy investigation are as follows.

i) Thematic cycle coding (TCC) often begins with data segmentation in order to approach the number of keywords; this allows for the coding identification within a variety of themes or patterns. The approach is iterative, allowing the research study to adjust the coding scheme as their understanding of TCC progresses through the data phases – abstraction and conclusion writing.
ii) Thematic co-occurrence analysis (TCA) usually entails generating a co-occurrence matrix that records the frequency of links between distinct patterns' coding or themes. The research study then uses group classification to detect co-occurrence patterns in this matrix of coding scheme. Keywords will be repeated frequently, and a separate group will emerge after the coding scheme rounds are completed - abstraction and conclusion writing.
iii) Thematic clustering (TC) can be done using a variety of methodologies, including manual clustering and more advanced algorithms, such as K-means clustering (bibliometric analysis or SPSS software) or hierarchical clustering. The research study of knowledge with clustering algorithms, as well as the extensive nature of the data, influence the method used. Here, the analysis technique preferably employed hierarchical clustering, which reveals levelling sequences from the priority keywords to the modest acquired – taxonomy table.

The literature review analysis for the method of 3T's Strategy research tool can execute TCC using either qualitative analysis software or manual coding methodologies. While software can help to speed the process by giving analysis tools for coding and organising data, manual approaches (such as utilising pen and paper or manually computing with Mendeley Online or Microsoft Excel spreadsheets) are also an option, especially for smaller datasets. Next, TCA frequently necessitates the use of

statistical tools or programming abilities in order to generate and analyse co-occurrence matrices. However, there are user-friendly tools and packages available (for example, network analysis software, Mendeley Online, or Microsoft Excel spreadsheets) that can make the procedure easier for researchers with limited programming knowledge. Lastly, TC can be accomplished using a variety of tools and software, including Microsoft Excel spreadsheet programmes, SPSS software, the SankeyMATIC Web Application, and specialised clustering algorithms. User-friendly software packages and tutorials are available to assist research studies in navigating the clustering process, making it more accessible to broader design societies.

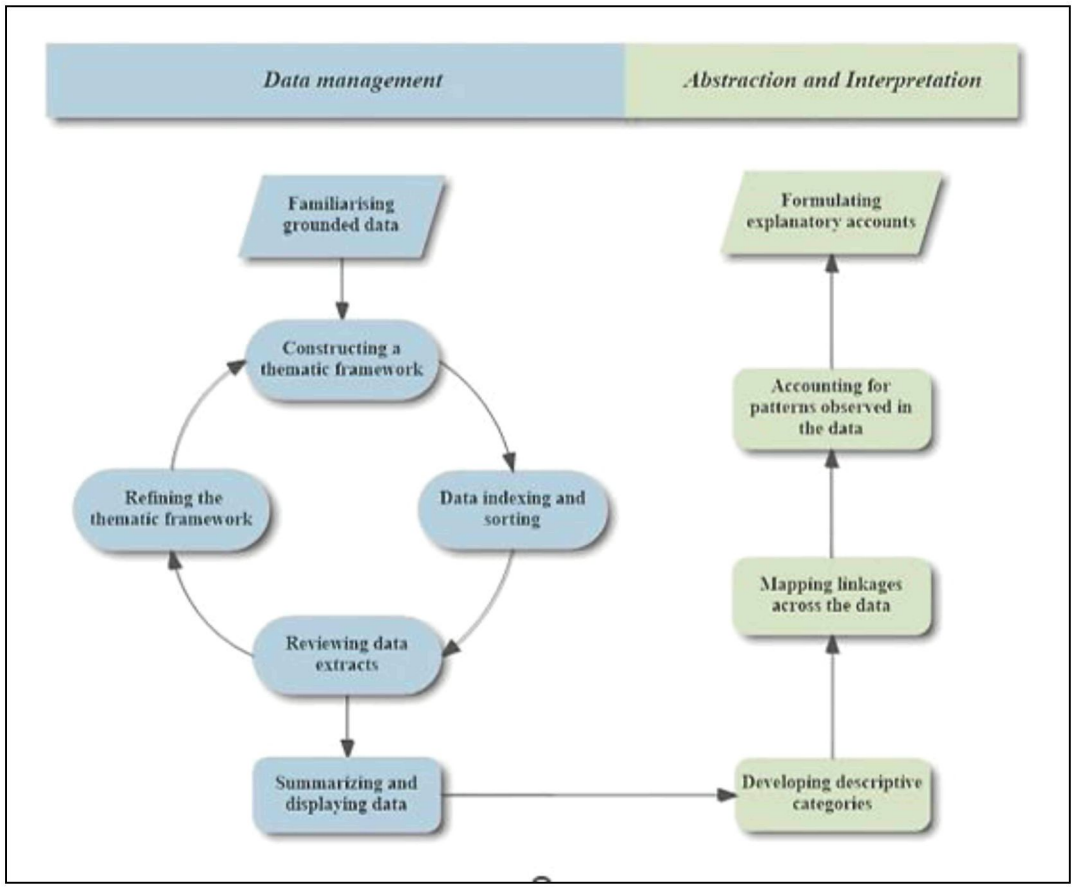


Figure 4.31 Formal Data Analysis Process of Qualitative Research

Source: Chai et. al. (2021)

According to Chai et al. (2021), the main data analysis process of CLR consists of two phases: (1) data management; and (2) abstraction and interpretation as Figure 4.31. Chai et al. (2021) prefer to approach this flow process in a way that is particularly ideal for theme analysis datasets. Simultaneously, the current research topic has

tentatively met with the context of cycle coding in the coding approach notion. The thematic analysis begins with the organisation of qualitative data, which may include CLR manuscripts, VPA method group presentations, or textual data from journal article sources. Formal data analysis is carefully organising this data into manageable pieces, such as segments or codes, for examination. Pattern recognition is based on carefully evaluating coded data to identify repeating patterns related to the research topic and/or concepts. The flow process may include comparing and contrasting codes in order to detect similarities and differences between highlighted data parts. Next, thematic analysis in the interpretation phase involves more than just identifying themes; it also involves evaluating the meaning and importance of these themes in the context of the research topic or broader theoretical framework. Thus, the formulating explanation will explain the supporting research findings that the function of the CLR is to validate the PS stage of the DRM framework in full. A more in-depth description of data analysis will be provided by subsequent DRM research topic sequences.

4.9.1 Chronological Order

In the grounded PS stage of the DRM framework, the fundamental creation to begin the chronological order (CO) is based on the inclusion and exclusion of dataset inquiries (Booth, 2016). The articles' sources are dependent on the subjects of the article's sampling, which refers to the authors' areas and expert communities as the population of the study (Booth, 2016; Mora, Sánchez and Camacho, 2017). The inclusion criteria identify the study population consistently, reliably, uniformly, and objectively. On the other hand, exclusion criteria include qualities or traits that render the recruited group ineligible for the study. These factors may operate as confounding variables for the outcome parameter.

Thus, the research study decided to gather the literature review source from the articles databases by Formgiving Design Research Group (FDRG), College of Creative Arts (CCA), Universiti Teknologi MARA (UiTM), which means referring to an appropriate research topic in the design thinking, design identity, and product form according to the research domain and field around the pragmatism parameter. To address the non-probability sampling for the purposive sampling focus group, just a small number of articles are sampled. For FDRG-CCA recognition, the research group entity received a "5 Stars EK Rating" for TIER 5 - Research Institute Group (RIG),

UiTM since 2019. The research article papers were recorded with 74 publications within the content of pragmatics characteristics, and the whole articles were indexed. According to this performance assessment, the FDRG databases store many years from 2014 to the current establishment in the cloud networking system. The Scopus Impact Factor is a metric used to evaluate the average number of citations obtained by articles published in a specific journal. In addition, the publication Impact Factor is based on Web of Science citation data and represents the annual average number of citations received by a certain publication.

Reasons for selecting the FDRG-CCA for the methodology review study in the dissertation of research topic: the FDRG-CCA is a proud pioneer research entity in design thinking towards design education for Malaysia's leading research group since the Design Society UK (DSUK) was introduced. Similar domains and concepts to DSUK are oriented by the industrial design research discipline, which focuses on artefacts and/or product systems in the industrial design field holistically. The DSUK is likely to have an enormous amount of experience and credibility in the design education arena. It may include experts, researchers, and practitioners who are knowledgeable in all elements of design education, from pedagogy to industry trends. The following is a statement of origin and activity characterising a relevant DSUK (2024) organisation,

> *"Since 2000 the Society has held the ICED conferences biennially in Stockholm, Melbourne, Paris, Stanford, Copenhagen, Seoul, Milan, Vancouver, Delft, Gothenburg and Bordeaux. Other Society events include hosting or endorsing the conferences Engineering and Product Design Education, International Conference on Design Creativity; DESIGN, Design for X (DFX), Dependency and Structure Modelling (DSM), International Conference on Research into Design (ICoRD), International Conference on Advanced Design Research and Education (ICADRE), and NordDesign. The Society publishes the journal Design Science in collaboration with Cambridge University Press and a wide range of conference papers and proceedings; it maintains a portfolio of design resources available to members on this website, including a repository of doctoral theses; and it endorses and supports a number of design research journals, doctoral summer schools, workshops and other speciality events. Its Special Interest Groups (SIGs) address a range of design topics of current interest, and its branches in Asia and North America serve as a regional focus of activities. The Society is particularly keen*

Aside from the design knowledge opinion, the research study regarded and connected the FDRG-CCA and DSUK relevant into three pin-points reasons, such as

i) The DSUK may provide access to research papers, articles, and publications on design education directly. These online resources could be useful for doing literature reviews, keeping up with current research trends, and learning about upcoming subjects in the field.
ii) DSUK organises design education-related events, conferences, and workshops. Attending such events might allow you to learn, present research findings, and network with other professionals and researchers in the sector.
iii) DSUK can assist professional development activities in design education. It enabled the creation of training programmes, mentorship opportunities, and grants or financing for research projects in the sector.

Therefore, the significance of familiarising datasets and/or search resources is one of the pillars in determining the number of studies when the total population of eligible studies is less than the number that are eligible to be included, for any reason (Booth, 2016; Nundy, Kakar and A. Bhutta, 2022). This is necessary for the understanding of the eligibility phase in the subsequent methodological review phase of the CLR process. There is debate and disagreement on the quantity of meta-synthesising for the sampling problems because of the definition of total population. Put alternatively, the population as a whole is most closely associated with a particular community and/or group society that is connected to the background of the issues, content, and dissertation context all at the same time (Booth, 2016; Nundy, Kakar, and A. Bhutta, 2022). Consequently, the choice to use the FDRG-CCA databases as a methodological review resource will undoubtedly close the knowledge gap regarding the number of pertinent databases. As applied to qualitative research methodology, it refers to examining the meta-study of articles in light of a sampling strategy based on the data saturation principle (Booth, 2016).

According to Booth (2016) and Abeedin et. al. (2023) the beginning of the methodological review is based on the understanding of inclusion and exclusion criteria or characteristics. Abeedin et al. (2023) emphasised that: (1) the manuscript sampling of a formal procedure through the research questions was formulated depending on the

topic at hand; (2) followed by keyword selection; (3) inclusion-exclusion criteria; (4) database selection; and (5) discovery strategy; (6) datasets' synthesis and analysis. For instance, he suggested the foundation step to begin the methodological review to identify the manuscript topic within the keywords' abstraction following the citation below:

> *"... to the keywords defined previously in the first step, a list of inclusion and exclusion criteria was established to limit the literature search and to select the articles that we would focus on. (Abeedin et. al., 2023 - p.03)"*

Thus, the CLR research takes deliberate steps to create a flow diagram of methodological review based on the 3T's Coding Scheme of the LRS concept. The research study follows the procedural steps of the procedure outlined by the experts Booth (2016) and Abeedin et al. (2023), which are: (1) identification; (2) screening; (3) eligibility; and (4) inclusion and/or included analysis. The flow diagrams guide future research by demonstrating effective methods for conducting methodological reviews. The research study can be used as a template or reference for creating and carrying out our research reviews, ensuring that they follow set criteria and norms. The research study improves the transparency and reproducibility of the current review technique by showing the process in a flow diagram.

Figure 4.32 shows how the research study can readily follow the sequence of stages followed in the review, making it easy to assess the rigour and validity of the review process. It enables the research study to quickly grasp the overall structure and flow of the evaluation procedure, as previously stated. In methodological review procedures, the number of research articles representing the sampling size is critical for determining the findings' strength and generalisability. The number and range of sampling sizes used in the review help to ensure that the findings are generalisable. Including studies with varying sample sizes enables researchers to analyse the consistency and robustness of evidence across distinct populations and environments. Next, while assessing the sampling size in the chosen studies, researchers strive to include a wide range of sample sizes to ensure that the findings are representative. This includes studies with small and high sample sizes, as well as research with varied degrees of statistical power. Overall, maintaining sufficient representation of sampling sizes in methodological reviews improves the findings' credibility and applicability,

allowing researchers to reach more meaningful conclusions and offer informed suggestions. However, the current research study has decided to take a small sample size due to the purpose of the grounded literature review is to support and display the think-aloud patterns that could be used for the interpretation of the VPA method. The general rules of qualitative technique apply to a grounded theory study. Qualitative experts advocate a small sample size of 4–42 people (Vasileiou et al., 2018).

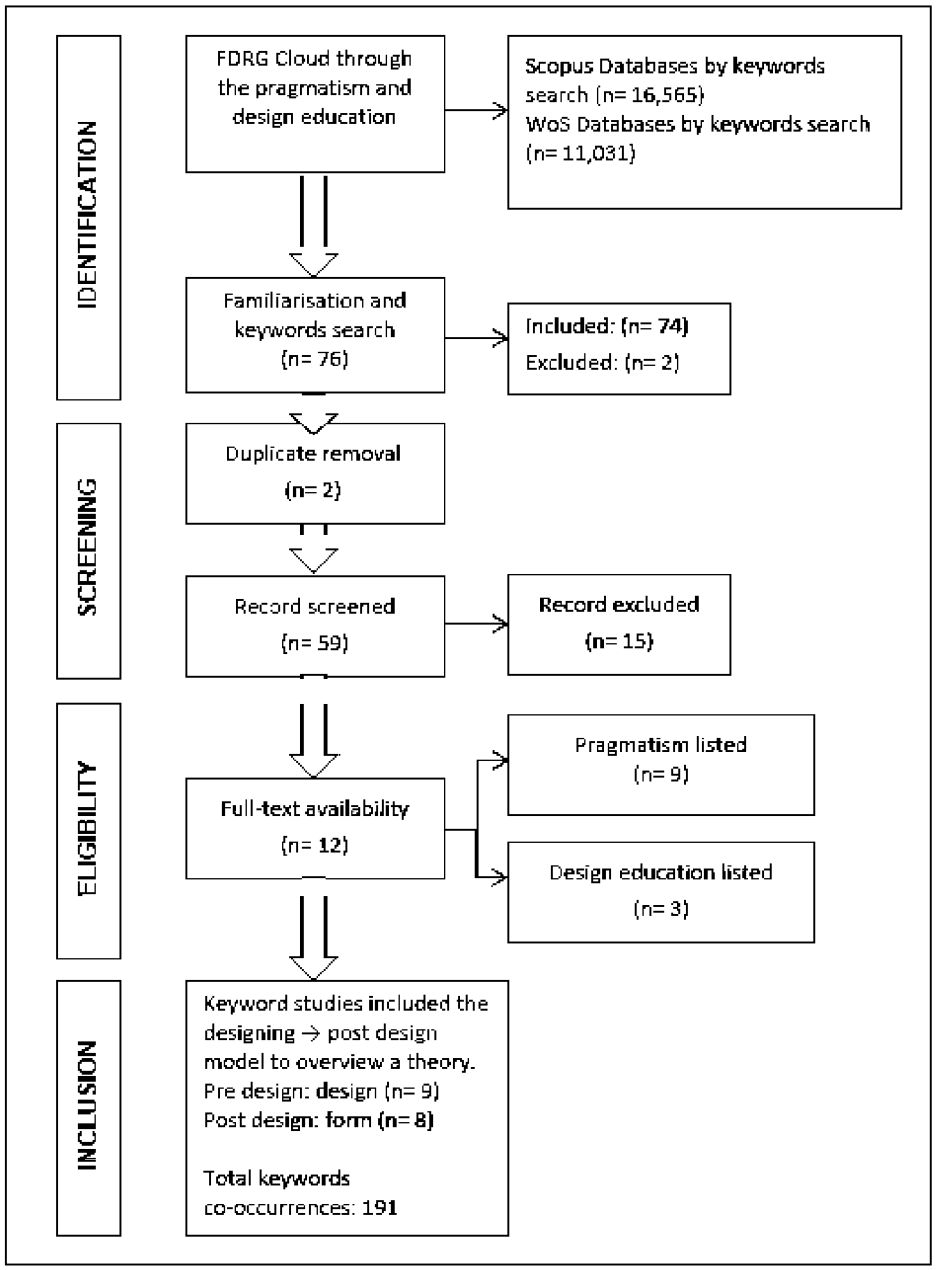


Figure 4.32 CLR Process of Methodological Review

Source: Adapted by Abeedin et. al. (2023)

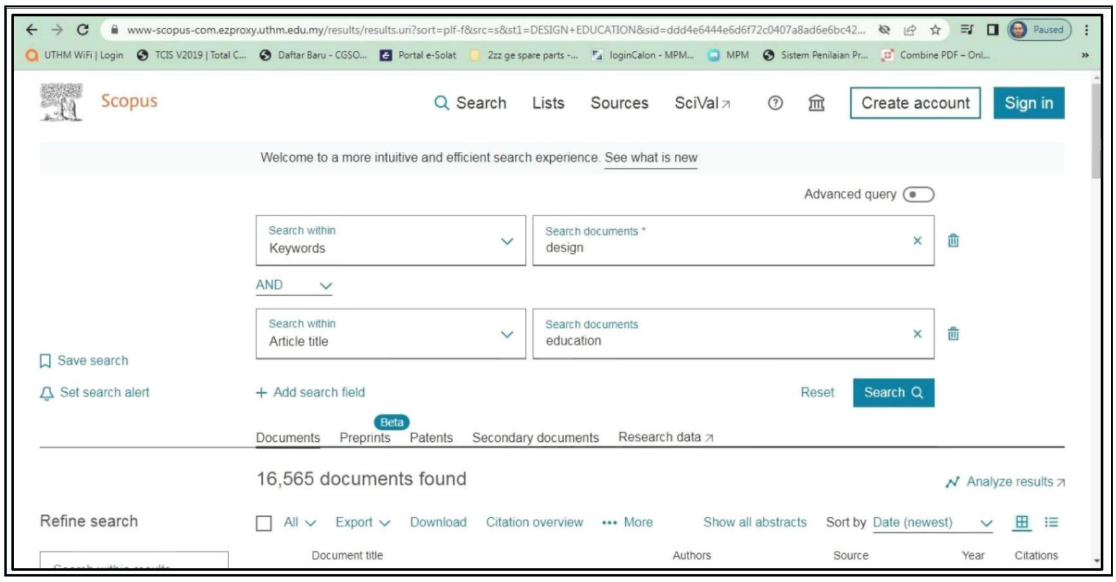


Figure 4.33 Scopus Databases: Keywords Search

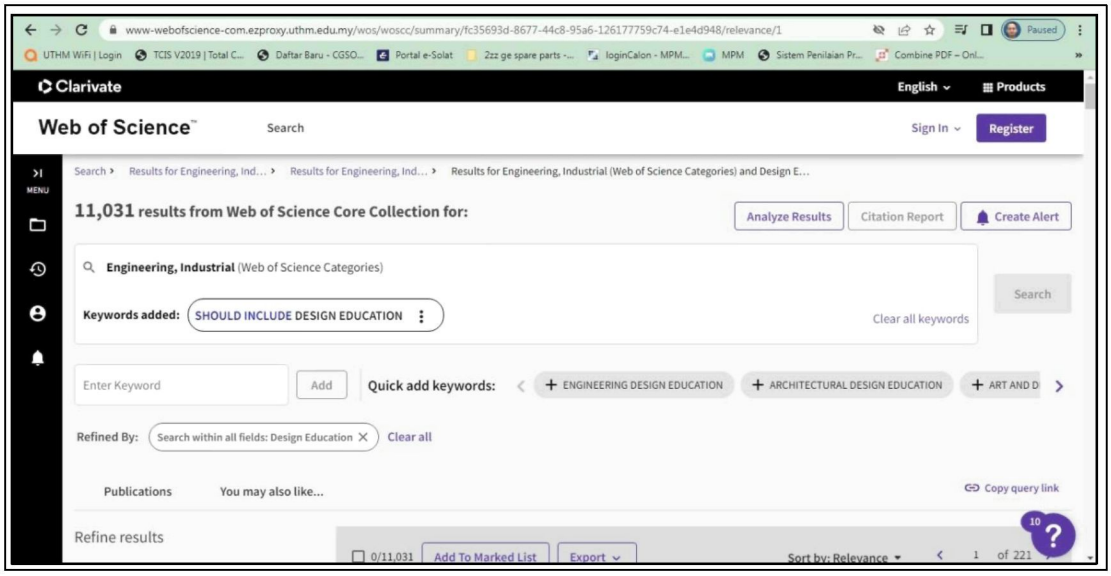


Figure 4.34 Wos Databases: Keywords Search

The identification of CLR sources from a previous study phase in Figures 4.33 and 4.34 involves reading manuscripts multiple times to enable the research study to get comfortable with the content. For every publication, article, and data source, the research study takes notes on preliminary findings, analysis, and conclusions (Ayton, 2023). For the identification phase, it is easier to use the specific term "design education," which might be related to the DRM framework's design niche (designing stage → post-design stage). The number of related articles will determine how closely the databases for WoS and Scopus synchronise.

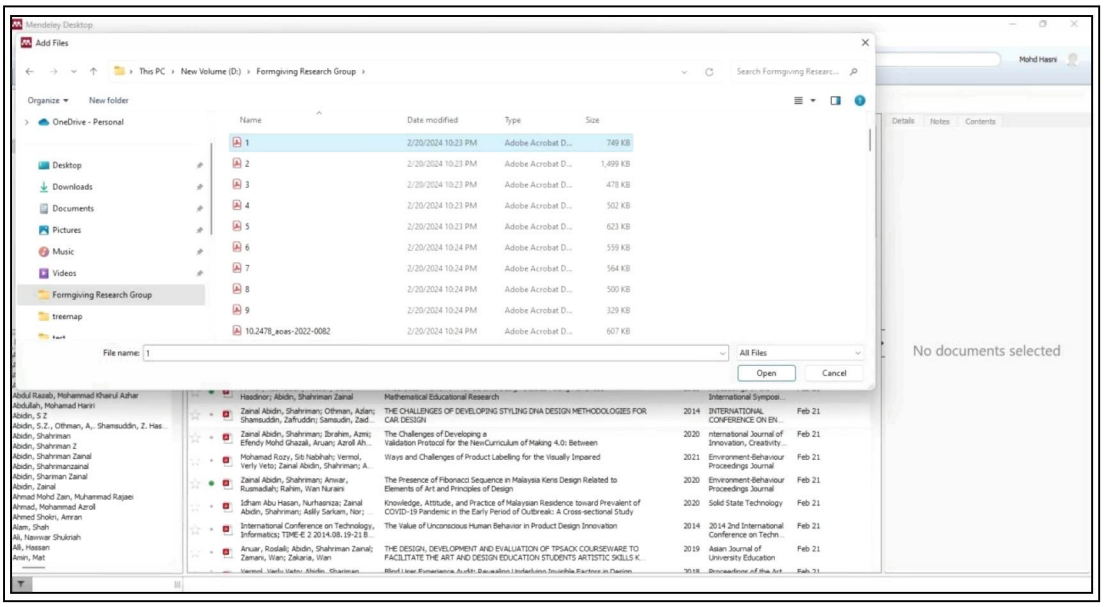


Figure 4.35 Mendeley Desktop: FDRG Cloud of Database Sources



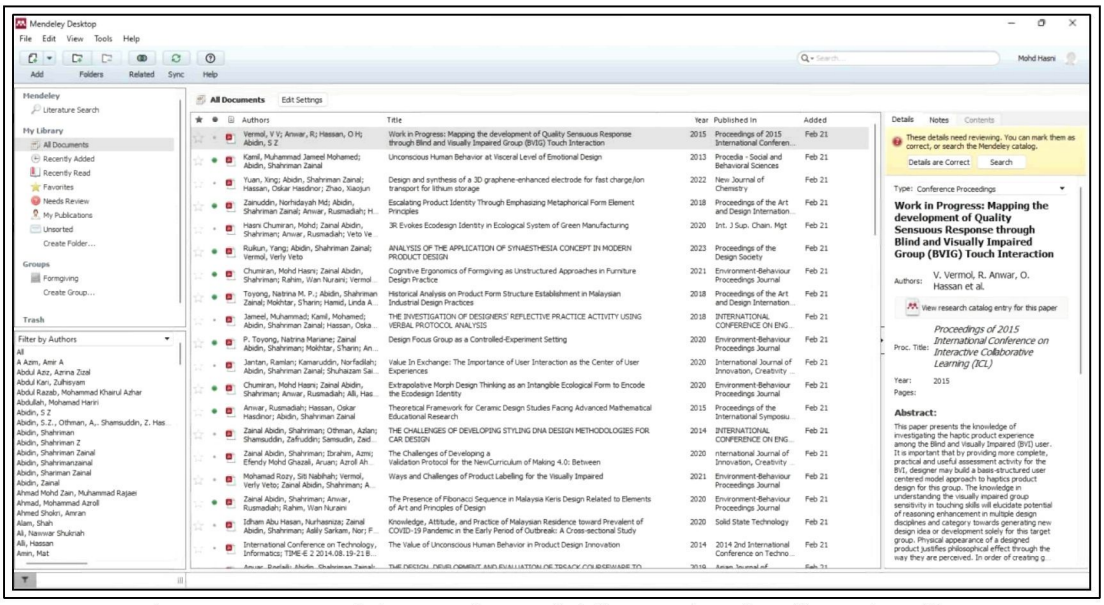


Figure 4.36 Mendeley Desktop: Adding and Uploading The Files

In Figures 4.35 and 4.36, Mendeley enables literature studies to filter and/or screen database references based on a variety of criteria such as title, author, publication year, and date added. Sorting by publication year is usually the most appropriate method for chronological arrangement. Mendeley's metadata management concept ensures that research study references are accurately dated and sortable by year.

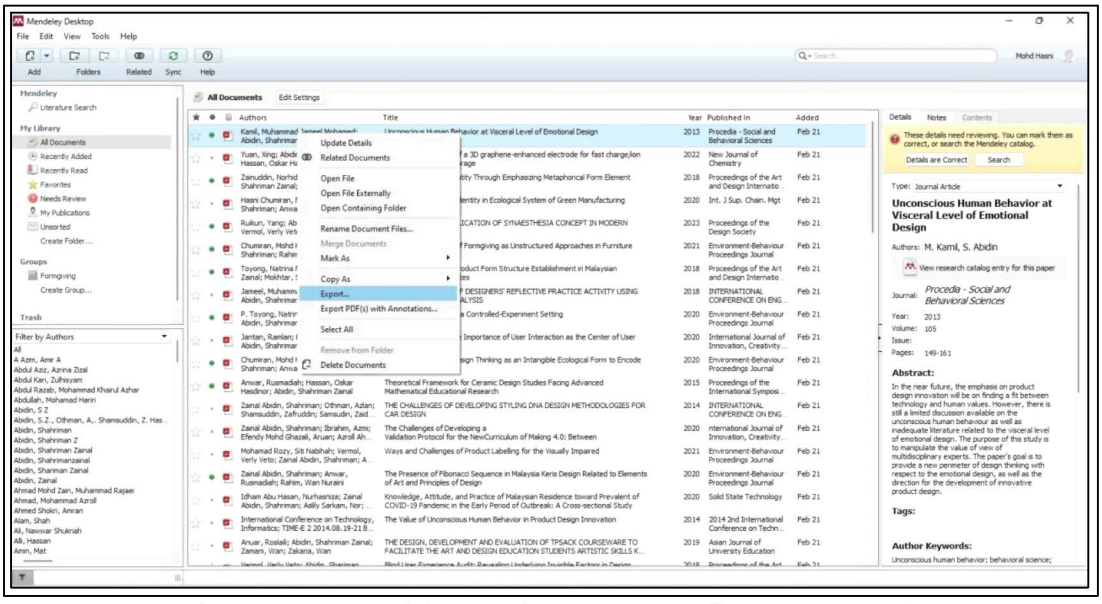


Figure 4.37 Mendeley Desktop: Export Files to MS Excel

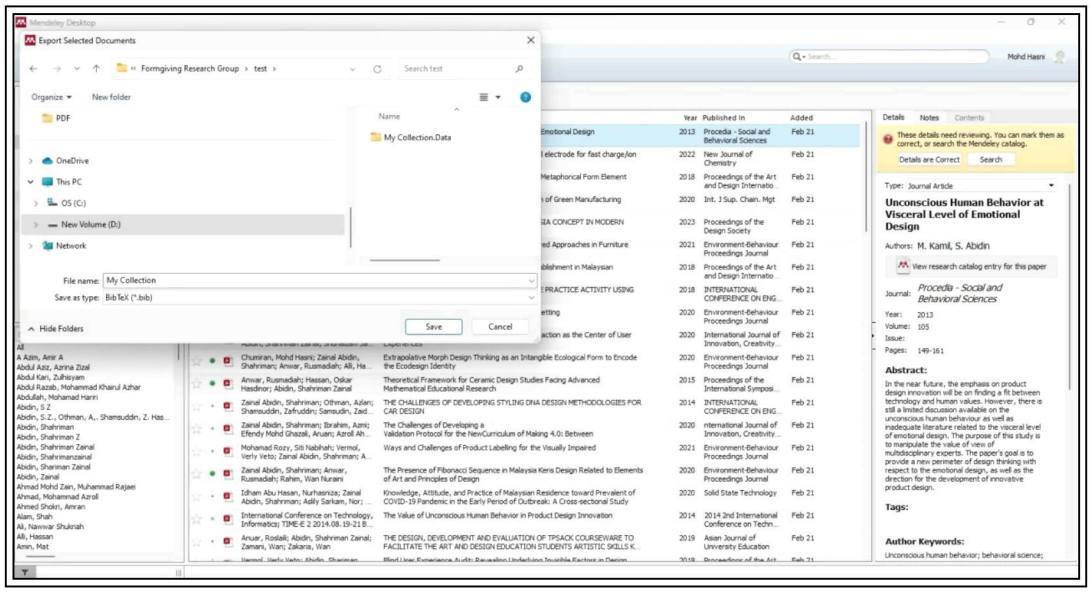
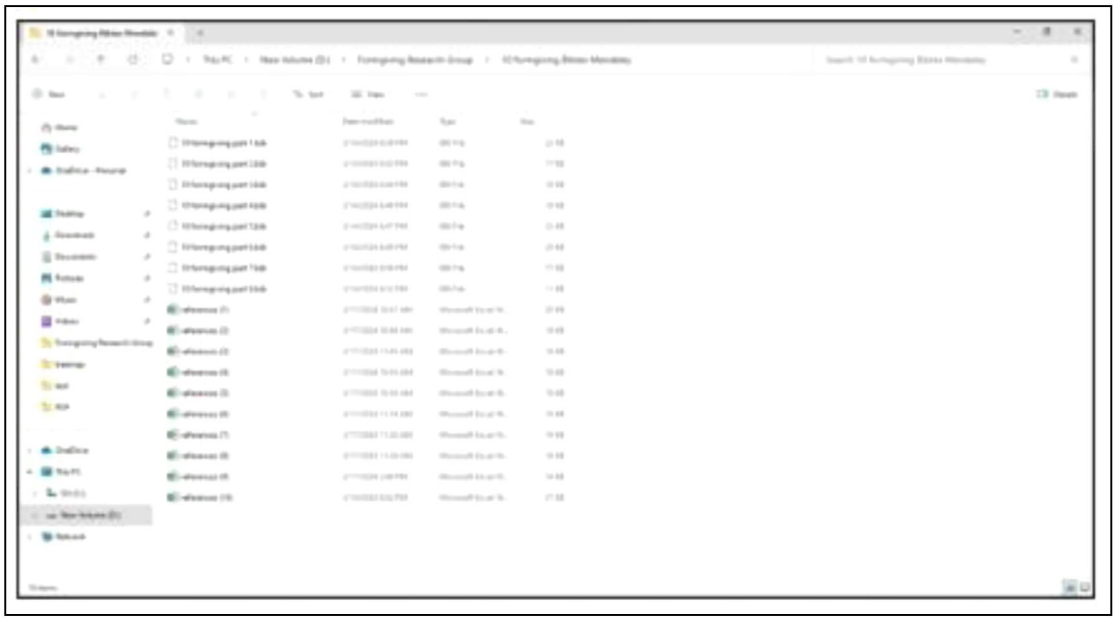


Figure 4.38 Mendeley Desktop: BibText File Format Into The File Folder

Figures 4.37 and 4.38 show that converting references from Mendeley Desktop to BibTeX format improves interoperability, facilitates collaboration with BibTeX-supported applications, allows for easy customisation and editing, and simplifies backup and sharing of CLR research citation data. This makes BibTeX a very useful format for efficiently managing academic references. Once the databases are computed, the BibTeX-specific folder is sequentially organised to achieve the purpose of eligibility context for the procedural phase of chronological order investigation.



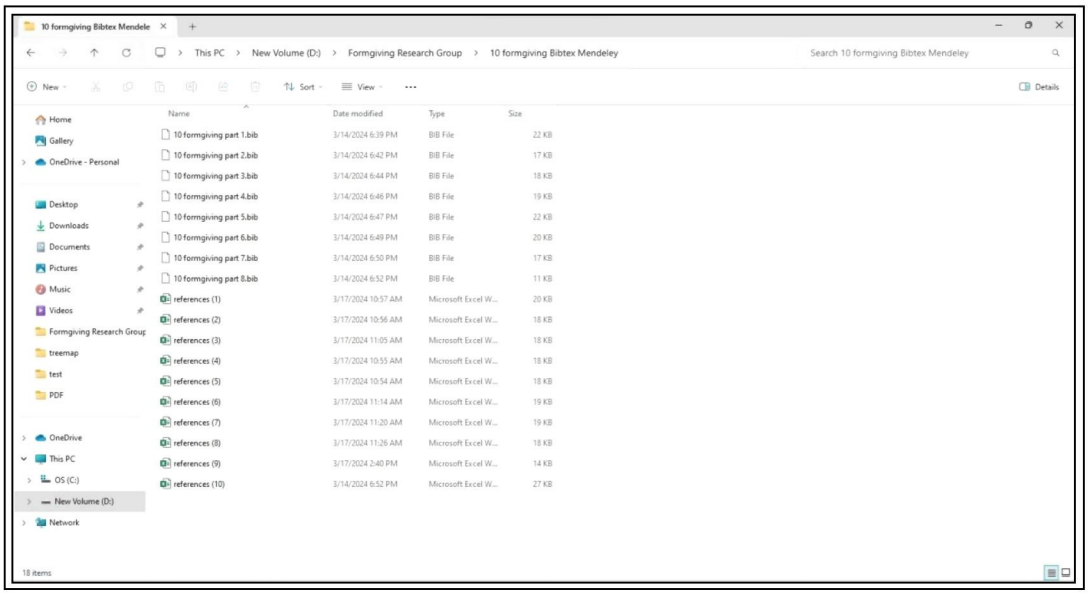


Figure 4.39 BibText File Folder: Categorisation of Manuscripts

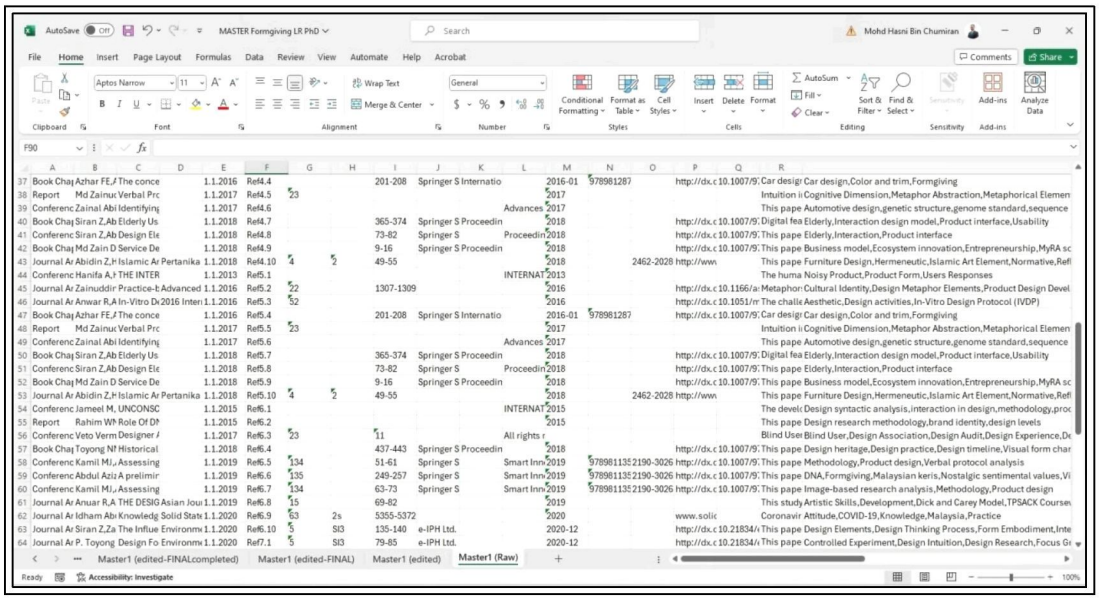


Figure 4.40 BibText File Folder: Categorisation of Manuscripts

In Figures 4.39 and 4.40 exporting files from Mendeley Desktop to MS Excel enhances the literature study's ability to categorise, organise, analyse, and manage the study reference library efficiently. It provides a structured format for data organisation, offers powerful sorting and filtering capabilities, supports basic data analysis, allows for customisation according to CLR study needs, integrates with other tools, and facilitates easy backup and sharing of research reference data. Again, the eligibility of the actual amount of the keywords co-occurrences will lead to the right and/or appropriate full-text availability of journal articles. The full-text availability of journal

articles is categorised by two branches listed such as: (1) pragmatism listed; and (2) design education listed concurrently.

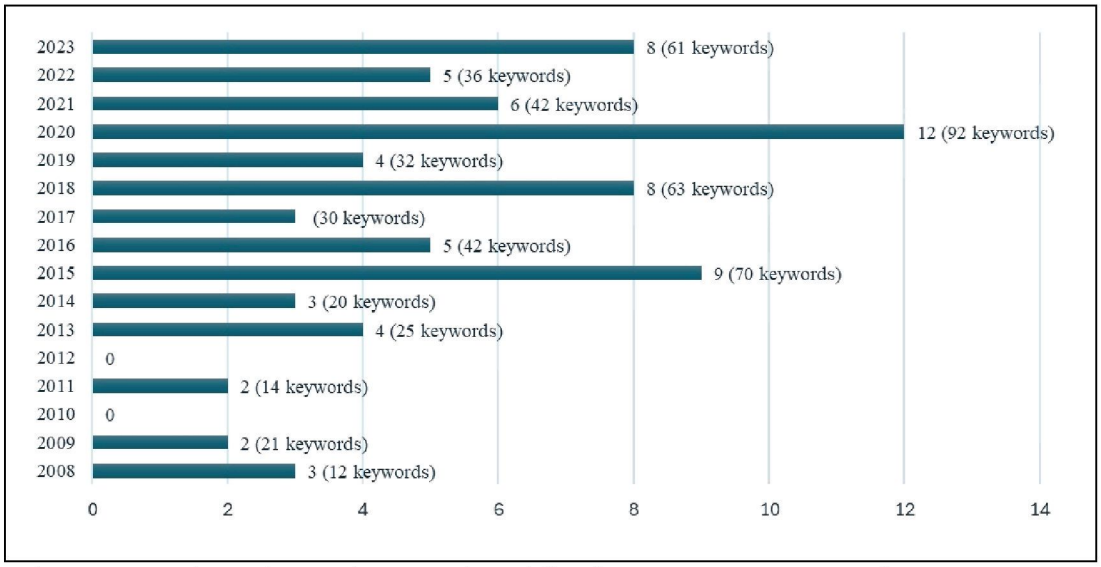


Figure 4.41 Chronology of Research Publication By FDRG-CCA UiTM From Year 2008 Until 2023

Lastly, the result of the chronology of research publication by FDRG-CCA UiTM using the CLR study as Figure 4.41. For the essential of the axes and labels understanding, each bar represents the number of occurrences in a particular year, with the length indicating the count and the text inside indicating the number of keywords associated with those occurrences. So, the horizontal axis refers to represents the number of occurrences and keywords for each year. Meanwhile, the years from 2008 to 2023 displayed the vertical axis as well. According to the chart, the study of CO found a significant description of statistics under three pinpoints summarising,

a) From 2008 to 2012, little activity was observed, and keywords only seldom appeared.
b) From 2013 to 2016, the number of occurrences and keywords gradually increased, reaching a peak in 2016.
c) 2017-2019, a small decline is followed by stability.

4.9.2 Concept of Cycle Coding Approach

In qualitative research, thematic analysis is a method used to identify, analyse, and interpret patterns or themes within data. Within thematic analysis, there are different coding techniques used to systematically analyse the data. Suitable with the application of the VPA method that the participant of think aloud is possibly used the pattern of the ecological form of ecodesign identity. The research study focuses on the keywords in the literature review. Since the executing the conceptual framework in the research design of the DRM framework concurrently. The highlighted keywords' occurrences indicate funnel thinking and a goal research strategy. The concept of coding approach should be initiatively used in the form of coding categorisation according to the three types of cycle coding introduced by Saldana (2003) and (2008) systematically following the: (1) open coding; (2) axial coding; and (3) selective coding. Referring to the definition of open coding involves the initial exploration of data to identify concepts, categories, or themes without preconceived notions. It is the first step in the coding process and focuses on generating initial codes to capture the diversity of the data.

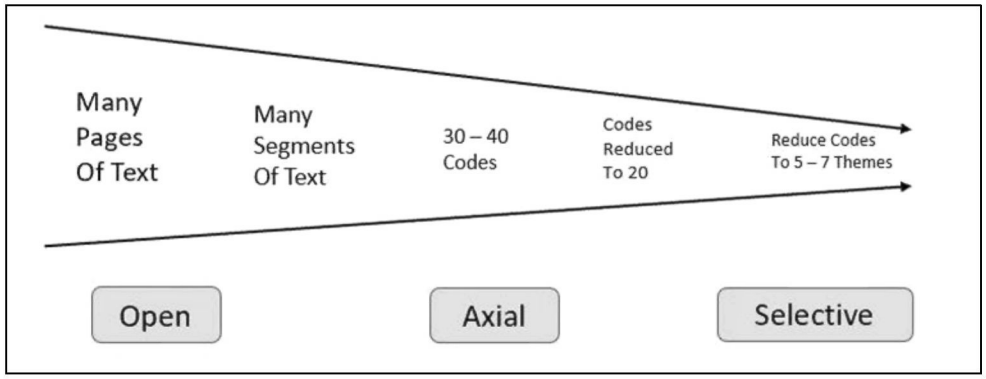


Figure 4.42 Overview of Coding Process: Open, Axial and Selective Coding

Source: Williams and Moser (2019)

Meanwhile, axial coding involves organising and connecting the initial codes identified during open coding into broader categories or themes. It focuses on exploring relationships between codes and developing a more structured framework for analysis. Lastly, selective coding involves further refining and consolidating the coding framework by focusing on the most significant or central themes identified through

axial coding. It involves selecting key categories or themes that best represent the essence of the data.

In Figure 4.42, the research study exhibits a similar knowledge of cycle coding to Williams and Moser (2019), who demonstrated the consistency of cycle coding overview utilising the convergence form to navigate the arrows for the occurrence of themes. Saldana (2003) and (2008), the pioneer, recognised thematic analysis through the similarity process of cycle coding. Through each coding cycle, researchers improve their comprehension of the data and emerging trends. The analysis might reveal overlaps between themes, improve definitions, and clarify boundaries. The iterative method improves the reliability and validity of the analysis by ensuring that themes appropriately reflect the facts. For the current context of iterative processes, thematic analysis is an iterative process by definition, and cycle coding encapsulates this non-linear process of iterative approach, as shown in Figure 4.43.

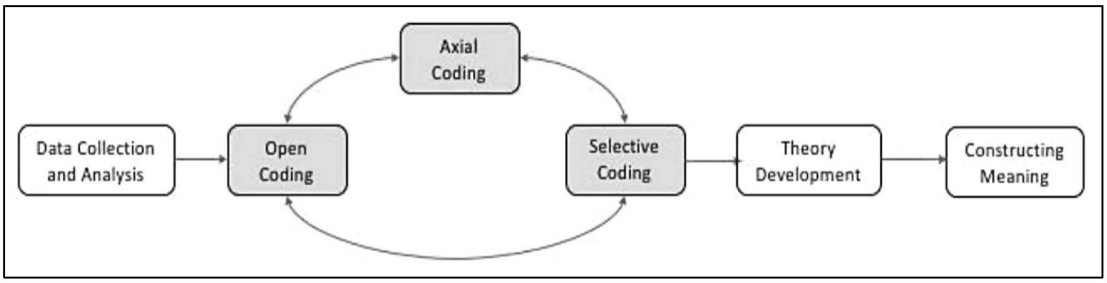


Figure 4.43 Non-Linear Process: Qualitative Research (

Source: Williams and Moser (2019)

Each cycle of coding improves and deepens the analysis. The iterative process allows for flexibility and adaptability, allowing the research study to examine the data from many aspects and perspectives. According to the analysis, cycle coding is vital for theme analysis because it allows for a full, systematic, and nuanced exploration of qualitative data, resulting in rich and informative discoveries. It guarantees that the themes are data-driven, well-defined, and indicative of the phenomenon being investigated. The memoing content must be established concurrently with the manuscript's coding method. Memoing is used to approximate writing or statements that interpret manuscript datasets, which are framed in the field of research topic to fulfil the goals and expectations of the answers to research questions. Table 4.12 provides a thorough explanation of responsibilities and functions.

Table 4.12
A Comparison of Open Coding, Axial Coding, and Selective Coding

No.	Descriptions	Open coding	Axial coding	Selective coding
1	Purpose	To gain a preliminary realise of the data, pick a wide range of prospective topics or categories from "abstract writing".	To improve the deep understanding of information, theory, and knowledge, as well as consolidate the basic codes into a more coherent and systematic framework. The "conclusion's content" is required.	To determine the major themes or core concepts from the key findings, which signifies the most relevant and accurate content to the research topic/study.
		Function: The foundation for further analysis must be addressed, as well as assisting the research study in developing hypotheses or research questions.	*Function:* A more in-depth examination of the connections between concepts should be encouraged. In addition, identify the data's primary themes or aspects.	*Function:* It is preferable that the research study focus on a consistent story. It highlights the essence of the data and is consistent with the research objectives.
2	Process	To investigate "keyword occurrence data" with underline-by-underline classification, assigning codes to pertinent concepts or ideas for keywords as they develop. The technique then provides for constant abstraction of essential groupings, including flexibility and responsiveness to new discoveries or patterns.	Examine "the conclusions of key findings" on how distinct codes relate to one another and begin to arrange them into higher-order categories based on similarities or links. This method is looking for patterns or themes that appear throughout multiple codes.	Prioritise "the most significant themes or categories" revealed during axial coding and investigate how they intersect or relate to one another. The insight phase entails delving further into these fundamental themes and responding with consequences for the study questions and objectives.

However, this study should be redefined in the use of cycle coding formation (open, axial and selective coding) that it must be in line and aligned with: (1) the research objectives; (2) CLR within pragmatism study; and (3) goal of PS stage of DRM framework. In the cycle coding situation, memoing or note-taking is needed so that it could deal with capturing an insight interpretation (Chandrasegaran et al., 2017). There should be an improvement on the formats' matrices due to the manual approach for the coding scheme demonstrates the fundamental theory based on the memoing (Saldana 2003 and 2008) preferably. Chandrasegaran et al. (2017) state that the memoing corresponds between the memos and texting will result in a label that is appropriate for

the texting statement's context. The ability to establish the labels of theme representation consistently is thus made possible by an essence coding that is relevant to all phases of the process. Memorisation involves looking at the dataset's analytical evidence and looking for something that is highlighted (underlined) in writing or statements that are used to support what is known as the essentials of grounded theory. As such, the concept of coding technique can be effectively anchored through the application of purposes-process planning. This outcome validates the cycle coding procedure's efficacy by allowing a strict coding selection to express the logic theme representation in the selective coding finding.

4.9.3 Thematic Analysis Method

Thematic analysis method (TAM) in a literature review involves identifying, analysing, and synthesising themes or patterns across a body of literature related to a specific research topic. It's a method used to systematically organise and interpret the content of existing studies to gain insights into key themes, ideas, or findings. To establish TAM, the fundamentals of pragmatic studies are required. Pragmatic research aims to understand and solve real-world problems. It is grounded in the data itself, allowing researchers to develop themes based on what participants say rather than imposing preconceived categories. This aligns with the pragmatic emphasis on data-driven, context-specific findings.

In the grounded theory of the DRM framework, the application of TAM is a vital qualitative methodology that could be enabled to describe the data of cycle coding and coding system heuristically. All these reasoning will be engaged with an earlier 3T's Coding Scheme Strategy of CLR study, and it enables to address the process flow of data cycle coding context such as hypothetical form following TCC → TCA → TC. The iterative processes, 3T's Coding Scheme Strategy of CLR involves an iterative process of coding and theme development, which allows researchers to refine their interpretations in light of new data and emerging insights, a practice that is in line with the adaptable and evolving nature of pragmatic research. Overall, thematic analysis supports the pragmatic approach by providing a method for generating actionable insights that are directly relevant to real-world problems and practical applications.

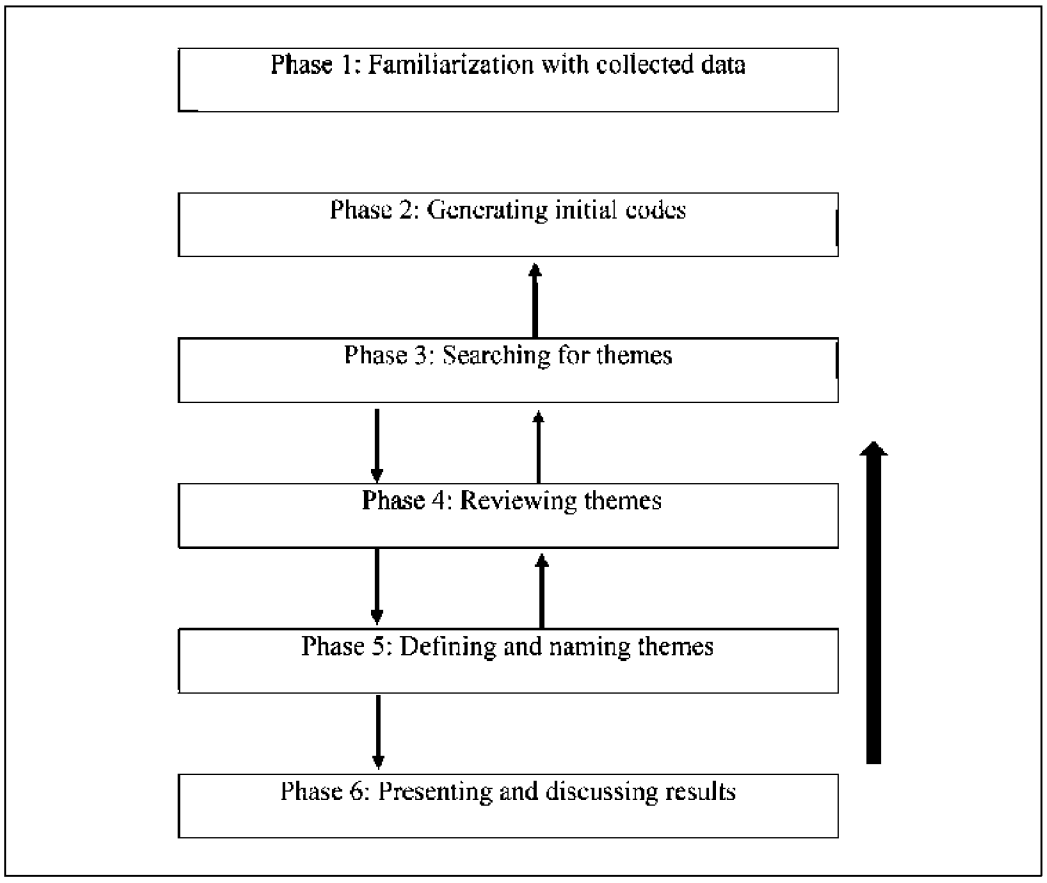


Figure 4.44 Thematic Analysis Method. Six Interactive Phases (Labra et al., 2019)

The research study was advised to employ the six interactive phases of TAM to experience data-driven collecting by the specialists in qualitative technique Labra et al.; (2019), as shown in Figure 4.44. The entire idea of TAM procedure initiatives was continually influenced by this research study on TAM. The experimental exercise to apply the interacting processes is what the study believes. These six pinpoints will all explain how they function here, while also providing a parallel analysis of the CLR study's findings.

a) *Phase 1: Familiarisation with Collected Data* - Immersion in the data allows the research study to fully understand the title of the subject matter and keywords as in Table 4.14. To do this, you must read the information several times over, read to article manuscript, and make notes on your first thoughts and observations heuristically. To begin to think through possible patterns and interpretations, one must first have a thorough knowledge of the database sources – within indexes namely WoS, Scopus and/or MyCITE.

b) *Phase 2: Generating Initial Codes* - In this stage, the research study starts methodically identifying and labelling the data's essential qualities. This entails thoroughly and inclusively coding the data's intriguing features. The codes may be theory-driven (deductive) or data-driven (inductive). To facilitate subsequent analysis, this phase aids in grouping the data into useful categories. This study uses inductive reasoning in the TC categorisation of two designing → post design modelling definitely as Table 4.14.

c) *Phase 3: Searching for Themes* - To find important, more general patterns or themes in abstract writing, the research study looks at the codes and compiled data. This is grouping various codes into prospective topics and compiling all information pertinent to each subject. Finding overarching trends in the data requires a process of distilling and fine-tuning the analysis as Table 4.16.

d) *Phase 4: Reviewing Themes* - Review and improvement are done to the topics found in Phase 3. At this stage, there are two review levels: (1) each coded data extract is examined to make sure it makes sense; and (2) each theme's validity is evaluated in light of the full data set. Ensuring that the themes are different from one another and appropriately represent the data is the aim of the abstraction writing as Table 4.16.

e) *Phase 5: Defining and Naming Themes* - Every theme's central idea and the specific feature of the data that each theme captures are identified by the TC of TAM research. All themes are given precise names and definitions, along with a succinct description that highlights the essence of each subject in the conclusion writing and its relationship to the main research issue as in Table 4.17.

f) *Phase 6: Presenting and Discussing Results* - Writing up the topic analysis is the last step. This comprises an in-depth examination of every theme in the conclusion writing, supplemented with striking and captivating data samples – referring to Memoing 1 and 2 as Table 4.17. The data should be presented in a way that makes sense in light of the research questions. Additionally, the researcher evaluates and discusses the conclusion writing results during this phase, taking into account their consequences, applicability, and contributions to the field of study.

Finally, these stages are interactive and iterative, which implies that the TAM of CLR may alternate between stages to improve and focus the analysis (move back and forth between phases – following to large arrow vertically). As of right now, the development of grounded theory is expected to become apparent during the research study, and critical thinking is in line with the 3T's Coding Scheme Strategy.

ID# No.	Year(s)	Title(s)	Keyword(s)	Index(s)	Thematic Cluster(s)					
					DESIGNING			OUTPUT		
					Theme #1	Theme #2	Theme #3	Theme #4	Theme #5	Theme #6
1	NIL	NIL	NIL	WoS/Scopus/ MyCITE	-	-	-	-	-	-
UNTIL										
74	NIL	NIL	NIL	WoS/Scopus/ MyCITE	-	-	-	-	-	-
				Total of keyword(s)	0	0	0	0	0	0
				Percentage (%)	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%

Figure 4.45 The Format of Recorded Screening for The Keywords Co-Occurrences in The TAM

To clarify the actual "record screening" of CLR's methodological review, the research study compulsorily sorts the total number of papers published in Figure 4.45. The number of articles published will be used to determine the "record excluded" indicator of articles published. By distinguishing between the two technique records, it is possible to move on to the next stage of an article's publishing for additional CLR procedures, which are referred to as the eligibility phase of the methodological review.

THEMATIC CO-OCCURRENCE ANALYSIS		THEMATIC CLUSTER				
ID# Paper	ABSTRACT (Open Coding)	Designing Phase	Occurrences	Output Phase	Occurrences	Memoing 1 (Thematic Area)
04		Coding #1	0	Coding #2	0	1) Theory/ Law/ Elements/ Principle/Essence
	Sub-Open Coding	Coding #3	0	Coding #4	0	

Figure 4.46 The Abstraction of 3T's Coding Scheme Strategy within The TCC and TCA

THEMATIC CO-OCCURRENCE ANALYSIS	THEMATIC CLUSTER					
CONCLUSION (Axial Coding)	Designing Phase	Occurrences	Output Phase	Occurrences	Memoing 2 (Thematic Area)	Subjects (Authors =n)
	Coding #5	0	Coding #6	0	1) Theory/ Law/ Elements/ Principle/Essence	0
Sub-Axial Coding	Coding #7	0	Coding #8	0		

Figure 4.47 The Conclusion of 3T's Coding Scheme Strategy within The TCC and TCA

Figure 4.46 and and 4.47 demonstrate how these two types of 3T's Coding Scheme Strategy consistently evolve the supporting coding scheme processes into the selective coding scheme. Together, the two features of 3T's Coding Scheme Strategy allow for the triangulation of coding datasets, allowing for the simultaneous observation of Memoing 1 and Memoing 2's mix-match context. When Memoing 1 and Memoing 2 consistency occurs, at that point, it will become evident what particular pattern or theme the selective coding has. To support the PS dataset in appropriately responding to the research questions, the pattern and/or topic of selective coding can then be justified.

However, according to the 3T's Coding Scheme Strategy, TCA can help navigate the conceptual framework of qualitative research by contributing to framework formation, conceptual mapping, theory building, conceptual refining, and findings integration - all of which align with the DRM framework. By methodically analysing themes and patterns within qualitative data, the supporting analysis procedural step via TC supports CLR research studies in organising and making sense of complicated occurrences, definitely contributing to knowledge growth in their sector. In summary, a greater emphasis on data-driven collecting will provide a methodological grasp of how iterative replies can considerably contribute to study results.

4.10 Administrative Design

An important part of a PhD thesis dissertation is the administrative design sub-chapter, which describes the organisational and procedural components of the research. This component guarantees the transparency, reproducibility, and methodical organisation of the research process.

Initially, determining the research scope and objectives is the most important role in the study of administrative design. It explicitly defines the scope of the research, including precise objectives and goals that must be met, and establishes the parameters within which the research will function. The objective of the purpose is to keep the research study focused and relevant to the primary research topics. Next, research planning and scheduling can be used to create a calendar and schedule for research activities, including milestones, deadlines, and major deliverables. Typically, the Gantt chart will be presented with a set timeline to help manage time and guarantee that the research is finished within the timeframe specified. On the other hand, basic resource

management remains important and necessary in this administrative design research. Details the resources required for the research study, such as funding, equipment, software, and other materials, to ensure that all relevant resources are recognised. Then it was procured to avoid disturbances during the research procedure.

To fulfil ethical responsibilities and concerns, the research study must guarantee that participants are adequately informed about the nature, purpose, procedures, risks, and benefits of the research before choosing to participate. Participants should give their consent voluntarily, without any pressure or undue influence as Appendix 8, 9 and 10. Furthermore, the ethical considerations and approvals required for performing the research must be described, such as participant consent, confidentiality, and ethical data handling. As a result, understanding ethical procedures guarantees that the research follows ethical standards and regulations, thereby protecting the rights and welfare of participants.

Next, the importance of a data management plan in DRM activities is a critical research study that will represent the full flow process of the research title. The categorisation of chapter folders describes the protocols for data collecting, storage, and processing, as well as data security and backup mechanisms. Its purpose is to maintain data integrity, confidentiality, and accessibility via the study process. The communication strategy produces a specific set of communication tactics and channels for regular updates, feedback, and collaboration among the research team and stakeholders. As an influence on the communication plan, the benefits of facilitators are more effective in terms of communication, ensuring that all stakeholders are informed and engaged throughout the research study process.

This meant that the research project needed to show appropriate phases for reporting and maintaining records. The idea of research documentation phases is explained in detail to ensure that all research activities are thoroughly recorded. These include keeping track of progress, keeping records, and sharing discoveries. Furthermore, the advancement is consistently documented. Thus, by incorporating these components, the administrative design sub-chapter offers a dynamic and interactive phase model for overseeing the research endeavours. To produce accurate and dependable results, it guarantees that the study is carried out methodically, effectively, and ethically.

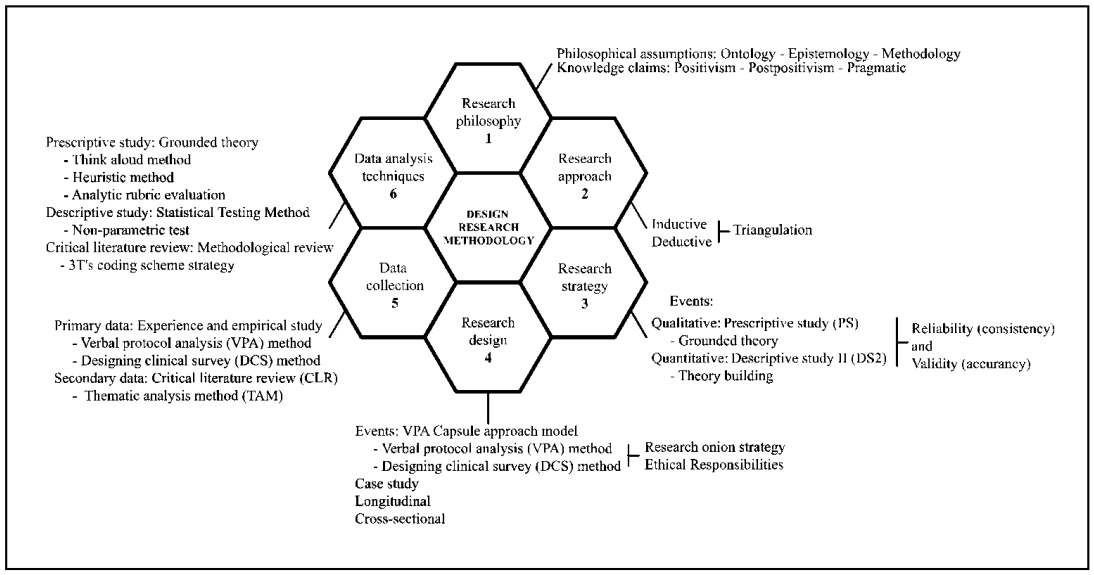


Figure 4.48 Six Interactive Phases of The Honeycomb Concept

Source: Adapted by Wilson (2014)

Design research methodology is a structured strategy for performing systematic research. Figure 4.48 depicts the procedural processes for administration design using a honeycomb model concept, which represents the main concept of research networking (Wilson, 2014; Oberholzer & Buys, 2023). There were no direct linear models to handle the procedural phases. Because the non-linear model uses honeycombs to depict the options of engagement, it performs substantially better than a standard linear model. Hence, the contents of the first six procedural stages will be puzzled in the research study, and the DRM framework will effectively anchor the six elements of the honeycomb design (Wilson, 2014; Oberholzer & Buys, 2023).

First, a research philosophy entails defining the philosophical assumptions that support the investigation. It comprises an ontology, epistemology, and methodology, which means it represents issues concerning the nature of reality in knowledge. - Why the nature of knowledge? - How should one approach learning? Thus, the relatedness of knowledge claims will be imposed on the three areas of positivism, postpositivism, and pragmatics, respectively. Second, research approaches are chosen to tackle the guidance within the overall direction of the research using: (1) inductive reasoning to create theories based on observations; and (2) deductive reasoning to test theories through hypotheses. Once the datasets for both reasonings are established, triangulation should be utilised to combine multiple methodologies to assure reliability and validity in a systematic manner. Third, research strategy refers to the approach to conducting

research that is formally known as: (1) qualitative, which focuses on exploring phenomena, prescriptive study (PS), and grounded theory; and (2) quantitative, which focuses on measuring phenomena, descriptive study II (DS2), and theory development. Critical dataset recognition indications are the impact of the research plan study and the establishment of reliability and validity. The research findings must be consistent (reliability) and accurately represent the phenomena researched (validity). Fourth, research design involves proper planning of the study design, including the overarching strategy and framework. The study addressed the VPA Capsule approach paradigm through the usage of events. Including the model, two ways are considerably applied to the VPA and designing research context in the DRM framework. Simultaneously, ethical responsibilities to research participants and/or respondents are necessary, and the study must abide by regulatory requirements and ethical guidelines, which frequently specify particular protocols for safeguarding human beings. Adherence to these guidelines assists in avoiding legal ramifications and upholding public confidence in the scientific community. Fifth, data collecting determines the data required to answer research questions. Primary data is obtained directly from experiences and empirical investigations using the VPA and DCS methods. Meanwhile, secondary data were acquired from the available literature using the critical literature review and theme analysis methods. Sixth, the final phase of data analysis techniques is defined as analysing the collected data using various techniques such as: (1) prescriptive study, which includes grounded theory, think-aloud method, heuristic method, and analytic rubric evaluation; (2) descriptive study, which includes statistical testing and non-parametric tests; and (3) critical literature review (CLR), which includes methodological review and 3T's coding scheme strategy. Therefore, following these procedural steps allows research studies to methodically develop and perform their research, assuring rigour and robustness in their technique and effectively using the six aspects of the honeycomb pattern.

However, the research study identified the COVID-19 pandemic (both before and after the pandemic: until the endemic) as an important challenge in completing the administrative design of the dissertation goal. Three phases of honeycomb networks, such as study strategy, research design, and data collecting, were used to affect important environmental changes caused by the COVID-19 pandemic. The majority of schools and colleges in Malaysia were forced to close due to the MCO, which had a substantial impact on the country's educational system and millions of

students (Kamil & Sani, 2021). As a real example, the initial intention for the VPA technique was to employ the subject's participants with experience-based learning physically following the human-centred design strategy for product creation in the fundamental and/or basic research mode. The VPA method's complete setting mode was then shifted from data-gathering activities to online distance learning (ODL) within the design pedagogy environment.

Therefore, the interactive design pedagogy approach differed significantly from the intended research outcome, indicating that another technique solution seemed more appropriate for achieving problem-based learning beneath ODL delivery. Consequently, the time frame of the research study has been extended owing to co-incidental concerns and research environmental have emerged from the period of the COVID-19 pandemic according to the unintentional transformation of three phases of honeycomb networks. Gani, Alied and Huy (2023) noticed the pandemic to endemic, after more than two years of the COVID-19 pandemic; Malaysia was able to successfully contain the outbreak thanks to its vigorous reaction. Prime Minister Datuk Seri Ismail Sabri Yaakob declared in March 2022 that the nation will enter the endemic phase in April.

4.11 Summary

In the data collection summary, insights into exploratory design emerged primarily from the prescriptive study, guided by two key verbalisation models: (1) the VPA capsule method and (2) the VPA boundaries approach, both contextualised within the Design Research Methodology (DRM) framework. The VPA capsule model, a qualitative technique, captures participants' cognitive processes by prompting them to verbalise thoughts during task execution, with task performances shaped through grounded theory development. In contrast, the explanatory design employed survey methods within the descriptive study to assess the reliability and consistency of qualitative findings. Within this context, verbalisation models are integral to addressing conceptual and contextual research aims. The structured implementation of these models is aligned with the data collection process, ensuring coherence with the core flow of the VPA methodology. Thus, it is determined that there are certain advantages to using the verbalisation model of the VPA approach for data acquisition. The verbalisation model's constituent parts were outlined in the research study as follows:

(1) critical thinking; (2) inductive reasoning; (3) contextual understanding; (4) flexibility application; and (5) customisation and adaption. The verbalisation model was driven through two phases simultaneously by all of these components.

During the first stage, participants' cognitive processes and decision-making techniques are thoroughly elucidated through critical thinking and the VPA approach. Research studies can gain a better understanding of how subject participants approach and solve problems by recording verbalisations in real-time. Compared to retrospective self-reports, VPA reduces recall bias and offers more accurate representations of thinking processes because data is induction captured as people do tasks. Retrospective self-reports meaning context pertains to the style of reports generated from the research that was done. These reports rely on people's subjective recollections of the past, which are useful in a variety of fields of study, such as social sciences, psychology, and education. A dissertation, however, can offer insightful information, but it must be completed carefully, taking into account the biases and difficulties involved.

In the second stage, contextual knowledge becomes essential, highlighting the value of the insight tool method through the use of analogical reasoning. As participants articulate the rationale behind their actions - along with the motivations and environmental factors influencing them that researchers gain a deeper understanding of the decision-making context. Concurrently, improvements in task analysis, particularly in critical thinking, lead to the identification of verbalisation-based problem-solving strategies. Consequently, task or tool analysis across disciplines such as usability studies, education, and cognitive psychology benefits significantly from VPA data collection. It helps identify errors, cognitive bottlenecks, and areas requiring refinement in task design or instructional materials. During processing, a flexible implementation component emerges, facilitating the contextual application of knowledge through the VPA boundaries approach. This technique proves valuable across a range of domains, including problem-solving, learning, decision-making, and human-computer interaction, provided the VPA capsule model is deliberately applied. At this stage, the role of customisation and adaptation becomes critical in ensuring the reliability and relevance of the dataset. The model can be tailored to meet specific research needs, enabling researchers to target particular cognitive domains relevant to their investigative focus.

Overall, the VPA method's verbalisation model is a powerful tool for getting a thorough knowledge of cognitive processes and enhancing task, system, and

instructional material design based on exploratory design findings. There could be assisted data collection operations, as well as the development of non-linear flow process patterns, along with the observation of research methodology. As an outcome, the following chapter will employ all approaches and methodological strategies to systematically address the research questions using the DRM framework.

CHAPTER 5
RESULTS AND DATA ANALYSIS

5.1 Introduction

The sources of primary data sets have been prepared, and is readily exist to choose the appropriate design methods that answered the research questions within the problem solving and enabled us to achieve the research objectives from the earlier data collection chapter. Based on the fundamental research mode within the orientation of the DRM framework, the data analysis of the research study should be reflected in the three research design studies, namely (1) theoretical, (2) philosophical and (3) methodological. Furthermore, the establishment of research design in this research topic is very crucial since the contribution of primary data sets study had figured out the exact meanings and definitions of population, sample size and sample unit from the previous Chapters 3 and 4.

In the reflection of the prescriptive study, the VPA method was used to increase the consistency source of qualitative data sets, especially about the interpretation of think-aloud by the subjects' participants, and it represented the nature of the grounded theory. Portz et al. (2020) and Amaresan (2022) proved the knowledge of grounded theory in human-centred design (HCD) could improve the quality of product services following the specific requirements in product development. To discuss a close perspective, the experts Amaresan (2022) stated evidence,

> *"...your new product could have sold out this year, but that doesn't necessarily make it successful. Customers could have disliked the product or thought it was faulty, causing them not to return to your company. As a business owner, you can't tell how satisfied customers are solely by looking at your number of sales."*

Thus, the content of data analysis must be developed and suggested to figure out the knowledge of grounded theory, which is meant to take into account inductive reasoning to reach the requirement of fundamental research mode. This cited lesson revealed a pattern of thick description, which is the statement of products' perception derived from the quantitative method survey that achieved the increment sale targeted

to reach the goal. Then, the content explained the unknown dissatisfaction of customers' sales without any sign or signal of the lack of understanding of the feelings expressed from their reflection of customers' responsiveness to the product or thought obviously. However, something has gone slightly wrong with the satisfaction of customers' needs. It is still never talked about an untold feeling or thought from their response or perspective, which is the use of product and services company again repeatedly**.** By right, the research study has found the statement characteristic of thin description is similarly same and aligned with the previous chapter's study. Hence, the primary data sets from the qualitative methods analysis were required to assist the untold feeling or thought issues referring to the product quality and the user interaction itself. In the issues of product perception, the role of the product designer is to responsibly create and develop a few data sets of visual communication as design representation according to the product's feeling or thought. To expedite, the data sets of study used to recycle the form of product feeling interpreted an example with hypothetical form following "product form imagery → verbalisation ways (message) → design thinking (product) → product representations (attractiveness)." This hypothetical form was discussed in the previous Chapter 4 previously.

Therefore, to engage with the research topic, it must focus on the primary data sets according to the area of product and industrial design field that was assigned to supply the prescriptive data sets from the judgemental sample size (within the sampling unit as known as focus group specifically). The prescriptive data sets aimed to generate the think-aloud from the subjects who participated using the VPA method platform. Besides, the essential grounded theory of research approach via qualitative methodology was divided into two methods: transcription, namely (1) interviewing: cognition data sets → verbal recording to coding manuscript, and (2) observation: think aloud context in psychomotor data sets → video recording to design/drawing manuscript. Both of these techniques were used simultaneously throughout the clinical investigation.

Nonetheless, current research data analysis was chosen research technique priority, as the method of transcribing observation. The study's chosen research methodology, which was guided by observations made throughout the implementation, aimed to analyze the psychomotor aspects of creating activities where they symbolized the tangible aspects of the design process.

The research scope of the designing activity explained the stages of differentiation following two folds, namely (1) pre-design – the plausibility study and (2) post-design activity – the feasibility study. Also, the priority level of post-design activity dealt with a primary source to the role of PS primary data sets highlighted, and this study was well explained in the previous Chapter 3.

Next, the complementary two stages between the PS and DS-2 stages demonstrated the effective implementation of the DRM framework had some impact on the problem-solving and the solution itself. The PS and DS-2 stages were always discussed in the verification of DRM framework flow using the observation of the VPA method and survey statistical methods concurrently. Thus, the study of data analysis recognised two patterns of dataset for (1) metaphor visualisation as the visual elements (VE) study represented the design thinking knowledge and (2) bipolar digitisation refers to principal solution study from the system thinking knowledge.

5.2 Validity and Reliability

Validity for VPA in qualitative data analysis referred to the degree to which the findings consistently represented the design phenomenon or cognitive processes of design thinking and system thinking, which were studied through the analysis of verbal protocols, such as think-aloud protocols and other forms of spoken or written or drawing expressions. Ensuring validity for qualitative research was crucial to ensure a belief that the conclusions drawn from the analysis were trustworthy and reflective of the participants' experiences and thoughts.

In the VPA approach, the research study's responsibility was to systematically and rigorously collect, code (encode and decode), and interpret the verbal data (by design scheme) in a way that minimised bias and subjectivity. By addressing the above considerations and employing various validation techniques, researchers enhanced the validity of their findings and ensured that they provided a "consistent" representation of the phenomenon under investigation. Thus, an appropriate explanation of validity for VPA in qualitative data analysis referred to accurately observing the events in the verbalisation of the VPA process procedure. However, the study highlights the VPA method, known as grounded theory, as well. There are some considerations for assessing and enhancing validity in the VPA method, namely (1) content, (2) face

validity, (3) criterion, (4) environment, (5) subjects' competencies, (6) triangulation and (7) contextual understanding.

i) *Content Validity* – Ensured that the questions or prompts are used to elicit verbal protocols using the comprehensive visual aid. They should effectively capture the specific design studies according to the theme/coding/variables of the phenomenon under investigation.
ii) *Face Validity* - The VPA should appear to gauge what they intend to evaluate. Review the clinical trial steps of procedures to check if they seem appropriate for the research objectives.
iii) *Criterion Validity* - Compare the findings from VPA with other established methods or criteria that measure the same phenomenon. This could develop and address the validity of the protocol analysis results.
iv) *Environment Validity*- Consider the context in which the VPA were collected. The analysis should reflect the real-world situations and conditions relevant to the phenomenon, and this enhances the environmental validity of the findings.
v) *Subjects Competencies* - To enhance validity, consider involving participants in the validation process. A reflective practice from the participants can build their feedback to confirm whether the interpretations align with their experiences and perspectives.
vi) *Triangulation* - Use multiple sources of data or methods between design thinking and system thinking to cross-validate the findings from the VPA requirement. Combining data from designing experiments with observations or document analysis, for example, can strengthen the validity of the results.
vii) *Contextual Understanding* - Develop a deep understanding of the context in which the verbal protocols were collected. Consider how cultural, social, or environmental factors may influence participants' responses and interpretations.

In Table 5.1, the research study focused on the methodological context that was very crucial to describe the research design processes and their philosophical relation. The VPA method was implicitly represented by the grounded theory, which guided the development of essential research within the research design strategy (like the research onion technique, incorporating longitudinal and cross-sectional approaches). This

ensured that the research questions were addressed and the problem statement was systematically researched and solved. Thus, the research study found four (4) components of contextual qualitative testing methods which were (1) design scheme, (2) artefact categorisation, (3) new product development and (4) design manuscript.

Table 5.1
The Methodological Context of Mixed Methods Strategy for Reliability and Validity

a) Grounded theory (Verbal protocol analysis – VPA method)			
Contextual Qualitative Testing Methods	**Assessment Methods**	**Reliability (Consistency)**	
		Credibility	**Transferability**
1. Design scheme	Think aloud method	Thematic analysis	Semantics design
2. Artefact categorisation	Heuristic method	Quality review of the procedure	Tacit pattern of design manuscript
3. New product development		Design of product positioning	Design identity identification
4. Design manuscript	Analytic rubric evaluation	Criteria, scaling and value - Inter-coder reliability testing	Evolution of form
b) Theory building (Product clinical adoption of survey method)			
Contextual Quantitative Testing Methods	**Measurement Approach / Methods**	**Validity (Accuracy)**	
		Internal	**External**
5. Pilot as clinical survey	Correlation of variables	Nominal, ordinal and scale ranking Items' variables Sig. at the 0.01 & 0.05 level (2-tailed).	Rehearsal of small sampling
6. Fieldwork as a clinical survey	Spearman rho correlation*		Generalisation
	Correlation coefficient*	Value interpretation Strong to weak	Setting population
	X2 Independence Test*	Association	Labelling and bipolar adjectives
7. Instrumentation of items	Reliability analysis and coefficient	Cronbach alpha and Intraclass Correlation coefficient (ICC)	

*Note: Non-parametric test

On the other hand, validity in the context of clinical survey adoption in quantitative data analysis referred to the extent of theory building in which a clinical survey accurately measured (1) what was intended to measure and (2) referred to procedural steps leading to consistency, stability, and repeatability of the survey's results. It was a critical aspect to ensure that the data collected from the survey were meaningful and trustworthy for quantitative analysis during the fieldwork stage. Also, the verification functions to assess whether the survey instrument (instrumentation of items) produced consistent measurements when administered to the same participants

under similar conditions. This study was to display how suitable several statistical testing methods towards the engagement of research onion technique concurrently. Therefore, conducting a reliability test was crucial to ensure confidence in the collected data and its suitability for quantitative analysis:

a) *Test-Retest Reliability* – Test-retest reliability assessed the consistency of survey responses over time. It involved administering the same survey to the same participants on two separate occasions and comparing their responses. High test-retest reliability indicated that the survey produced consistent results when measuring the same construct at different time points.
b) *Internal Consistency Reliability* – Internal consistency reliability evaluated the extent to whicsh items within the survey were consistent with each other in measuring the same construct. Cronbach's alpha is a commonly used statistic to measure internal consistency, with higher values indicating greater consistency among items.
c) *Intraclass Reliability* – If multiple raters or observers were involved in survey administration, inter-rater reliability measured the degree of agreement among them. This was especially relevant in clinical settings where different healthcare professionals may administer the survey.
d) *Administration Consistency* – Standardised the administration of the survey, including clear instructions for participants and consistent environments in which the survey was administered. Variability in administration conditions can introduce errors and affect reliability.
e) *Sample Size* – Larger sample sizes generally provide more stable estimates of reliability. Adequate sample sizes were essential for robust reliability assessments. By the generalisation of a large sample size, the application of the MMS strategy was used for accessibility sampling in qualitative research methodology based on heterogeneous sampling characteristics.
f) *Item Clarity and Wording* – Ensure that survey items are clear, concise, and free from ambiguity. Unclear or confusing items can lead to inconsistent responses and reduced reliability.
g) *Data Management* – Implement a systematic approach to data management to minimize errors in data entry, coding, and data cleaning. Errors in data handling

can compromise reliability.

Hence, the theory building as Table 5.1, known as the design survey method, has summarised three (3) components for the context of quantitative testing methods, namely (1) pilot of the clinical survey, (2) fieldwork of clinical survey, and (3) instrumentation of items. However, the research study can only be used with some related statistical testing methods. The bubbling model of the DRM approach had assigned the expected prediction of the networking of branches' findings. In this study circumstance, construct validity for the survey instrument is required. Table 5.2 demonstrates that the use of scale determines the reliability analysis utilising the Cronbach's Alpha (CA) coefficient values in each sectional-item question. In addition, an exact distribution of scales will be specified, with datasets represented by nominal, ordinal, ratio, and interval values in Appendix 17.

Table 5.2
The Construct Validity for the Instrument of Survey Method

Part(s)	Section(s)	Application of Scale(s)	Items Questions	Estimate Percentage (%)	Case Processing – Valid	Cronbach's Alpha (Reliability)
C	C1	Nominal	5 Items	11.11%	N=45	0.482
	C2 & C3	Semantic Differential Scale	10 Items	22.22%		0.766
	C4 & C5	Likert Scale	10 Items	22.22%		0.768
	C6 & C7	Numerical Scale	10 Items	22.22%		0.810
	C8 & C9	Ratio Scale - Multiple Choice for "Duration/ Series" as Time Context	10 Items	22.22%		0.713

5.3 Triangulation in Testing Methods and Procedures

The pragmatism reasoning is the crucial point to apply the triangulation method in the research study due to the complexity area in the boundaries of inversion design interpretation. This inversion thinking was revealed from the triangulation in the method processed by the degree of philosophical assumption previously (Chapters 2

and 3). Duffy (2022) explained the definition of inversion thinking as *"... is a mental model for solving problems by working backward from potential adverse outcomes to identify challenges that might otherwise go unseen."* The history of the mental model introduced from the term *"inversion"* was credited to German mathematician Carl Jacobi in the 19th century where he encouraged the students to approach the inverted wording frequently. He said, *"Invert. Always invert,"* and he noted that through reverse-engineering the known solutions to difficult issues, they could uncover new areas of study and draw surprising findings (Duffy, 2022). According to Merriam-Webster (2024), the meaning of inversion refers to "*a reversal of position, order, form, or relationship: as a dislocation of a bodily structure in which it is turned partially or wholly inside out.*"

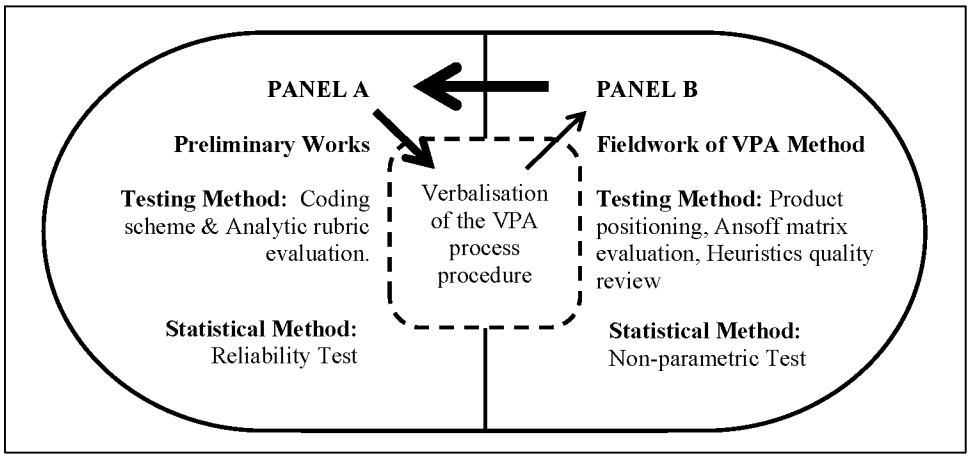


Figure 5.1 A Triangulation of VPA Capsule within The Inversion Thinking Approach

To facilitate the process of VPA's triangulation, Figure 5.1 presented the three arrow signals in varying sizes sequentially. Begun from Panel B's fieldwork inverted into Panel A's preliminary works, the first (biggest) arrow started. Next, the verbalization of the VPA process procedure is shown by the second arrow (bigger), which turns down from Panel A's preliminary works. Finally, a substantial, thin arrow with upright moves took place in the fieldwork of Panel B. Through inversion thinking, the research study lessened the processes of the steps beyond a VPA capsule approach. By rephrasing issues and encouraging research studies to think creatively and beyond the box, the inversion thinking process inspired research studies to develop novel answers that might not have been immediately apparent.

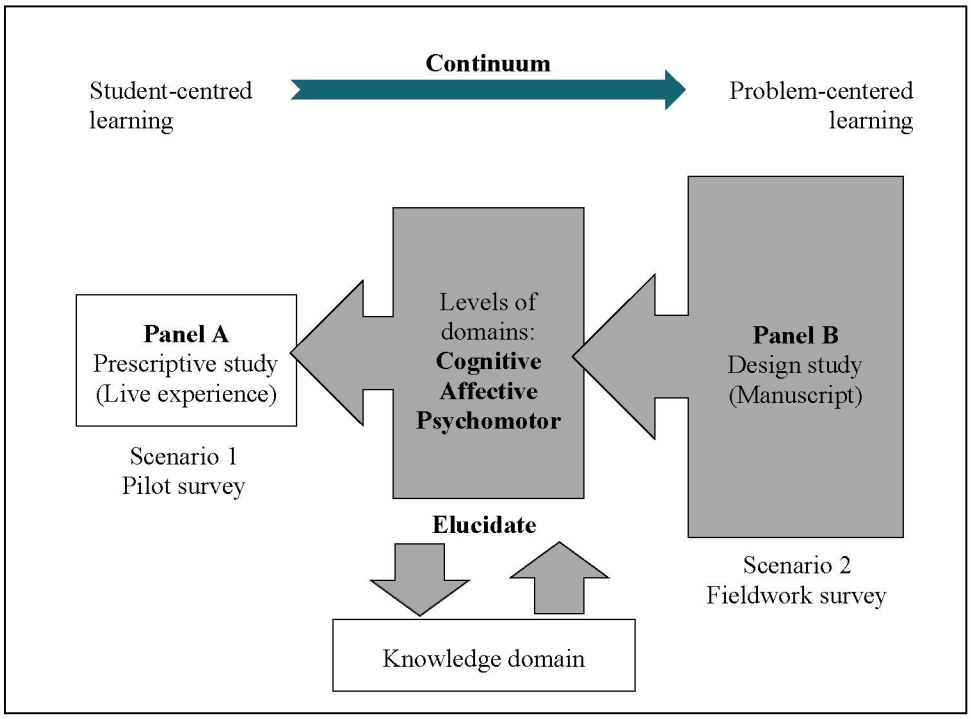


Figure 5.2 An Expectation of Novel Answers Reveals The Inversion Thinking Process of VPA's Capsule Triangulation

As a reflection, Figure 5.2 shows how methodically reversing the conventional cognitive processes might help a research study gain a more holistic grasp of the data and its consequences. The application of the inversion thinking model in the VPA capsule can greatly improve the depth, quality, and consistency of data analysis by revealing hidden biases, encouraging creative solutions, ensuring systematic analysis, and strengthening think think-aloud of verbal protocols. This strategic approach resulted in a more detailed and nuanced knowledge understanding of the research data. Therefore, an explanation of datasets is framed to provide unique responses, allowing it to answer research questions within its goal objectives.

The evidence from datasets revealed that the continuous arrow crosses over the inversion thinking model, starting with the emergence and progressing to standardization, which indicated that the dataset's transformation effectively be led to discovery and result. As expected, preparing and managing data resulted in a distinct methodological perspective for the data analysis study.

5.4 Preparing and Managing Data

The research study prioritized the PS stage and DS-2 stage in the data preparation and management process. The study's design necessitates that qualitative and qualitative techniques be used to structure the DRM framework's important progress. The research study will undoubtedly demonstrate the sampling step of the data-gathering process, which is a hallmark of both homogeneous and heterogeneous mixes. This mixed condition resulted from the study's methodology, which is grounded in the pragmatism of philosophical assumptions relevant to the research topic and title. Because the context of the product form included the ecological form of eco-design identity, the research focused on articulated datasets (induction and deduction approaches) where the format of the design representative pattern was highly subjective. To concurrently accomplish the study objectives inside the research questions, consistent datasets were needed, as supported by the design manuscript derived from the mental process of the VPA method and the interpretation of the statistics testing method.

First, the organisation and coding of qualitative data by the goals and design of the study were necessary to prepare data entry for a design scheme in a qualitative prescriptive study. The framework and structure directing the process of data collection, coding, and analysis was referred to as the design scheme of the VPA technique in a qualitative prescriptive study. Examples included established or data-driven categories, themes, or constructions. Next, choose the categories of data the study wanted to use, such as text (such as observation studies, design manuscripts, video recordings), numerical ratings, or category codes. After the kind datasets have been identified, the study needed to create a codebook with the categories, themes, or constructions that are pertinent to the investigation. This codebook served as a guide for spoken data manual coding.

On the other hand, the study needed to determine whether to create a manual data segmentation system specifically for the VPA method of observation. The plan outlined how the spoken data were segmented for the mental process records using certain signs or indicators in the research project. The VPA segmentation of the design scheme for the mental process was provided by Panel A's probing stage, as shown in Appendix 11. Here, some manual design scheme content preparation was done by asking questions after dataset analysis,

i) *Participant ID* − The identification of subjects who have understood and are connected to the research investigation.
ii) *Segmentation of Verbal Data* − Write down or make a note of a specific verbalisation or think out loud.
iii) *Time Stamp* − Indicate the exact moment the section begins (e.g., minutes and seconds).
iv) *Code/Theme* − Using the codebook as a guide, assign codes or themes to each segment.
v) *Context/Memoing* − Provide any background knowledge or researcher memoing.

Second, there were various phases involved in getting data entered, sorted, and ready for analysis in SPSS (Statistical Package for the Social Sciences). Select the variable types and type the precise label in the box or column that the SPSS software provides. Next, determine the type of each variable: numeric, date, category (string), or another type. Sort the variables according to their defined labels in the codebook. Make a codebook with numerical codes (e.g., 1 = Male, 2 = Female) for each category if the variables were categorical. The research study used in the design survey included this numerical number as part of the conversion of kind wording. At the moment, "Data View" and "Variables View" indicated on two spreadsheet pages. The dataset that was gathered and generated using the survey form must be made available. It is simple to handle the sorting of label contents, as shown in Appendix 11. The label number setting assigns the content of items.

However, the quantitative descriptive study incorporated the fundamentals of the DRM paradigm, which originated from the qualitative prescriptive study. The non-linear process and model that was previously used followed in the preparation and management of the data. Therefore, Figure 5.3 indicates that the inverted process thinking idea was necessary. Thus, the research study changed to apply inverted thinking to advance the data analysis process in a reverse-directional pattern or backward. The purposeful inversion or flipping of a traditional method to problem-solving or decision-making is known as "inverted thinking" in the context of a flow process. It was a creative approach to challenge presumptions, break out from conventional thought processes, and come up with original answers.

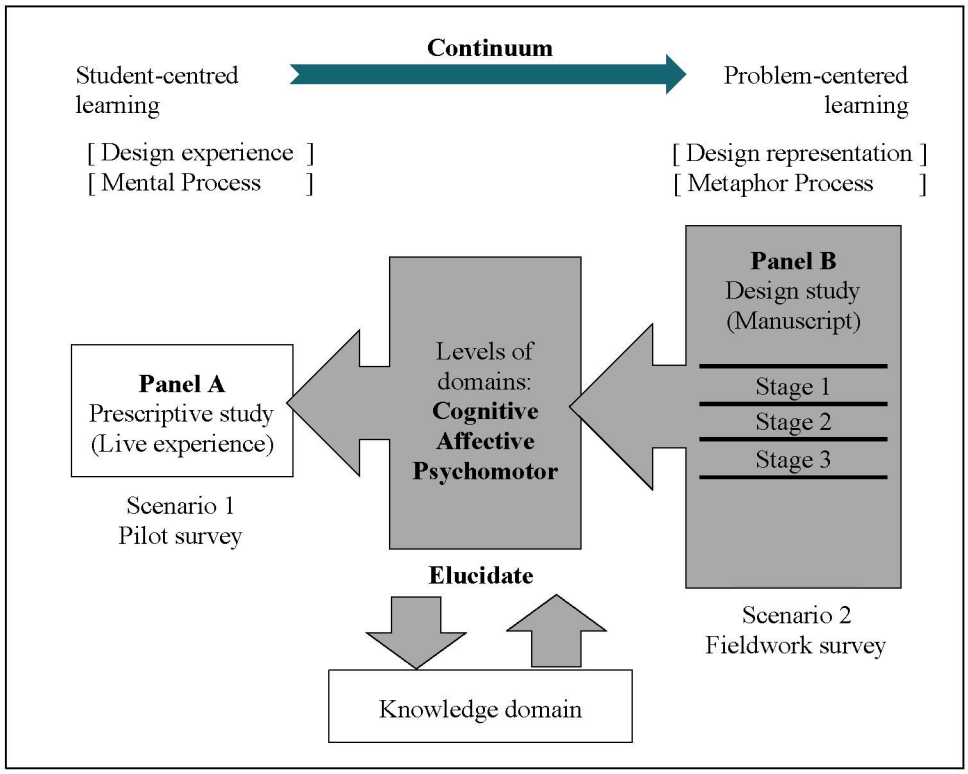


Figure 5.3 A Beginning Process of VPA's Capsule Triangulation from Panel B

Hence, for Panel B's examination stage, the application of funnel thinking must be attempted during the data analysis study. In Panel A, an appropriate selection of grounded theory testing methods enabled the funnel quality of primary data sets to analyse the psychomotor of designing activity – the figure explains about funnel thinking tool. According to Sekaran and Bougie (2016), there are three stages to implement the practice of grounded theory studies and enable to use of the focus group of qualitative research method in the data analysis chapter as follows:

a) *Stage 1: Data reduction* − A method of choosing, coding, and classifying the data. Coding is the analytical process by which the qualitative information gathered is condensed, reorganized, and combined to create theory. The process of sorting, placing, and classifying code units is known as categorization.
b) *Stage 2: Data display* − involves gathering research-compressed data and presenting it in a well-organized, concise way. Lines, charts, matrices, diagrams, graphs, frequently used terms, and drawings are all used to depict data.
c) *Stage 3: Drawing conclusion* − is used to describe the "last" analytical step in the assessment of qualitative data. It is at this point that the study may answer

the research questions by figuring

To engage the observation method related to verbal think-aloud, the study assigned the VPA method consisting of the product clinical adoption (PCA) strategy holistically, which meant the grounded theory testing method was conducted and handled by the task directly together with the environmental needs. Using the CA approach during the data collection, it's assisted the study in planning, managing, and executing the psychomotor of prescriptive data sets. At this moment, design cognition was not a priority study because of the scope of the data analysis being based on the imitation of post-design (known as feasibility study) and the use for the interrelation of practice-based evidence (PBE) knowledge.

However, the evaluation of the DS-2 stage for quantitative methodology is needed when the reliability test measurements are truly examined accurately, along with the use of Statistical Package for Social Sciences (SPSS) software in survey testing method practice. This function is to validate the interpretation of prescriptive data sets that the supporting data analysis enhanced the quality of data display and conclusion concurrently. The improvement of funnel thinking occurred, which meant the description of data analysis frequently reflected and impacted the findings and results.

5.5 PS Data Analysis for Panel A: Transcribing

Assuring that verbal data is precisely recorded, methodically examined, and consistently interpreted is essential for producing legitimate and useful prescriptive recommendations. Transcription is a crucial stage in the study of verbal protocols. Understanding the context and nuances of participants' cognitive processes requires the creation of rich qualitative descriptions, which transcriptions help to achieve. Three transcription process pinpoints are markedly followed in Table 5.3 to initiate the transcription of PS data analysis.

Table 5.3
The Transcription Process

Deidentify participant's data	**Discuss with transcriptionist**	**Transmission of meaning to the text**
Participants were given an deidentifying number	Purpose of the research study	Italicize or capitalize for inflection
Interview recorded	Types of words to deidentify	Capture meaning through use of pauses, laughter, and other indicators
	Management of fillers Use of double-space	

Source: Stuckey (2014)

Deidentification is the first step, which entails deleting or changing any personal data that can be used to identify participants. This was done to safeguard the confidentiality and dignity of participants, which was an important ethical factor in research. Then, having conversations with the transcriptionist was crucial to guaranteeing that they comprehend the precise needs for the transcribing procedure, the study's background, and the goals of the research. Third, transcription aimed to preserve the spoken word's content, context, and nuance and translate spoken words into written language. Ensuring the integrity and depth of the qualitative data is crucial. After identifying the transcription of PS data analysis, it is vital to understand the pattern of squiggly lines that represent the cognitive process. Because the ecological form of eco-design identity was built on the platform of the NPD phase, an appropriate data analysis approach to evaluate the PS context is considered for a similar application of the convergence of system thinking, essentially as Figure 5.4.

According to Wynn, Eckert, and Clarkson (2007), the application of convergence of system thinking should be compatible with the NPD understanding. Engineering design (ED) is centred on design iteration and modeling. The experts originally discovered six perspectives on iteration models that were formally practiced in the ED process. Consequently, the convergence of perspectives model provided a strong framework for analysing VPA data, notably in discovering non-linear squiggly line patterns of thought. Research can acquire a better grasp of the dynamic and complex nature of human cognition by combining numerous data sources, using iterative coding, and visual mapping. This approach not only improved the validity of data but also provided significant insights into how individuals who were industrial designers think, reason, and solve.

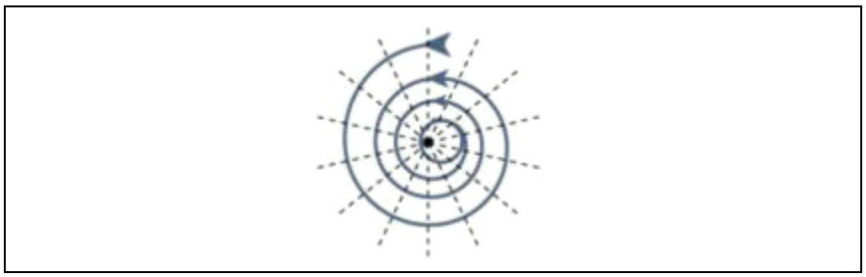


Figure 5.4 An Iterative Pattern of Convergence Perspectives

Source: Wynn, Eckert and Clarkson (2007)

In Figure 5.5, the interdependence and connectivity of the components that made up a system were highlighted by systems thinking. This indicated, in the context of VPA, that many cognitive, emotional, and contextual elements interacted to produce the non-linear patterns that appeared as squiggly lines. The research study discovered that responsive feedback looping had occurred. One of the main components of systems thinking was the feedback loops. Interpolative and extrapolative techniques were two ways in which system outputs are fed back into the system. Both techniques worked together to drive an iterative process that produced the spiraling, looping, or backtracking patterns that were distinctive of squiggly lines. The research will be able to comprehend the mechanisms behind non-linear mental processes more fully by locating these feedback loops. Systems were therefore capable of adapting and learning from experience, something that systems thinking recognises. Systems can adapt to input and develop new patterns and behaviours as a result. Owing to the psychomotor domain in which the behaviour was represented, the research study identified leverage points—important areas in which minor adjustments had a major impact—by visualising the "squiggle line area" in accordance with this comprehensive knowledge understanding of the system's structure and behaviour.

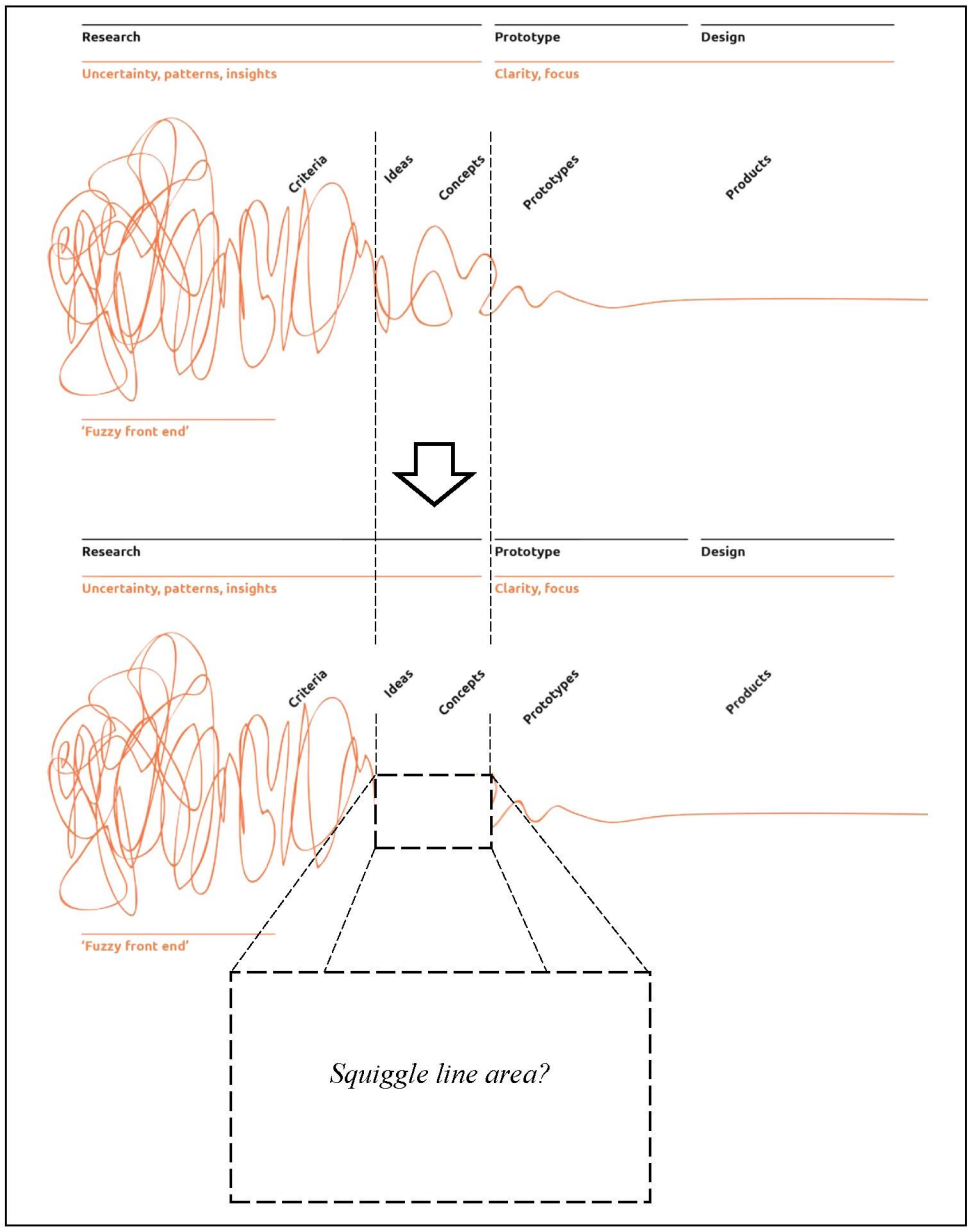


Figure 5.5 A Squiggle Line Area – "Ideas" and "Concepts" Positioned The Convergence Perspectives

5.5.1 Design Scheme: Frequent Designing Sign

Ensuring data availability, richness, reliability, validity, and trustworthiness in a VPA technique of prescriptive qualitative methodology is made possible by data entry for the design scheme. To potentially record the observation transcript consistently, the design scheme analysis concealed the substance of the data entry. The materialization of VPA data collecting and data management must happen at the same time. Because it facilitated the methodical collection, arrangement, and analysis of the verbal data

produced throughout the design process, data entry of a design scheme was therefore important.

The participant count needed to be correctly tagged and marked at this point so that it was included in the results. As an outcome of the VPA, people frequently think aloud when completing tasks like designing. The study documented the ideas, choices, and reasoning behind each design decision by entering data into the design scheme. This facilitated comprehension of the thought processes and methods employed by designers. As a result, the research study discovered some crucial decision-making for data management that it uses for the frequent designing sign (FDS) procedural phase as the goal of the data transcribing on purpose following,

i) *Understanding thought patterns* – The study recorded participants' mental processes in real-time by using think-aloud protocols. Participants disclosed how they approached activities, made decisions, and solved problems by speaking out loud about what was on their minds. This information provided important new understandings of mental models and cognitive methods.
ii) *Understanding decision-making* – This was important for studies that center on designing experience because it enabled researchers to comprehend participants' motivations and methods to come to particular decisions.
iii) *Increase data accuracy* - Think-aloud patterns revealed nuances in cognition that observation alone had missed. Participants may voice uncertainties, hesitations, or realisations that provided further information and context.

The data entry of the design scheme in a verbal protocol analysis technique was an expected output of the study data analysis, and it was important because it offered an organized means of capturing, organizing, analyzing, and interpreting the intricate cognitive processes involved in designing. Using a systematic method was crucial to obtain relevant findings and insights from the research. According to explanatory research, a squiggly line can stand in for moments of convergence (when the participant narrows down to a certain concept or choice) and divergence (when the participant explored various ideas or alternatives). This pattern demonstrated how people frequently switched between considering various options and then concentrated on particular conclusions.



Figure 5.6 FDS Phase 1-PA1#1-8 Data Entry of VPA Segmentation of Design Scheme Manually

Source: The participants PANEL A USM#1-8

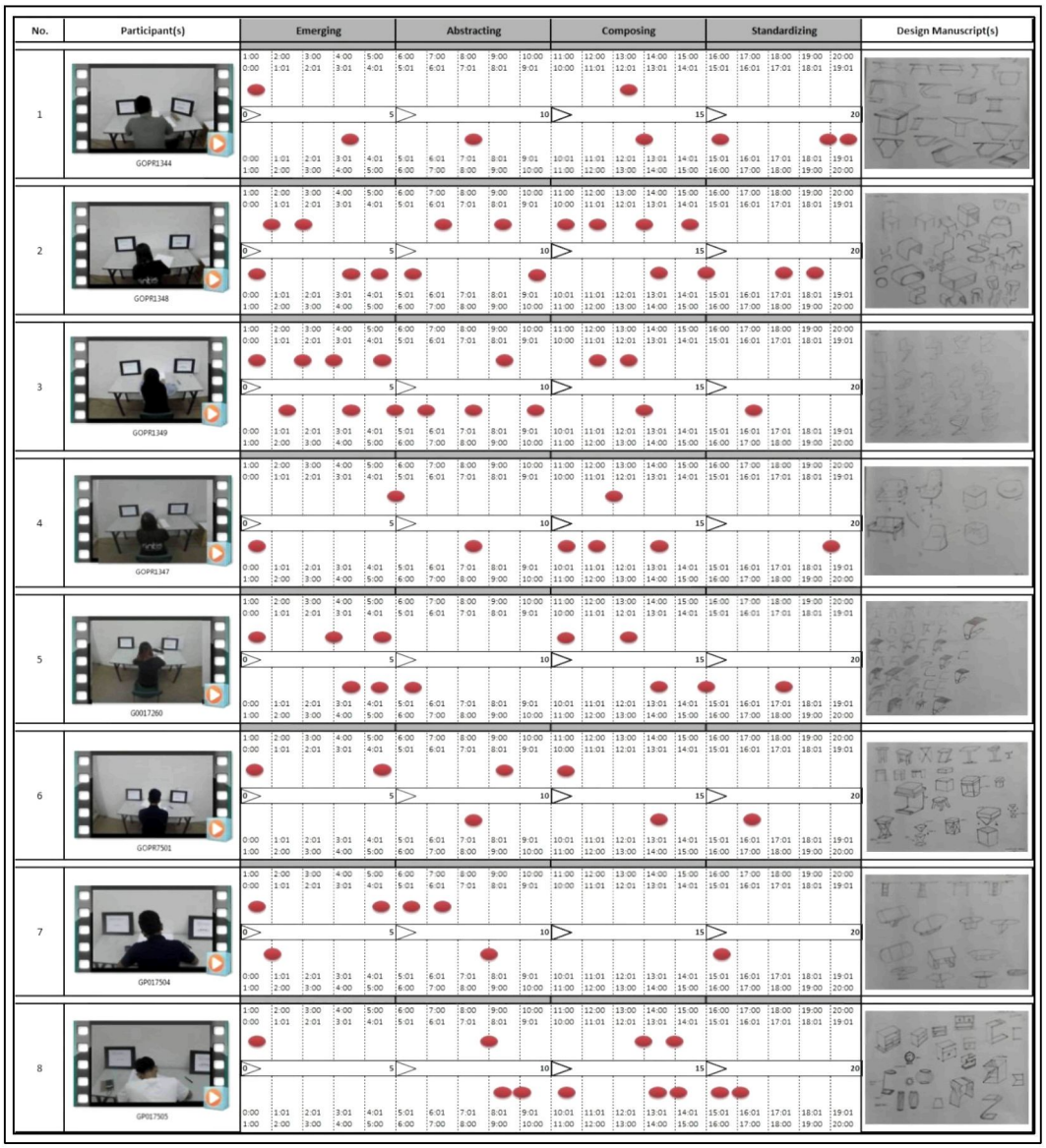


Figure 5.7 FDS Phase 2-Tagging and Marking The Participants PANEL A USM#1-8 (PA1#1-8)

Data Analysis of The Participants PANEL A USM:

In the first step of the FDS, which involved the manual data entry of VPA segmentation of the design scheme as Figure 5.6, eight participants were assigned PANEL A USM#1-8 (PA1#1-8). During the product clinical adoption (PCA) approach session, the participants complied with the VPA's guidelines and protocol. Data analysis is well-materialized through video recordings and well-written design manuscripts.

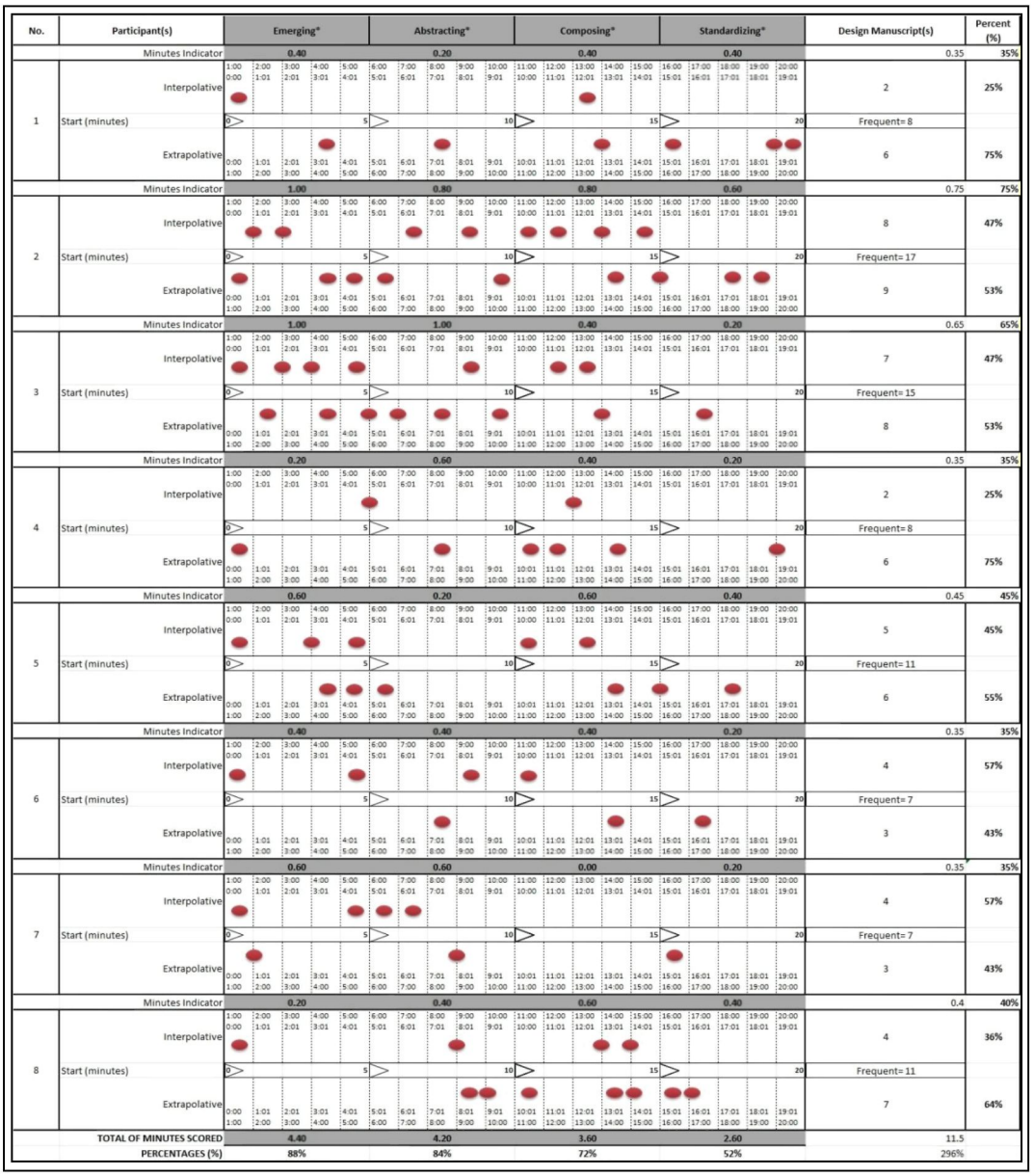


Figure 5.8 FDS Phase 3-Examine The Minutes Indicators PANEL A USM#1-8 (PA1#1-8)

The minutes indicators in Figure 5.7 indicated with a dotted condition then show that, as FDS phase 2, they were contingent on the person's thought process during the video recording session. Two sources of mental cognitions were categorized by table segmentation in Figure 5.8, the participants' column namely (1) interpolative and (2) extrapolative within the minute's indications specified. Each segmented column was calculated using a percentage of 25%, adding up to four columns that each created 100% of the total. Therefore, the amount determined by marking the minutes suggested that it depended on the response from the participant.

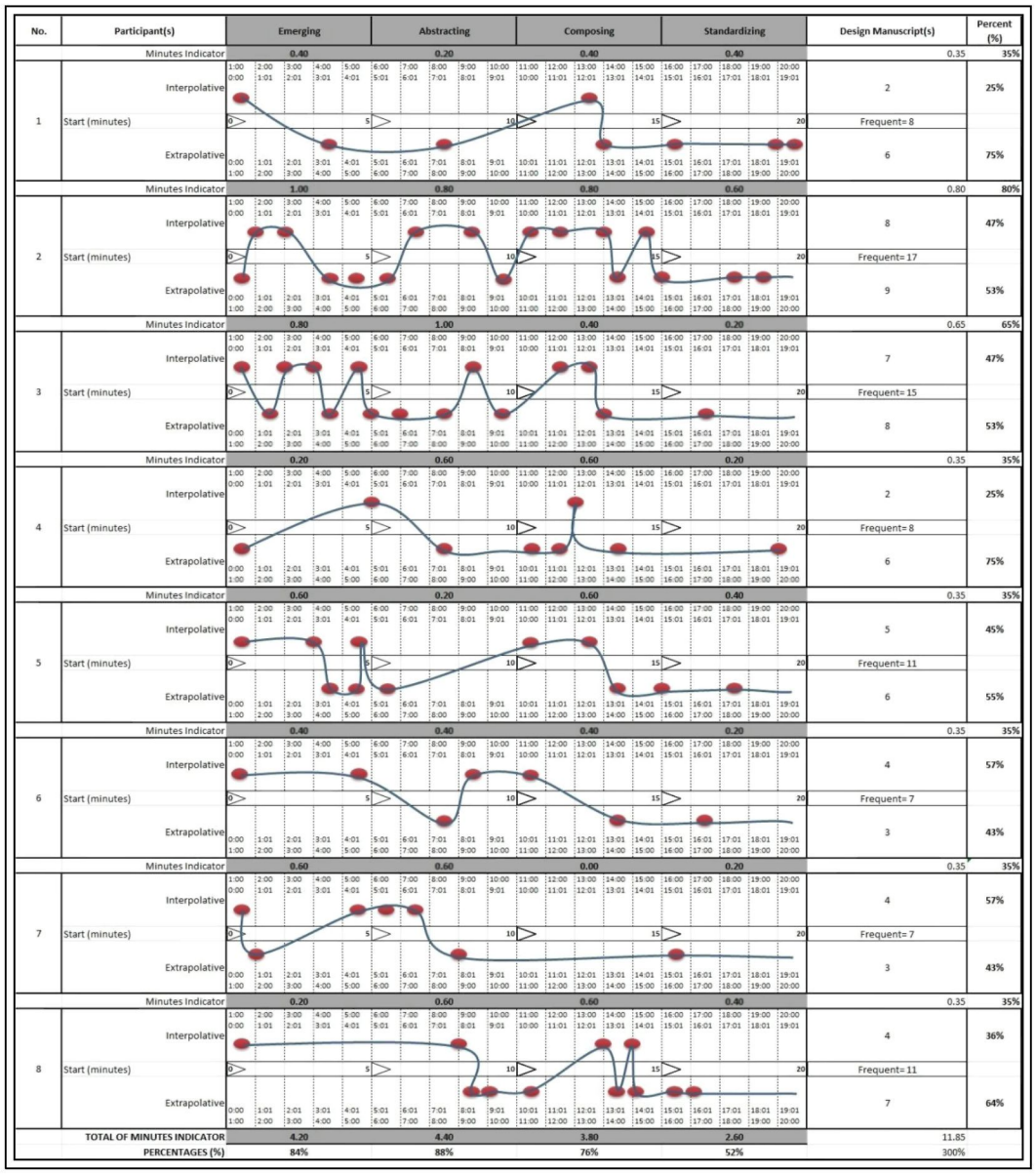


Figure 5.9 FDS Phase 4-Examine The Minutes Indicators PANEL A USM#1-8 (PA1#1-8)

Next, a squiggly line referred to real-time convergence mental process during the segmentation activity of the VPA method that described the PCA response was triggered when the participant narrowed down to a certain notion or choice, as shown in Figure 5.9. As a consequence, the rigorous pattern of think-aloud from the VPAs participants was completed, and a subsequent data analysis for the pattern of think-aloud was explained accordingly.



Figure 5.10 FDS Phase 1-PA2#1-8 Data Entry of VPA Segmentation of Design Scheme Manually

Source: The participants PANEL A GMI#1-8

Data Analysis of The Participants PANEL A GMI:

In the initial step of the FDS, which entailed manual data entry of VPA segmentation of the design scheme as shown in Table 5.23B, eight participants were allocated PANEL A GMI#1-8 (PA2#1-8). During the PCA approach session, participants followed the VPA's standards and protocol. Data analysis was well-documented in video recordings and design documents.

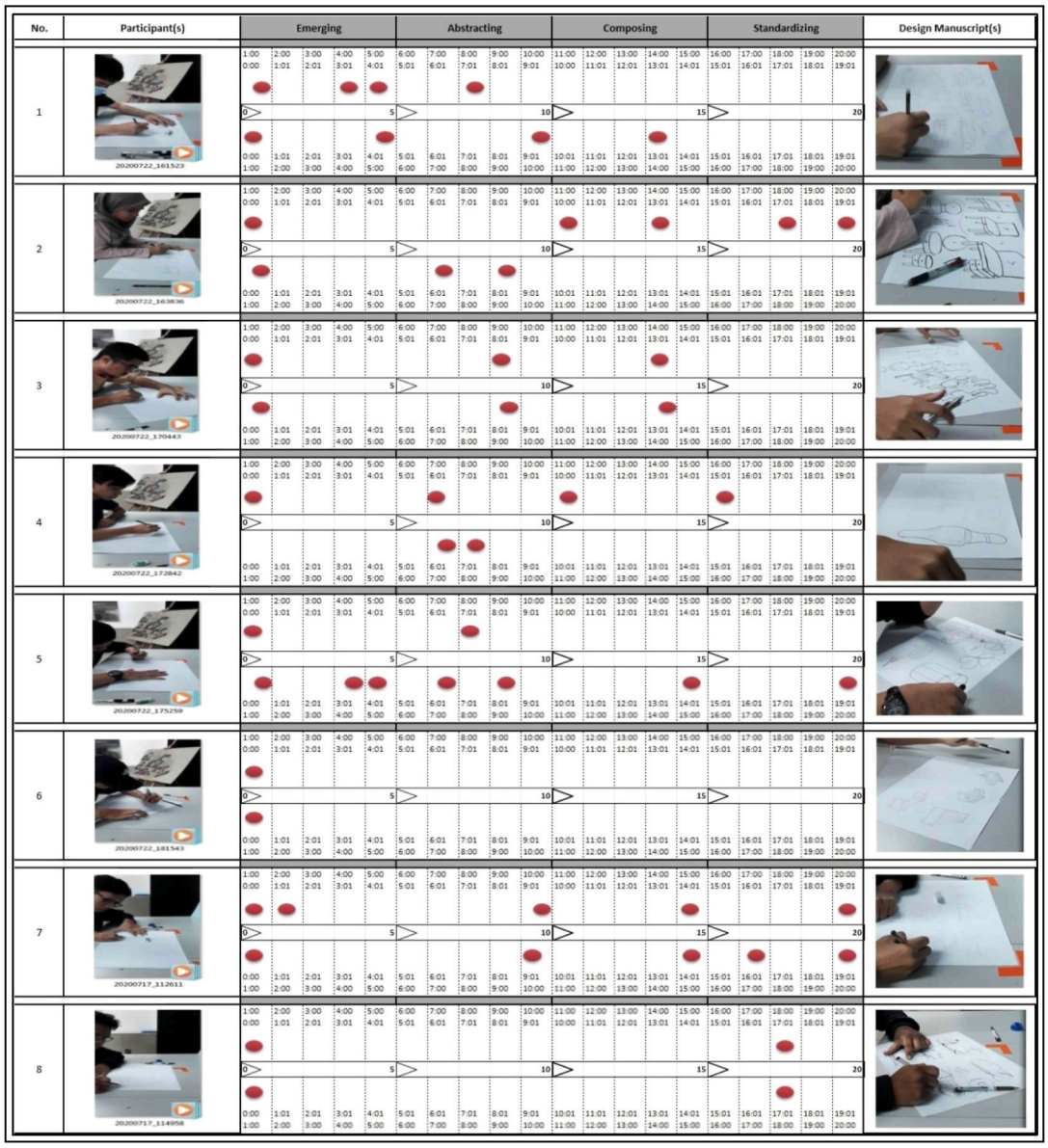


Figure 5.11 FDS Phase 2-Tagging and Marking The Participants PANEL A GMI#1-8 (PA2#1-8)

As FDS phase 2, the minutes indicators in Figure 5.11 that were marked with a dotted condition subsequently demonstrated that they depended on the individual's mental state during the video recording session. Following an analysis of the video recording, the investigation identified two insufficient participants in the VPA approach session.

The individuals numbered PA2#6 and PA2#8 disregarded the directive to reflect it in the necessary artwork, which was the design language. Simultaneously, in the manual VPA segmentation of the design scheme, the dotted pattern was not well displayed.

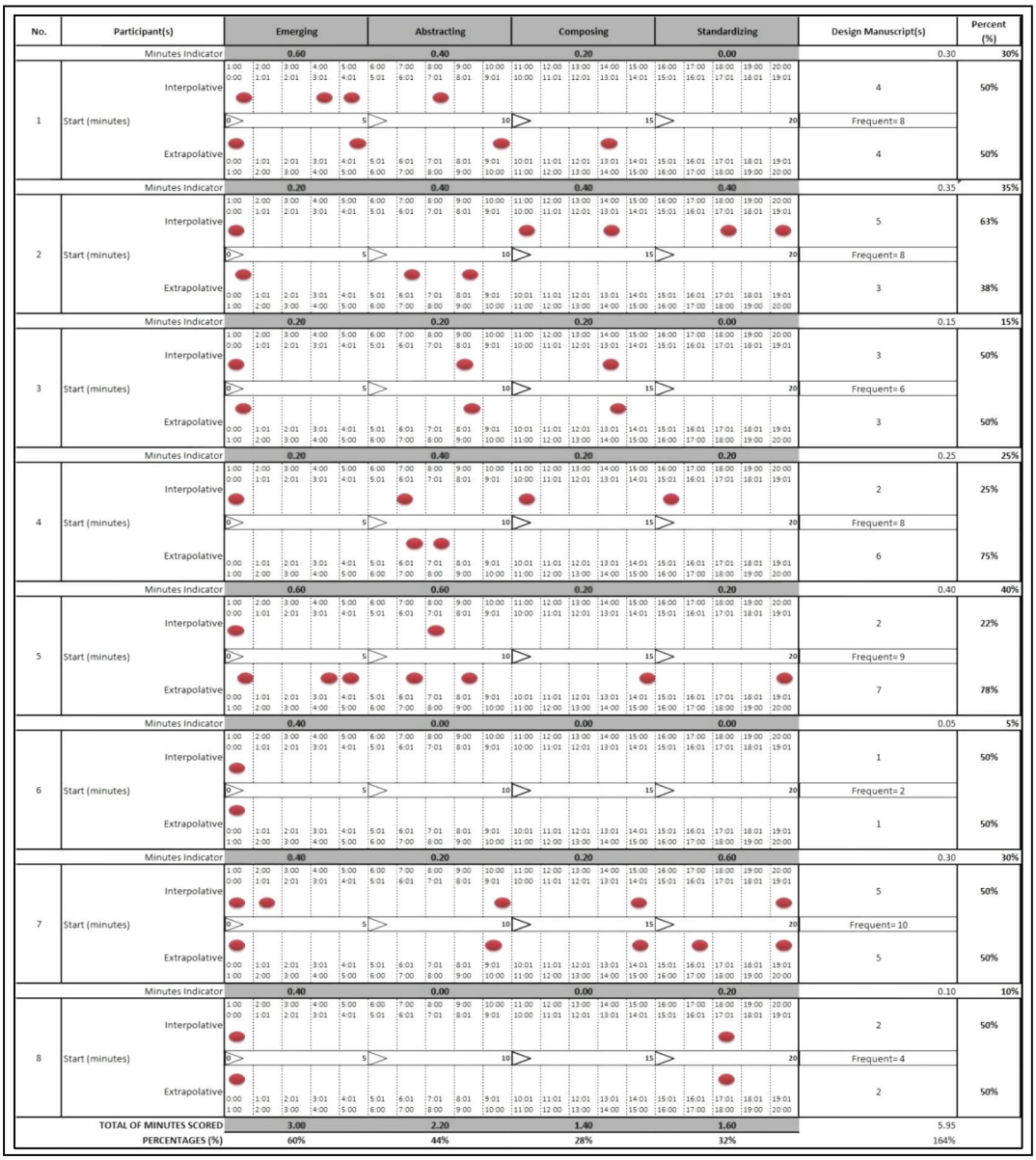


Figure 5.12 FDS Phase 3-Examine The Minutes Indicators PANEL A GMI#1-8 (PA2#1-8)

The study found that two insufficient participants did not reach the sum-sum-number of columns/rows that each created a total of 100%. These two sources of mental cognitions were categorized by table segmentation in Figure 5.12, the participants' column namely (1) interpolative and (2) extrapolative within the minute's indications specified. As a result, the engaged PA2#6 and PA2#8 did not understand and were not prepared for the VPA technique session as Figure 5.13. However, because the participants had not objectively completed the VPA session rules instruction and associated disciplines, the design scheme's defect result analysis was never considered in the study's final conclusions. By right, the data analysis had only considered the

highest percentage rate while frequently utilizing extrapolative and/or interpolative strategies.

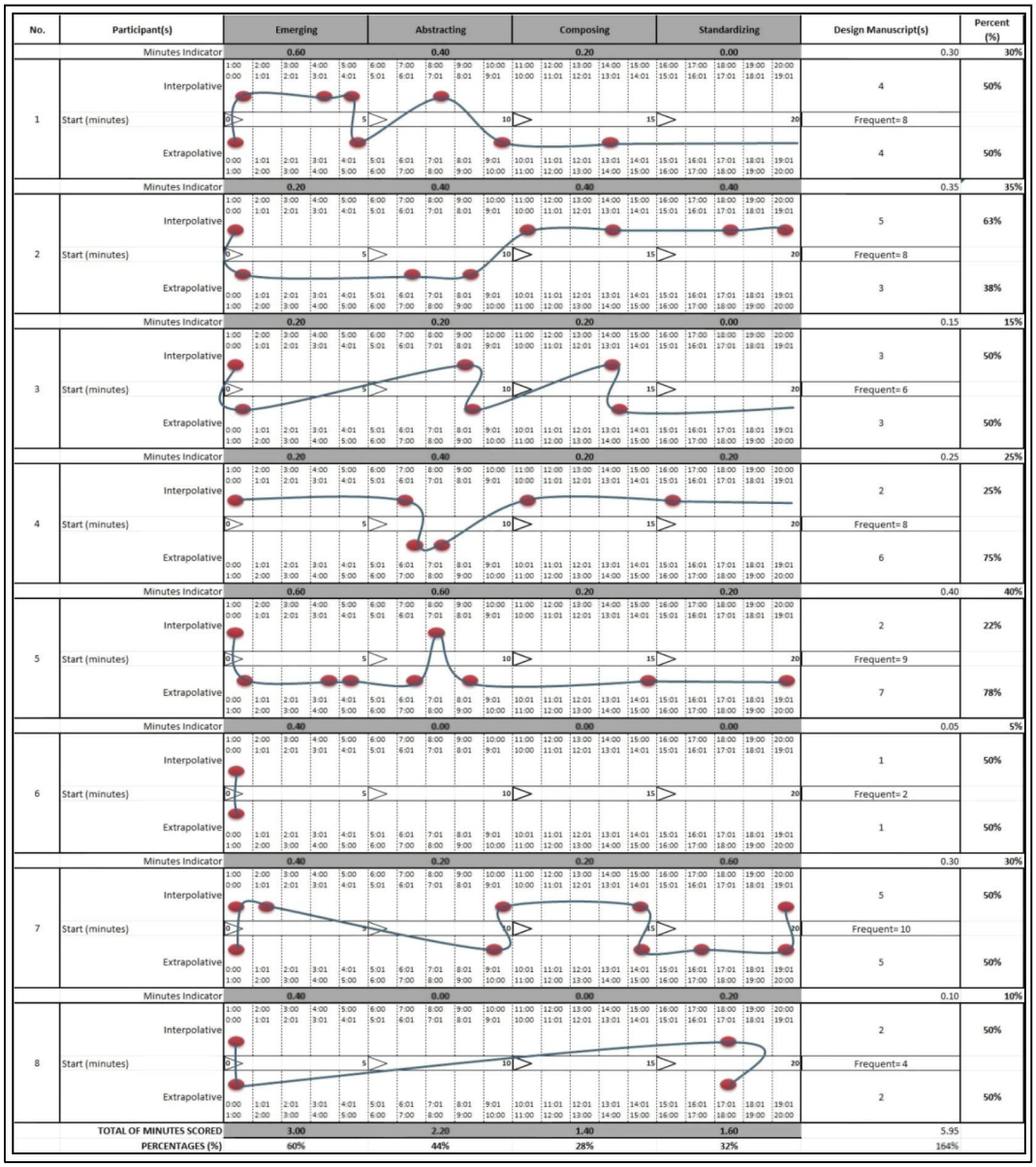


Figure 5.13 FDS Phase 4-Examine The Minutes Indicators PANEL A GMI#1-8 (PA2#1-8)

5.5.2 Design Manuscript

A design manuscript is an organised blueprint or document that outlines the study's framework, procedures, and methods in the context of data analysis for an observation prescriptive study. This work served as a thorough manual to ensure that the inquiry is systematic, logical, and rigorous from a scientific perspective. Provide an

in-depth data analysis strategy that outlined the methods (statistical, content, and theme analysis, for example) that were employed to look at the observational data.

The study included a description of any software tools that were utilised. On the other hand, the classification and coding of the data is specified by the study project. It included manually designed coding schemes for data organisation. Especially when researching cognitive processes, decision-making, and user experience, the think-aloud pattern was essential to design work. Think-aloud techniques enhanced the calibre and extent of data gathering throughout a design process, producing more comprehensive insights and prescriptive suggestions. Consequently, a subsequent study would demonstrate (1) the Design Scheme Analysis Segmentation and the accompanying data analysis for (2) the transcription of coding analysis to define what is meant by squiggly line complexity.

5.5.2.1 Pattern of Think Aloud

The pattern of thinking aloud was complicated, with concepts interacting in surprising ways. Therefore, the fundamental query was as follows: Why should the convergent of the squiggly line be used to examine the think-aloud pattern? The squiggly line can depict this interconnection via the prescriptive data analysis, demonstrating how several thought strands were connected to and may impact one another. It offered a more comprehensive understanding of the mind. When examining think-aloud patterns, the application of a "squiggly line" metaphor points to a dynamic, non-linear method of comprehending cognitive processes. This non-linear form can more accurately replicate the cognitive processes that occurred in real-time during think-aloud sessions, which led to a more detailed transcription of coding analysis (TCA).

The application of a squiggly line approach in reflection of observation transcript reasoning permitted adaptable analytical frameworks that took into account different cognitive strategies. Its capacity to identify moments of insight, confusion, hesitancy, or decision-making allows for a more thorough comprehension of the cognitive processes at work. Thus, two important discoveries from the study of data analysis for the think-aloud pattern were (1) PANEL A USM#4 (PA1#4) and (2) PANEL A GMI#5 (PA2#5).

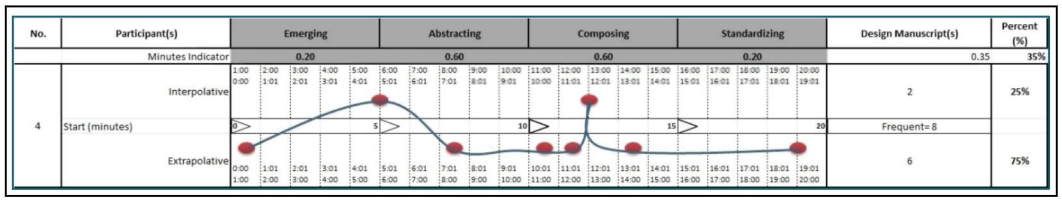


Figure 5.14 Segmentation of Design Scheme Analysis - PANEL A USM#4 (PA1#4)

Table 5.4
Transcription of Coding Analysis PANEL A USM#4 (PA1#4)

No.	Minutes *(Duration)*	Observation Transcript	Media			Memoing *(Head, eyes and arm movement)*
			HB pencil	*Black ball pen 1.0*	*Black Artline 0.6*	
1.0	0:25 (0.3s)	Free form of hand stroke ***Geometric lines and perspective lines***	-	✓	-	Emerging stage - Extrapolative
2.0	5:11 (0.2s)	***Geometric lines*** and form of hand stroke Structural lines and repetition lines	-	✓	-	Abstracting stage - Interpolative
3.0	7:59 (0.2s)	***Detailing cantilever lining***…free form of hand stroke	-	✓	-	Composing stage - Extrapolative
4.0	10:10 (0.2s)	Curves and ellipse lining… free form of hand stroke... and repetition lines An emergence of ***3Rs method and elements*** - Reducing and recycling shapes	-	✓	-	Composing stage - Extrapolative
5.0	11:05 (0.25s)	Vertical lining…***cantilever form*** of hand stroke	-	✓	-	Composing stage - Interpolative
6.0	12:30 (0.2s)	Bold the outlining shape and simplicity design. **Reducing and recycling shapes – Cantilever and cube form**	-	✓	-	Composing stage - Interpolative
7.0	13:30 (0.25s)	Bold the outlining shape and simplicity design. An emergence of ***organics shape*** – Bowl and bean form	-	✓	-	Composing stage - Extrapolative
8.0	19:11 (0.2s)	Touch-up works	-	✓	-	Standardizing stage - Extrapolative

According to Figure 5.14, the Design Scheme Analysis revealed that participant PA1#4 frequently referred to the extrapolative visual assistance, with 6 of 8 times (75% highest rate) from the right-hand side (VPA setting). All segment stages were recorded, and each indication consistently addressed each of the four stages of design scheme analysis. To emphasize the substance of Design Scheme Analysis, the research study generated the detail transcription of coding analysis as shown in Table 5.4 below.

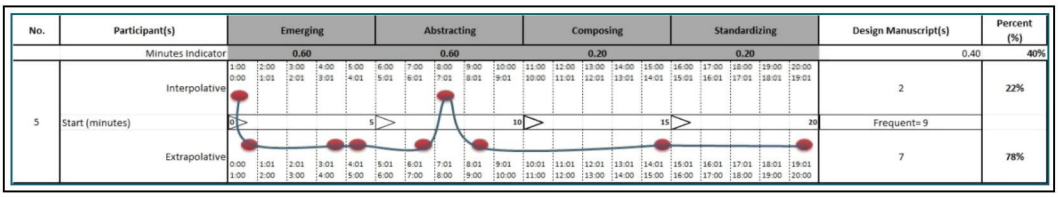


Figure 5.15 Segmentation of Design Scheme Analysis - PANEL A GMI#5 (PA2#5)

Table 5.5
Transcription of Coding Analysis PANEL A GMI#5 (PA2#5)

No.	**Minutes** *(Duration)*	**Observation Transcript**	**Media**			**Memoing** *(Head, eyes and arm movement)*
			HB pencil	*Black ball pen 1.0*	*Black Artline 0.6*	
1.0	0:01 (0.1s)	Curves shape… free form of hand stroke Construction lines and repetition lines	✓	-	-	Emerging stage - Interpolative - Extrapolative
2.0	3:55 (0.2s)	Circle and ellipse shape… free form of hand stroke Construction lines and repetition lines An emergence of ***floral motif***	✓	-	-	Emerging stage - Extrapolative
3.0	4:51 (0.2s)	Vertical lining…***free form of hand stroke***	✓	-	-	Emerging stage - Extrapolative
4.0	6:53 (0.2s)	Curves and ellipse lining… free form of hand stroke... and repetition lines An emergence of ***design elements - crescent and bowl shapes***	✓	-	-	Abstracting stage - Extrapolative
5.0	7:24 (0.2s)	Vertical lining…free form of hand stroke	✓	-	-	Abstracting stage - Interpolative
6.0	8:13 (0.25s)	Change the media - HB pencil to Black Artline. Bold the outlining shape and design	-	-	✓	Abstracting stage - Extrapolative
7.0	14:59 (0.2s)	Change the media - Black ball pen 1.0 to Black Artline. Bold the ***contouring and outlining shapes***...	-	✓	✓	Composing stage - Extrapolative
8.0	19:35 (0.2s)	Touch-up with both media - HB pencil to Black Artline.	✓	-	✓	Standardizing stage - Extrapolative

Figure 5.15 showed that participant PA2#5 used the extrapolative visual aid 7 of 9 occasions, with a 78% highest rate from the right-hand side (VPA setting). All segments' stages were recorded, and each indication addressed each of the four stages of the design scheme analysis. To emphasize the substance of Design Scheme Analysis, the research study generated the detail transcription of coding analysis as shown in Table 5.5.

Hence, referencing the observation transcript of participant PA1#4 and PA2#5, the precise type of code attribution was detailed extensively based on the data analysis findings from the Segmentation of Design Scheme Analysis. For the research findings to be accepted and for the convergent of the squiggly line to be recognized thoroughly, a detailed data analysis report is required.

5.5.2.2 Inter-Coder Reliability

The prescriptive qualitative approach requires inter-coder reliability testing to verify the validity and consistency of the coding process, which was particularly important when interpreting design manuscript documents in the phase of Panel A. Inter-coder reliability testing serves the following important purposes: (1) maintaining objectivity consistency; (2) enhancing the quality of coding schemes; (3) validating findings; (4) encouraging cooperation; and (5) enabling valid interpretation of themes and patterns.

i) *Maintaining objectivity consistency* - The degree to which many coders—researchers—agree on the coding of the same data set is measured by inter-coder reliability, which showed consistency in the interpretation of qualitative data. Consistent coding by several academics guaranteed that interpretations of design documents, which frequently contained subjective components and imaginative descriptions, were not skewed or unduly subjective. It increased the validity of the results by demonstrating that several researchers employing the same coding scheme come to comparable conclusions. Consequently, the aim prescriptive establishing in the evaluation and/or assessment of design manuscripts was delivered by the significance of consistency.
ii) *Enhancing the quality of coding schemes* – Finding ambiguities or overlaps in the coding scheme was the first step towards refining the codes, and verifying inter-coder reliability is necessary for this. Coder disagreement was an indication that the coding categories required explanation or revision. The approach was designed to produce a feedback loop whereby the coding scheme could be enhanced and improved, hence increasing its robustness and data-reflectiveness.

iii) *Validating findings* – The quality of prescriptive qualitative research would be examined in relation to the validation of credibility and reliability. High inter-coder reliability typically indicated reliable coding and analysis, which raised the research's credibility. It demonstrated that the findings were not reliant on the unique interpretation of a single researcher. Therefore, one must use heuristics to locate the word of generalizability in the observation context. Reliable coding essential ensured that practical instructions or hypotheses derived from prescriptive qualitative research were grounded in consistently interpreted data.

iv) *Encouraging cooperation* – The participants' relationships with one another inside the group team members are crucial. The study, which originated in team-based research, referred to the various participants that were involved and how inter-coder reliability guaranteed that everyone in the team was in agreement and fostered a common understanding of the data. Next, the appearance of standardization showed that a multiple metacognition combination quality procedure took place, which allowed the coding procedure to be consistent for all researchers. Therefore, in turn improved efficiency and coherence of the research process.

v) *Enabling valid interpretation of themes and patterns* - Themes and patterns were frequently created from the co-occurrence of codes, making thematic co-occurrence analysis (TCA) an accurate labelling approach with superior results in qualitative research. Reliability between coders guaranteed that these themes were actual patterns in the data rather than artefacts of uneven coding. Reviewing the datasets with great precision is necessary for interpreting the design aspects. Consistent coding, for instance, guaranteed accurate interpretation of design decisions, standards, and principles in design manuscript documents, where interpretation may entail reading both textual and visual elements.

Thus, it was essential to conduct inter-coder reliability testing when interpreting design manuscripts using a prescriptive qualitative approach to ensure that the study findings were trustworthy, reputable, and able to influence the creation of useful design guidelines or principles. By guaranteeing that several coders can consistently use the

coding scheme, it facilitated a rigorous research process and produces reliable and valid interpretations of the qualitative data.

Table 5.6
Calculation of Percent Agreement (Fictitious Data)

Var#	Raters		Difference
	Mark	Susan	
1	1	1	0
2	1	0	1
3	1	1	0
4	0	1	−1
5	1	1	0
6	0	0	0
7	1	1	0
8	1	1	0
9	0	0	0
10	1	1	0

Number of Zeros = 8
Number of Items = 10
Percent Agreement = 80

Interpretation: "The agreement is 80%. This meant that 20% of the data collected in the study was erroneous because only one of the raters can be corrected when there was disagreement. This statistic was directly interpreted as the percent of data that are correct. The value, 1.00 - percent agreement may be understood as the percent of data that are incorrect. That is, if percent agreement is 82, 1.00-0.82 = 0.18, and 18% is the amount of data misrepresents the research data" (McHugh, 2012).

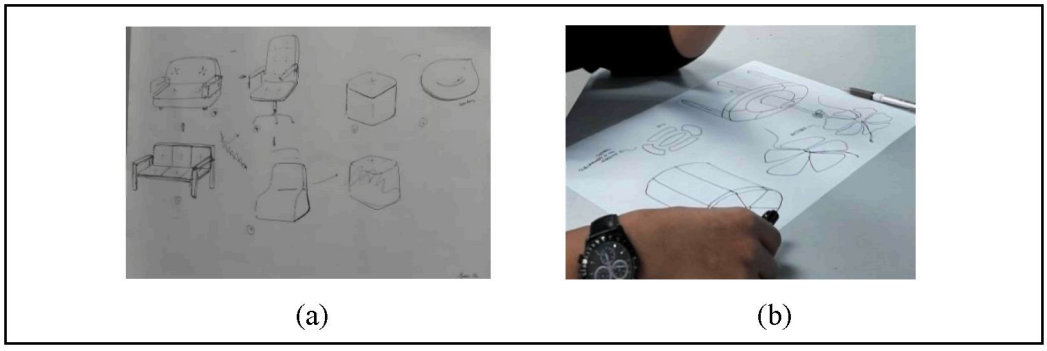
In Table 5.6, the research study displayed to demonstrate how the percent agreement analysis was used for the datasets in the evaluation of the design manuscript. Percent agreement is a simple measure of inter-coder reliability that indicates the proportion of instances in which different coders assign the same code to the same piece of data. With interpreting design manuscript documents, the desired percent agreement varied depending on the complexity of the coding scheme and the standards of the particular research field.

In addition, Cohen's Kappa frequently references some broad criteria and benchmarks. According to McHugh (2012), the subject, label, or category of object representation is critical for rater dependability since it occurred to ensure that datasets are measured correctly. He claimed that "…symbolized by the lower-case Greek letter, κ is a robust statistic useful for either interrater or intrarater reliability testing. Similar to correlation coefficients, it can range from −1 to +1, where 0 represents the amount of

agreement expected from random chance, and 1 represents perfect agreement between the raters. While Kappa values below 0 are possible, Cohen notes they were unlikely in practice. As with all correlation statistics, the Kappa is a standardized value and thus is interpreted the same across multiple studies." For example, McHugh (2012) converted the Kappa value to a level of agreement, as shown in Table 5.7.

Table 5.7
Interpretation of Cohen's Kappa Coefficient (k)

Value of Kappa	Level of Agreement	% of Data that are Reliable
0–.20	None	0–4%
.21–.39	Minimal	4–15%
.40–.59	Weak	15–35%
.60–.79	Moderate	35–63%
.80–.90	Strong	64–81%
Above.90	Almost Perfect	82–100%



(a) (b)

Figure 5.16 Design Manuscript of Panel A (a) PA1#4 and (b) PA2#5

Figure 5.16 depicts the study's design manuscript from two groups' perspectives. As an output from the design manuscript, the % agreement indicated dependability, which relates to how consistently coding segments are allocated in the same categories. According to Geisler and Swarts (2019), naming and assigning coders in the table's categories was appropriately documented as Table 5.8. A tangible coder denoted a complete agreement because it reflected the level of agreement. The study was successful in selecting and assigning the coders' theme based on the Spearman Rho correlation consequence, which represented the tagged with (1) the visual elements of product design: heuristic procedural step, quality of eco-design identity, (2) the perception of design belief: visual elements interpretation, exceeding level > 3 - quality

review, quality of lines, and (3) the emotion of a product's form quality: eco-design identity, cantilever principle, product form identity, visual elements understanding, < Level 3 - proficiency, cantilever design understanding.

Table 5.8
Calculation of Percent Agreement (Fictitious Data) for The Phase of Panel A

	(Themes' Codes) Var#	Raters		Difference
		PA1#4	PA2#5	
1	Heuristic procedural step	1	1	0
2	Quality of eco-design identity	1	1	0
3	Visual elements interpretation	1	1	0
4	Exceeding level > 3 - quality review	1	0	1
5	Quality of lines	1	1	0
6	Ecodesign identity	0	0	0
7	Cantilever principle	1	1	0
8	Product form identity	1	1	0
9	-< Level 3 – Proficiency	0	1	-1
10	Cantilever design understanding	1	1	0

Number of Zeros = 8
Number of Items = 10
Percent Agreement = 80

Interpretation: The raters for the agreement were 80%. Because only one rater can be right when there is disagreement, 20% of the data gathered for the study is inaccurate. Therefore, the level of agreement is "strong" as 64–81% of Reliable data.

Note: (1) PA1#4 = PANEL A USM, Participant#4; (2) PA1#5 = PANEL A GMI Participant#5

5.6 PS Data Analysis for Panel B: Evaluating

The research study incorporated tabulation analysis, the heuristics quality review approach, the Ansoff matrix, and the perceptual model of the product positioning canvas to accomplish the design representation goal. Researchers and/or industrial designers can approach their goal of creating a product that is both market-relevant and user-centric for purposeful trend design in a comprehensive way by combining data-driven insights from tabulation analysis, a visually mapped consumer perception through the product positioning canvas, strategic market planning with the Ansoff matrix, and usability improvements via the heuristic's quality approach.

Every technique works in collaboration with the others guaranteed that the design process is user-friendly, strategically positioned, and informed by data. Common

themes and significant design elements are revealed by this research, which aided in the improvement of the original design concepts see Table 5.9.

Table 5.9
Integration of PS Data Analysis for Panel B in the Manuscript Data Analysis

Types	Stage 1	Stage 2		Stage 3	
	Tabulation Analysis	**Product Positioning Canvas**	**Ansoff Matrix**	**Heuristics Quality Review**	**Analytic Rubric Evaluation**
Definitions	Arranging and evaluating data in order to find trends, correlations, and frequencies. It is used in design to organise consumer input, feature requests, and market reactions into an understandable and measurable manner.	Customers' perception of a design or product relative to rivals. Quality against price and classic versus modern are just a few examples of the axes it employs to graphically arrange products in a competitive market.	A tactical instrument for comprehending plans for product-market expansion. Market penetration, product development, market development, and diversification are its four quadrants.	Assesses a product's design using usability heuristics, a collection of broad guidelines for effective interaction of meta-morphing and semantics design.	Assesses a product's design through the quality of design manuscript. It is very significant for the "think aloud" of design experience and elaborates the verbalization ways.
				Inter-Coder Reliability	**Radar Chart**
				To confirm the accuracy and consistency of the coding procedure, which is crucial for analysing design manuscripts.	Spider net analysis is a visual tool to represent different or the codes functional zones of the orb web.

In the PS data analysis for Panel B, for the purpose of methodically reducing general observational findings into precise, useful design recommendations, funnel thinking techniques such as tabulation analysis were required. Ultimately, they provided more user-centric and efficient design solutions by improving the precision and dependability of design research. Researchers began broad (gathering a broad range of observations) and gradually focused on specific findings with the help of funnel thinking. Before concentrating on specific details, this approach was crucial for comprehending the larger context. Observations are generally the starting point for repeated testing and refinement in a data reduction design approach. The use of tabulation analysis made it possible to monitor changes over time and comprehend how changes to the design affected user interactions or perceptions. Researchers or industrial

designers can make evidence-based adjustments by referencing historical data and keeping a tabular record of observations.

Perceptual mapping in product positioning canvases is the next crucial element in figuring out how products are seen in the marketplace and where to put them for maximum effect. It offers operational understandings that direct creative and promotional choices, guaranteeing that goods satisfy customer requirements, differentiate themselves from competitors, and flourish in the market. With the aid of these resources, designers can improve the marketability and attractiveness of their products by making well-informed, fact-based judgements. Once more, the funnel thinking tools play a crucial role in design manuscript observation because they enable observers to strategically analyse and picture how products or design concepts are seen. For successful product design and development, these tools facilitate a knowledge of the user's perspective, the market environment, and positioning tactics. Furthermore, because it offers an organised technique for comprehending market and product dynamics, the Ansoff Matrix qualitative method solution is a useful funnel thinking tool for design document observation in the successful development of new products. The matrix assists in making sure that goods are not only well-designed but also strategically positioned to meet company objectives by coordinating design efforts with particular growth strategies. Design and strategy alignment increases competitiveness, market relevance, and the chance of successful product adoption. Using the Ansoff Matrix as a funnel thinking tool was particularly significant in the context of design manuscript observation for several reasons. It provided a methodical framework for making decisions that provided immediate effect on innovation and product design.

Finally, heuristic quality review (HQR) evaluation guarantees that design quality is in line with user-centred concepts and best practices, making it an essential tool in the observation of design manuscripts. HQR evaluations aid in the development of intuitive, effective, and pleasurable goods by methodically detecting and resolving usability problems. For improving user experience, directing iterative design processes, and guaranteeing consistent, high-quality product development, this tool's proactive and systematic approach to quality assurance made it indispensable. To evaluate and enhance design quality, HQR evaluation was an essential funnel thinking technique in the observation of design manuscripts. It’s a method of identifying usability problems by comparing design elements to recognised usability principles and/or heuristics.

Thus, in the design representation, an effect knowledge of the metaphor process will be in line with and compliant with the PBL environment. Metaphors were frequently used in design to help researchers and industrial designers understand new items by drawing comparisons to familiar objects. A desktop folder icon on a computer, for instance, is a metaphor for a real folder used to arrange documents. To effectively comprehend, one must be able to express meaning, and functionality, or elicit particular user reactions or emotions through the use of metaphors, particularly when it comes to ecodesign identity. The term "design representation" described the visual and communicative methods used to convey design concepts, such as sketches, prototypes, 3D models, and other visual media. The statement suggested that as part of PBL, designers and students should have a thorough understanding of metaphors in design and incorporate them into their problem-solving process. They should use metaphors to successfully express concepts, functions, or emotional reactions in a way consistent with the real-world challenges they were attempting to solve through design. This understanding should be represented in their design representations under Figure 5.3 (A Beginning Process of VPA's Capsule Triangulation from Panel B) provided earlier.

5.6.1 Stage 1: Data Reduction

The design manuscript was collected from participants upon the completion of the VPA method session. The study has sorted the design manuscript into physical assessments using the proposition canvas called product positioning analysis (PPS). This assessment examined design artifact on which area of position was categorised in the four matrix propositions. The knowledge of PPS was developed by the marketing business and strategy in many manufacturing sectors. By separating it from rival products, the design and product form will improve design perceptions – Also, it is called the process of data saturation in qualitative research. Therefore, the study screened to identify the three (3) procedural steps of data reduction for design manuscripts in qualitative methodology, namely (1) sorting and (2) placing and categorising.

First, the design manuscript was sorted by the tables' tabulation following the three industrial design course programmes within its institutions respectively, namely (1) Bachelor of Arts (BA), (2) Bachelor of Design (BDes), and (3) Bachelor of Science (BSc). The essential items of the table design manuscript described the product

category, number of subjects' participants, subject matter, name of the product, and the matric position. At this time, the name institution should be renamed and rebadged for the sampling with the code number within colour representative according to Tables 5.10, 5.11, and 5.12. The purpose of naming replacement was to set up the subjects' participants in a focused group of purposive sampling so that the datasets were available and to prevent bias data collection.

Table 5.10
List of Design Manuscripts for Bachelor of Arts (BA)

No. of Subject	Category	Green (Subject)	Subject matter	Name of product
1	Product	A1	Shark	Hair dryer
2	Furniture	A2	Leave	Open cabinet
3	Furniture	A3	Bee	Rocking chair
4	Product	A4	Eagle	Remote controller
5	Transport	A5	Giant manta rays	Supercar
6	Furniture	A6	Butterfly	Lounge chair
7	Transport	A7	Shark	Superbike
8	Product	A8	Beetle	Cutter
9	Furniture	A9	Beetle	Sofa – Single seater
10	Product	A10	Sea horse	Remote control
11	Transport	A11	Praying Mantis	Café racer bike
12	Transport	A12	Butterfly	Supercar
13	Transport	A13	Dragonfly	Aircraft
14	Product	A14	Penguin	Bottle
15	Furniture	A15	Honeycomb	Coffee table

Note: 5 of 15 subject participants followed the mimicry process (33.34%).

Table 5.11
List of Design Manuscripts for Bachelor of Design (BDes)

No. of Subject	Category	Pink (Subject)	Subject matter	Name of product
16	Transport	B1	Beetle	Supercar
17	Transport	B2	Beetle	Sport car
18	Transport	B3	Beetle	Sedan car
19	Furniture	B4	Butterfly	Chair
20	Furniture	B5	Butterfly	Round table
21	Transport	B6	Dragonfly	Aircraft
22	Product	B7	Beetle	Luggage
23	Furniture	B8	Butterfly	Round table
24	Transport	B9	Beetle	Supercar
25	Transport	B10	Beetle	Sedan car

26	Furniture	B11	Butterfly	Chair
27	Furniture	B12	Beetle	Sofa - Two seaters
28	Furniture	B13	Butterfly	Sofa – Single seater
29	Furniture	B14	Butterfly	Hanger
30	Product	B15	Dragonfly	Lighting

Note: 15 people of the subject participants followed the mimicry process (100%).

Table 5.12
List of Design Manuscripts for Bachelor of Science (BSc)

No. of Subject	Category	Blue (Subject)	Subject matter	Name of product
31	Furniture	C1	Butterfly	Sofa - Single seater
32	Product	C2	Butterfly	Lighting
33	Product	C3	Dragonfly	Lighting
34	Furniture	C4	Butterfly	Rocking chair
35	Product	C5	Butterfly	Stove barbeque
36	Transport	C6	Beetle	Sedan car
37	Furniture	C7	Butterfly	Lazy chair
38	Product	C8	Dragonfly	Lighting
39	Product	C9	Dragonfly	Hand watch
40	Product	C10	Dragonfly	Drone
41	Furniture	C11	Rabbit	Chair
42	Product	C12	Dragonfly	Fan
43	Product	C13	Beetle	Lighting
44	Furniture	C14	Butterfly	Sofa - 2 seaters
45	Product	C15	Beetle	Gaming mouse

Note: 14 of 15 subject participants followed the mimicry process (93.34%).

Table 5.10 refers to the green code of the subjects' participants; 66.67% (10 people of the subjects' participants) had decided to choose their subject matter, let enabled them to sketch for the mimicry process through the completion of the design manuscript. Thus, 5 people of the subjects' participants understood the event of the VPA session, reaching 33.34%. For the pink code of subjects' participants, 100% (15 people of the subjects' participants) had recognised to follow the subject matter required, as shown in Table 5.11. Thus, everyone had finished their sketch for the mimicry process as an event of the VPA session requirement. According to Table 5.12, the blue code of subject participants, 93.34% (14 people of the subject participants) recognised to follow the subject matter required. Thus, only 1 person of the subject participants disagreed with accepting the subject matter provided via the event of the VPA session, reaching 6.67%. However, there were no reflected or error datasets

according to the design manuscript result. As a context disagreed of data reduction, the study found that the degree of innovation, creativity, and lack of visual communication had emerged from the think-aloud events. The phenomena of think-aloud events were very important as it represented the subjects' logical design thinking.

5.6.2 Stage 2: Data Display

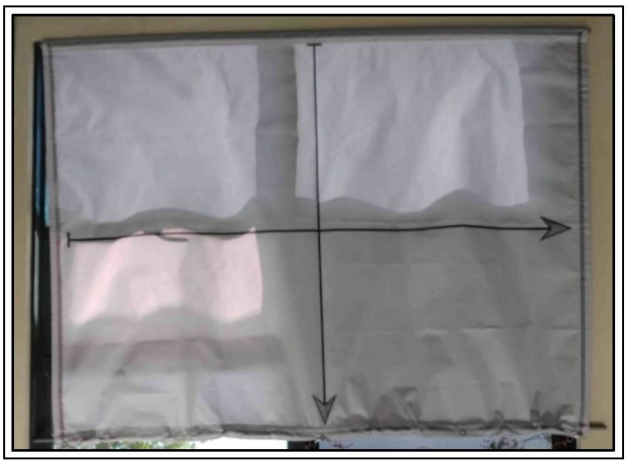


Figure 5.17 Printed Design Manuscript – Using The pPPc

Initially, the number of subjects was intentionally planned and arranged with the colouring paper (printed design manuscript) that was taken from the digital copy JPEG file format from the subjects' participants during the previous CA session. In the second stage of data display, all the design manuscript materials were readily used for the printed-product positioning canvas (pPPC) accommodate the actual datasets of product form quality using the comprehensive axis X and Y as Figure 5.17.

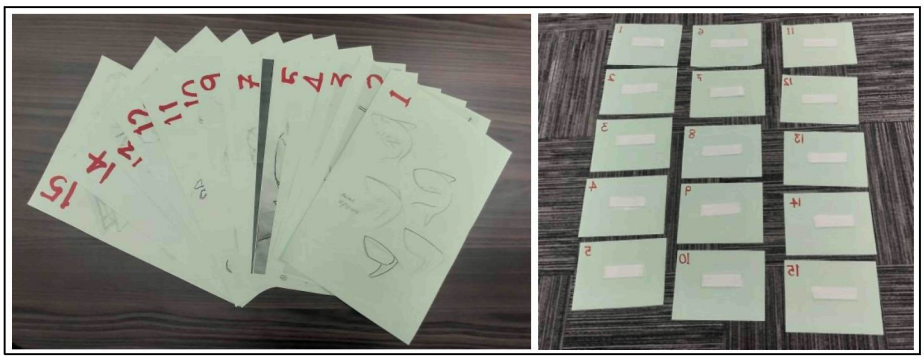


Figure 5.18 Printed Design Manuscript – Green Code for Bachelor of Arts (BA)



Figure 5.19 Printed Design Manuscript – Pink Code for Bachelor of Design (BDes)

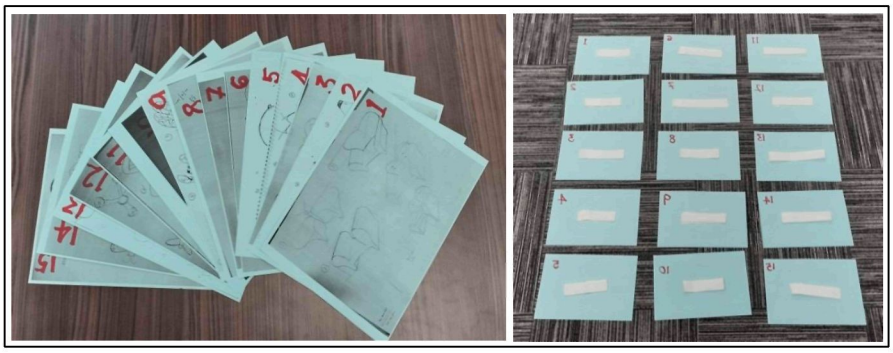


Figure 5.20 Printed Design Manuscript – Blue Code for Bachelor of Science (BSc)

The pPPC must be applied in physical activities so that it can screen the datasets as brainstorming concepts. In Figures 5.18, 5.19 and 5.20, the preparation of the design manuscript is always approached with the physical activity of data analysis as similarly used in the basic coding analysis in qualitative analysis (Creswell, 2003; Saldana, 2003; Creswell & Clark, 2007; Saldana, 2008).

Next, this placing stage used the (1) product positioning canvas and (2) Ansoff product-market growth matrix. The application of product positioning was required to screen and identify the artefact quality mapping so that the comprehensive result would be used to represent the three groups' institution similarly. Defining the product form identity of design mimicry position in the eyes of the evolution of form (EoF), particularly in comparison to competing design mimicry,was the product form identity positioning process. A key element of product form identity strategy is artifact quality positioning. The product and perceptual mapping assisted in the categorising of the matrix position (Abidin, 2012; Lischer, 2023) that should be aligned and focused into the area of study, namely new product development (NPD), commonly practised in the products' concept from the research and development (R&D) entity.

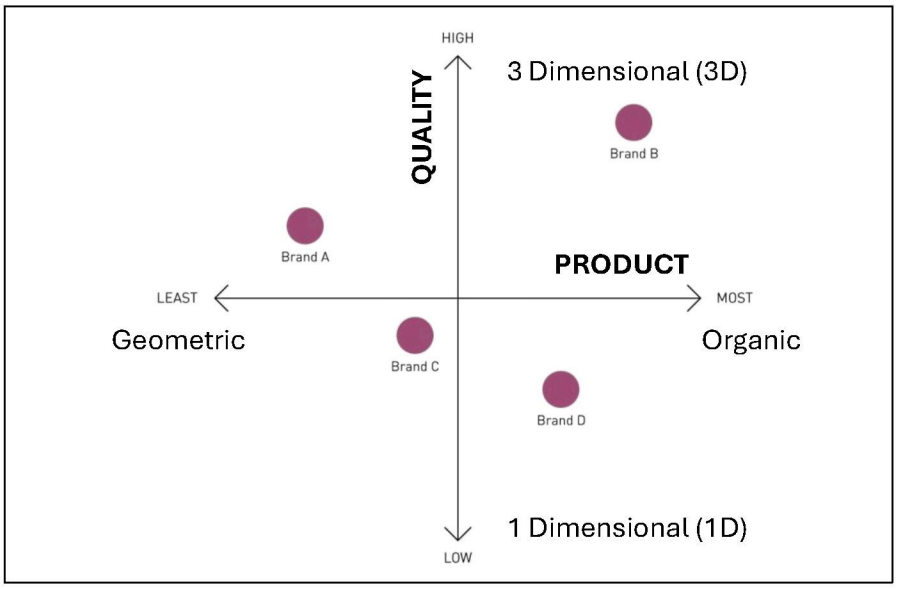


Figure 5.21 Perceptual Mapping in Product Positioning Canvas

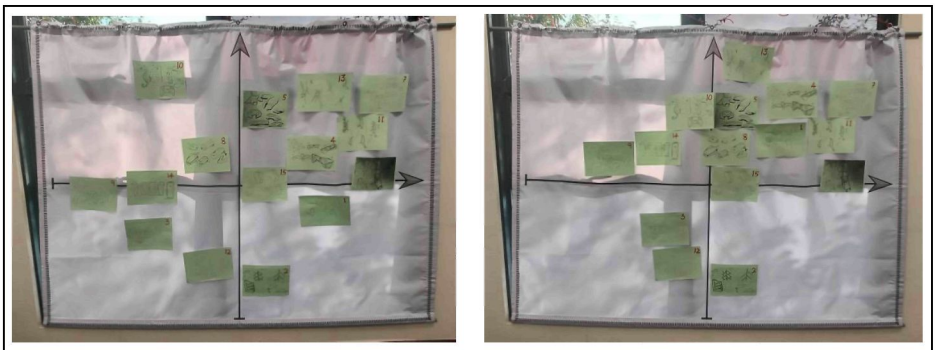
Source: Abidin (2012) and Lischer (2023)

Here, the X-axis represents products from EoF, which was "geometric to organic – least to most", and the Y-axis referred to product quality review levels "1 Dimensional (1D) to 3 dimensional (3D) – low to high quality" as Figure 5.21. In the meantime, the decision to select the mode of product-based positioning is required. Lisher (2023) possibly outlined seven types of product-based positioning that was compulsorily chosen before setting up the assessment, namely (1) quality-based positioning, (2) price-based positioning, (3) benefit-based positioning, (4) leader-based positioning, (5) competitor-based positioning, (6) lifestyle-based positioning, and (7) disruptive positioning. Therefore, the data analysis study chose "the quality-based positioning" due to product design is always merged with the interdisciplinarity studies between the human-centred design (HCD) and new product development (NPD) into one industrial design program via its model, process, and activities. During the assessment process, the embodiment of 3R's method of thinking was required to filter and eliminate the uncertain and weak design characteristics and criteria implicitly. In Figures 5.22, 5.23 and 5.24, the application of perceptual mapping assigned the printed design manuscript for two screening steps of BA, BDes and BSc:

a) *Initial* – the initial process of perceptual mapping is to develop the datasets of matrix prepositions as a whole.

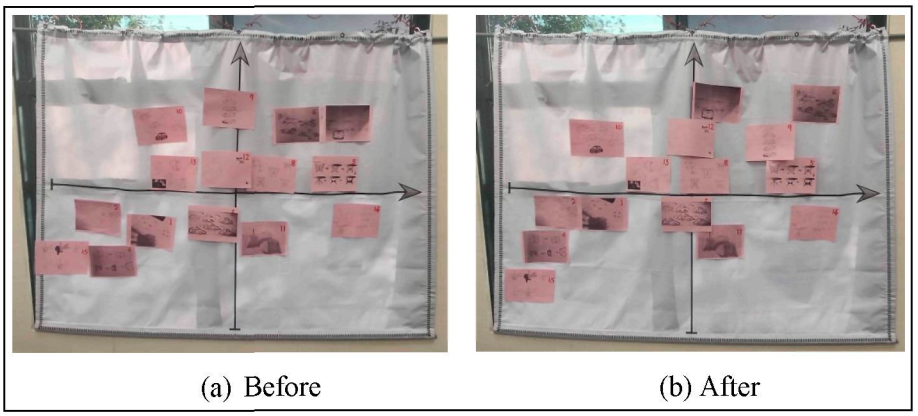
b) *Post* – to define the mimicry process of perceptual mapping that enables reaching an appropriate selection of detail product form based on four matrix prepositions.

The data displayed in the outputs was vetted through two stages: (1) initial and (2) post. The initial stage method entails acquiring data related to the perceptual properties that will be mapped. The datasets are organised to reflect various design features, user views, and criteria. During this step, perceptual qualities were organised into a matrix form that subsequently be used to evaluate the designs. Meanwhile, the perceptual mapping post-stage method stimulated user preferences or expectations, allowing the evaluator to choose the most appropriate ecodesign identity. By using four prepositional matrices, the emphasis moved to fine-tuning product form features based on how they corresponded with the mapped perceptions. This stage facilitated precise selection by assessing how well. Hence, both stage procedures assisted in leading the design decision-making process, ensuring that perceptual attributes were evaluated globally and in detail, resulting in a more personalised and user-focused design product.



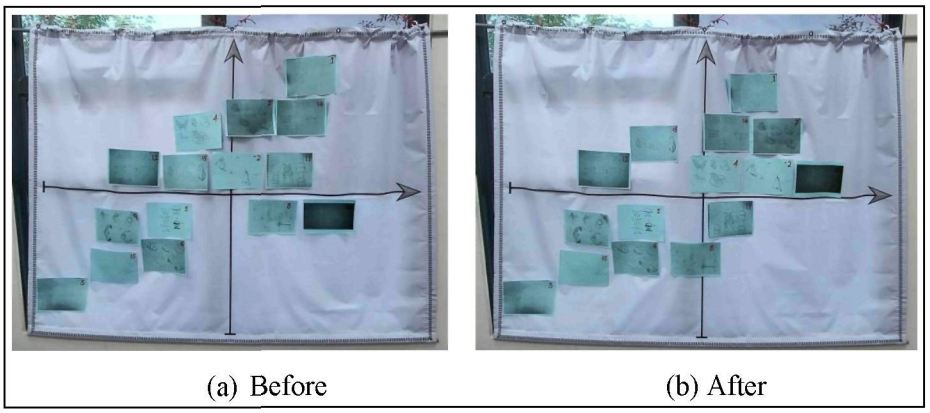
(a) Before (b) After

Figure 5.22 Before - After Screening Session Used pPPC: Green Code for Bachelor of Arts (BA)



(a) Before (b) After

Figure 5.23 Before - After Screening Session Used pPPC: Pink Code for Bachelor of Design (BDes)



(a) Before (b) After

Figure 5.24 Before - After Screening Session Used pPPC – Blue Code for Bachelor of Science (BSc)

The Ansoff Matrix (AM) approach is a fundamental framework taught in business schools all around the world. It is a straightforward and natural method to picture the controls a management group might use to examine growth potential. In the research study, this process is called the data saturation approach in the focus group and grounded theory practice. Thus, on the X-axis are Products, and on the Y-axis are Markets. The axes X and Y were divided into four prepositions of matrix disciplines. The design manuscript must be saturated so that it can find the appropriate sampling as a finding outcome in data analysis of qualitative research methodology. The AM is used to assess the relative attractiveness of growth strategies that capitalise on both existing products and markets vs. new ones, as well as the degree of risk associated with each.



Figure 5.25 Ansoff Matrix: The X-axis is Products, and The Y-axis is Markets.

Source:Peterdy (2022)

In Figure 5.25, Peterdy (2022) outlined that "each box of the AM corresponded to a specific growth strategy" as,

i) *Market Penetration* – "The concept of increasing sales of existing products into an existing market" (Peterdy, 2022).
ii) *Market Development* – "Focuses on selling existing products into new markets" (Peterdy, 2022).
iii) *Product Development* – "Focuses on introducing new products to an existing market" (Peterdy, 2022).
iv) *Diversification* – "The concept of entering a new market with altogether new products" (Peterdy, 2022).

Due to overlap or under-layering of the proposition with pPPC of data analysis under the decision strategy, the research study realistically selected and allocated to support the product development (PD) of the third quadrant from the AM data analysis technique in Figure 5.26, 5.27 and 5.28. However, in this case, the output of the AM approach from all fourth quadrants would guide the data analysis,

In the first quadrant of Ansoff's Matrix as market penetration (MP), the choice to map the relationship between geometric design and high-quality attributes focused

on improving the structural and aesthetic appeal of an already-existing product while retaining or improving its quality. By enhancing the product offering without introducing a completely new product, the decision strategy ensured a stronger position in the current market, which correlated with the goal of market penetration.

In the second quadrant of Ansoff's matrix, mapping the relationship between geometric design and low quality in the market development (MD) quadrant entails investigating ways to maintain a product's aesthetic appeal while reducing its cost and quality making it more accessible in new markets. The choice strategy centred on making an established product more affordable for new consumers while utilising the product's attractive geometric design to set it out in these new market niches.

In the third quadrant of Ansoff's matrix, which depicted the relationship between organic designs and high quality, the emphasis is on developing or improving goods that fuse forms inspired by nature with high-end components and craftsmanship in the product development (PD). The choice strategy enables businesses to innovate within their current markets, providing clients with a product that feels opulent, contemporary, and environmentally conscious while upholding the high standards of quality that their premium clientele wants. By including these components, the business will be able to stand out from rivals and draw in customers with a novel but recognisable product.

In the fourth quadrant of Ansoff's matrix, the relationship between low quality and organic designs is mapped under diversification (D). This involves developing a new product with visually appealing, nature-inspired designs, but keeping costs down by using economical materials and manufacturing techniques. Using the choice method, a business can enter new markets where premium workmanship is less important than price sensitivity. The objective is to preserve the aesthetic and emotional appeal of organic designs while offering them at a cost that allows for expansion into unexplored markets.

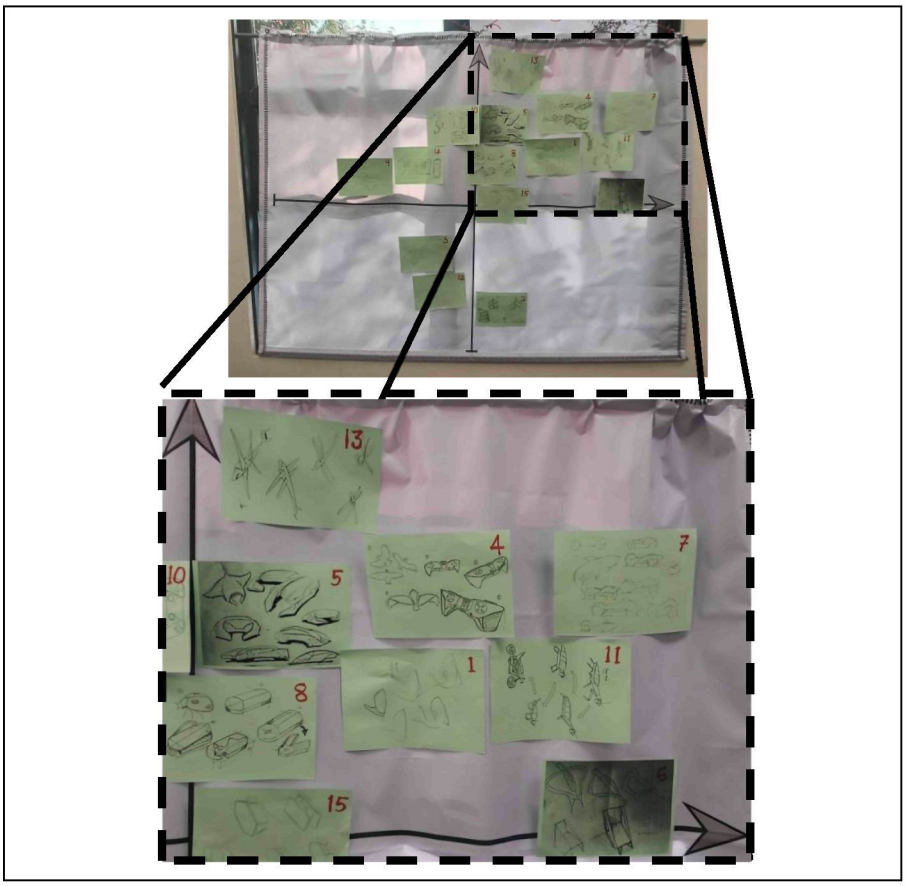


Figure 5.26 PD of Matrix Preposition for Bachelor of Arts (BA)

Table 5.13
List of Matrix Preposition - Ansoff Matrix for Bachelor of Arts (BA)

No. of Subject	Product Category	Green (Subject)	Subject Matter	Name of Product	Matrix Preposition
1	Product	A1	Shark	Hair dryer	PD
4	Product	A4	Eagle	Remote controller	PD
5	Transport	A5	Giant manta rays	Supercar	PD
6	Furniture	A6	Butterfly	Lounge chair	PD
7	Transport	A7	Shark	Superbike	PD
8	Product	A8	Beetle	Cutter	PD
11	Transport	A11	Praying Mantis	Café racer bike	PD
13	Transport	A13	Dragonfly	Aircraft	PD

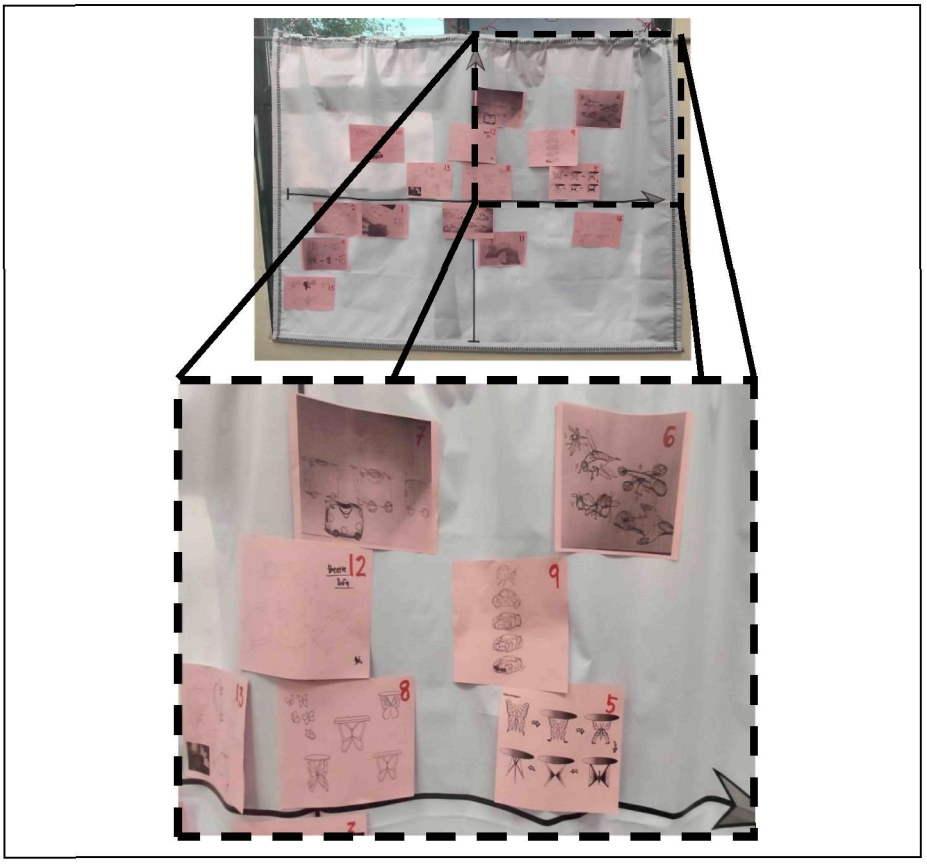


Figure 5.27 PD of Matrix Preposition for Bachelor of Design (BDes)

Table 5.14
List of matrix preposition - Ansoff matrix for Bachelor of Design (BDes)

No. of Subject	Product Category	Pink (Subject)	Subject Matter	Name of Product	Matrix Preposition
20	Furniture	B5	Butterfly	Round table	PD
21	Transport	B6	Dragonfly	Aircraft	PD
22	Product	B7	Beetle	Luggage	PD
23	Furniture	B8	Butterfly	Round table	PD
24	Transport	B9	Beetle	Supercar	PD
27	Furniture	B12	Beetle	Sofa - Two seaters	PD

Therefore, percentages output of AM approach from three industrial design course programmes within its institutions respectively following (1) Table 5.13 - BA: 53.3 % (8 people out of 15 subjects' participants), (2) Table 5.14 - BDes: 40% (6 people of 15 subject participants) and (3) Table 5.15- BSc: 40% (6 people of 15 subject participants). Therefore, all three universities' percentages showed that the majority of PD activities contribute more to product development in the AM preposition quadrants.

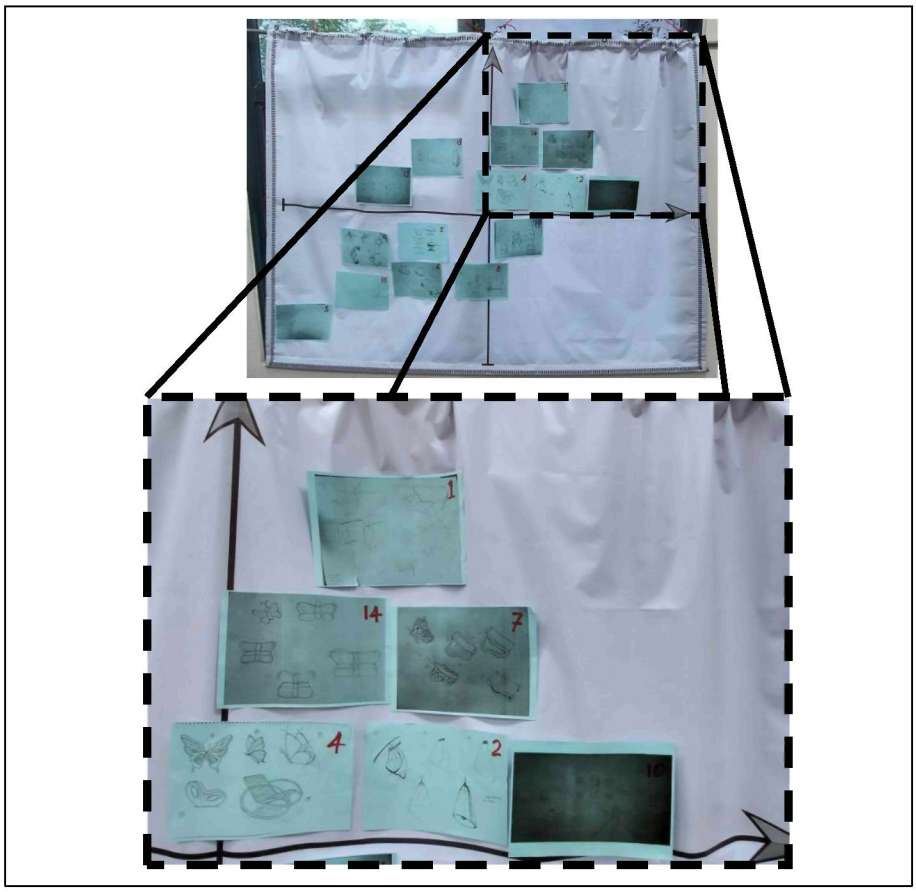


Figure 5.28 PD of Matrix Preposition for Bachelor of Science (BSc)

Table 5.15
List of Matrix Preposition - Ansoff Matrix for Bachelor of Science (BSc)

No. of Subject	Product Category	Blue (Subject)	Subject Matter	Name of Product	Matrix Preposition
31	Furniture	C1	Butterfly	Sofa - Single seater	PD
32	Product	C2	Butterfly	Lighting	PD
34	Furniture	C4	Butterfly	Rocking chair	PD
37	Furniture	C7	Butterfly	Lazy chair	PD
40	Product	C10	Dragonfly	Drone	PD
44	Furniture	C14	Butterfly	Sofa - 2 seaters	PD

Further, the review of the overall matrix preposition was needed so that it would possibly screen the specific data analysis findings. By the product category, the recognition of consistency represented reliability for classifying the design manuscript. In Table 5.16, the distribution of matrix preposition demonstrated the significant PD matrix preposition has reached 44% and 20 participants agreed to introduce new products to an existing market.

Table 5.16
Distribution of Matrix Preposition - Ansoff Product-Market Growth Matrix

No. of Subject	Product Categories	Overall Matrix Preposition			
		MP 1	MD 2	PD 3	D 4
1	Product			1	
2	Furniture				1
3	Furniture				1
4	Product			1	
5	Transport			1	
6	Furniture			1	
7	Transport			1	
8	Product			1	
9	Furniture		1		
10	Product	1			
11	Transport			1	
12	Transport	1			
13	Transport			1	
14	Product		1		
15	Furniture				1
16	Transport		1		
17	Transport		1		
18	Transport		1		
19	Furniture		1		
20	Furniture			1	
21	Transport			1	
22	Product			1	
23	Furniture			1	
24	Transport			1	
25	Transport	1			
26	Furniture				1
27	Furniture			1	
28	Furniture	1			
29	Furniture				1
30	Product		1		
31	Furniture			1	
32	Product			1	
33	Product		1		
34	Furniture			1	
35	Product		1		
36	Transport		1		
37	Furniture			1	
38	Product		1		
39	Product		1		
40	Product			1	

41	Furniture				1
42	Product	1			
43	Product		1		
44	Furniture			1	
45	Product	1			
Total		6	13	20	6
Percentages		13%	29%	44%	13%

Note: Market Penetration = MP; Market Development = MD; New Product Development = NPD; and Diversification = D.

Finally, the research study most likely chose purposive sampling over design sampling because it allows for the deliberate selection of participants or instances that are most relevant to the research goals. Purposive sampling involves selecting individuals based on specific characteristics and criteria that correspond with the study's objectives, ensuring that the sample is extremely relevant for obtaining in-depth insights. It was used for the research study because it allowed you to target and select relevant participants or construct scenarios that corresponded with the study's aims. In domains such as ecodesign identity where context and specificity are critical, the research study guaranteed that the data gathered is highly relevant, informative, and in line with the goals of the research by concentrating on samples that satisfy predetermined traits and criteria. Thus, four participants, including (1) A6 - butterfly, (2) A13 - dragonfly, (3) B6 - dragonfly, and (4) C7 - butterfly, will be emphasised in a subsequent stage 3 – Drawing Conclusion based on Table 5.17 appropriately.

Table 5.17
Summary of Matrix Preposition - Ansoff Product-Market Growth Matrix

No. of Subject	Product Categories	Green/ Pink/ Blue (Subject)	Subject matter	Name of product	Matrix Preposition
1	Product	A1	Shark	Hair dryer	PD
2	Furniture	A2	Leave	Open cabinet	D
3	Furniture	A3	Bee	Rocking chair	D
4	Product	A4	Eagle	Remote controller	PD
5	Transport	A5	Giant manta rays	Supercar	PD
6	Furniture	A6	Butterfly	Lounge chair	PD
7	Transport	A7	Shark	Superbike	PD
8	Product	A8	Beetle	Cutter	PD
9	Furniture	A9	Beetle	Sofa – Single seater	MD
10	Product	A10	Sea horse	Remote control	MP
11	Transport	A11	Praying Mantis	Café racer bike	PD
12	Transport	A12	Butterfly	Supercar	MD

13	Transport	A13	Dragonfly	Aircraft	PD
14	Product	A14	Penguin	Bottle	MD
15	Furniture	A15	Honeycomb	Coffee table	D
16	Transport	B1	Beetle	Supercar	MD
17	Transport	B2	Beetle	Sport car	MD
18	Transport	B3	Beetle	Sedan car	MD
19	Furniture	B4	Butterfly	Chair	MD
20	Furniture	B5	Butterfly	Round table	PD
21	Transport	B6	Dragonfly	Aircraft	PD
22	Product	B7	Beetle	Luggage	PD
23	Furniture	B8	Butterfly	Round table	PD
24	Transport	B9	Beetle	Supercar	PD
25	Transport	B10	Beetle	Sedan car	MP
26	Furniture	B11	Butterfly	Chair	D
27	Furniture	B12	Beetle	Sofa - Two seaters	PD
28	Furniture	B13	Butterfly	Sofa – Single seater	MP
29	Furniture	B14	Butterfly	Hanger	D
30	Product	B15	Dragonfly	Lighting	MD
31	Furniture	C1	Butterfly	Sofa - Single seater	PD
32	Product	C2	Butterfly	Lighting	PD
33	Product	C3	Dragonfly	Lighting	MD
34	Furniture	C4	Butterfly	Rocking chair	PD
35	Product	C5	Butterfly	Stove barbeque	MD
36	Transport	C6	Beetle	Sedan car	MD
37	Furniture	C7	Butterfly	Lazy chair	PD
38	Product	C8	Dragonfly	Lighting	MD
39	Product	C9	Dragonfly	Hand watch	MD
40	Product	C10	Dragonfly	Drone	PD
41	Furniture	C11	Rabbit	Chair	D
42	Product	C12	Dragonfly	Fan	MP
43	Product	C13	Beetle	Lighting	MD
44	Furniture	C14	Butterfly	Sofa - 2 seaters	PD
45	Product	C15	Beetle	Gaming mouse	MP

Note: Market Penetration = MP; Market Development = MD; New Product Development = NPD; and Diversification = D.

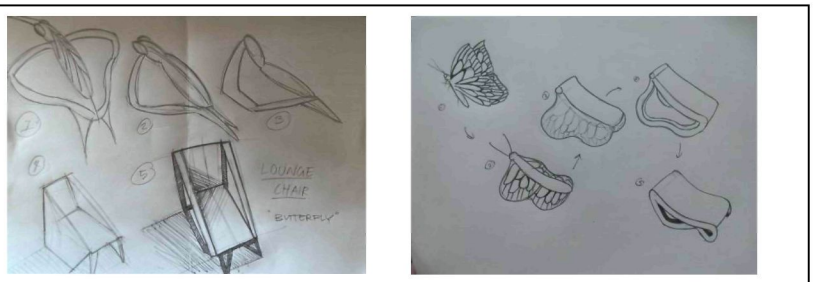
5.6.3 Stage 3: Drawing Conclusion

Concluding in the context of qualitative research during the coding analysis stage is the act of understanding the trends, themes, and classifications that show up in the coded data. Following the coding and analysis of the data, the researcher discovers these codes to produce significant understandings or insights that address the research answers for the research questions. Subsequently, the researcher recognised the codes within the framework of the study or the literature. This entailed placing the results in

the context of theory or known information to either support, add to, or contradict what has already been established. The findings in the framework of theory or existing knowledge were used to either support, build upon, or refute what has already been established. Contextual parameters like the social, cultural, or environmental background of the data impact the findings' outcome. The interpretation took into account how the meaning of the data was impacted by various circumstances. Consequently, the researcher chose to use rater pairing to find the important essence of design representation in the design manuscript for the aims.

In the beginning of drawing conclusion, the research study was required to select the pairing data sampling that was purposely used to define the kind of raters' criteria and characteristic in design manuscript. As common practise for reliability coding analysis, the raters of data sampling should be similarly the same between both parties. Pairing two raters for screening data sampling in reliability code analysis is a common method to ensure the consistency and trustworthiness of coding judgments. Pairing raters enabled the calculation of statistical measures of reliability, such as Cohen's Kappa or Krippendorff's Alpha, which quantify the level of agreement beyond chance. These metrics were often used to report the reliability of the coding scheme to external stakeholders. Again, the research study tested to recycle the 10 code of variants as an exact previous resulted in Panel A data analysis namely (1) Heuristic procedural step, (2) Quality of ecodesign identity, (3) Visual elements interpretation, (4) Exceeding level > 3 - quality review, (5) Quality of lines, (6) Ecodesign identity, (7) Cantilever principle, (8) Product form identity, (9) < Level 3 – Proficiency, and (10) Cantilever design understanding.

As previously mentioned in Table 5.17, the research study employed pairing data sampling to assess specific data recommendations in the summary of matrix preposition - Ansoff product-market growth matrix. All four of the shortlisted data samples were suggested as representative samples, with the idea being that they would demonstrate the essence of design representation and serve as implicit proof that the ecodesign identity theme's pattern was in line with the themes, classifications, and trends itself. The position level of agreement dependability was suggested by the Cohens' kappa rules of thumb by calculating the percent agreement. Thus, with the right interpretation, the research study may be able to formulate the research answers comprehensively.



(a) (b)

Figure 5.29 Design Manuscript of Panel B1- butterfly (a) A6 and (b) C7

Table 5.18
Calculation of Percent Agreement (Fictitious Data) for The Phase of Panel B1

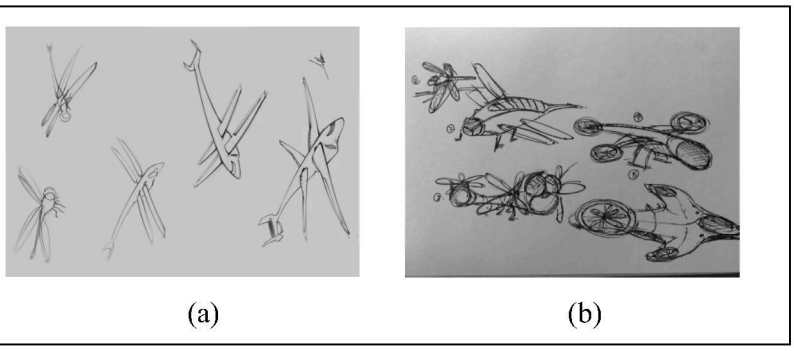
	(Themes' Codes) Var#	Raters		Difference
		A6	C7	
1	Heuristic procedural step	1	1	0
2	Quality of ecodesign identity	1	1	0
3	Visual elements interpretation	1	1	0
4	Exceeding level > 3 - quality review	1	1	0
5	Quality of lines	1	1	0
6	Ecodesign identity	1	1	0
7	Cantilever principle	1	0	-1
8	Product form identity	1	1	0
9	< Level 3 – Proficiency	0	0	0
10	Cantilever design understanding	1	0	-1

Number of Zeros = 8
Number of Items = 10
Percent Agreement = 80

Interpretation#1: The raters* for the agreement are 80%. Because only one rater can be right when there is disagreement, 20% of the data gathered for the study is inaccurate. Therefore, level of agreement is resulted "strong" as 64–81% of data that are Reliable.

*Note: (1) A6 = PANEL B UiTM, Participant#6; (2) C7 = PANEL B UTMSPACE KL Participant#7

The evidence of pairing data sampling (raters) in Figure 5.29 and 5.30. demonstrated that both design manuscripts dealt with the same subject matter and that a certain biomimicry process drove the product form identity. In order to find both agreement consistently, the percent agreement is calculated using Table 5.18 and 5.19 matching the contextual codes.



(a) (b)

Figure 5.30 Design Manuscript of Panel B2 - Dragonfly (a) A13 and (b) B6

Table 5.19
Calculation of Percent Agreement (Fictitious Data) for The Phase of Panel B2

	(Themes' Codes) Var#	Raters		Difference
		A13	B6	
1	Heuristic procedural step	1	1	0
2	Quality of ecodesign identity	1	1	0
3	Visual elements interpretation	1	1	0
4	Exceeding level > 3 - quality review	1	1	0
5	Quality of lines	1	1	0
6	Ecodesign identity	1	1	0
7	Cantilever principle	1	0	-1
8	Product form identity	1	1	0
9	< Level 3 – Proficiency	0	0	0
10	Cantilever design understanding	1	0	-1

Number of Zeros = 8
Number of Items = 10
Percent Agreement = 80

Interpretation#2: The raters** for the agreement are 80%. Because only one rater can be right when there is disagreement, 20% of the data gathered for the study is inaccurate. Therefore, level of agreement is resulted "strong" as 64–81% of data that are Reliable.

**Note: (1) A13 = PANEL B UiTM, Participant#13; (2) B6 = PANEL B UPM Participant#6

Next, the main emphasis in the context of Heuristic Quality Review (HQR) analysis was on comprehending how the components of the design interact to produce a unified vision, especially when evaluating the ecodesign identity of a design sketch or drawing through the lens of Gestalt Theory (GT). According to GT, objects are perceived by humans as wholes and ordered patterns rather than as discrete parts. Because it sheds light on how various components of a design were perceived in connection to one another, this theoretical framework is helpful for analysing designs.

Gestalt principles namely (1) proximity, (2) likeness, (3) closure, (4) continuity, and (5) figure-ground are applied in this way as Figure 5.31.

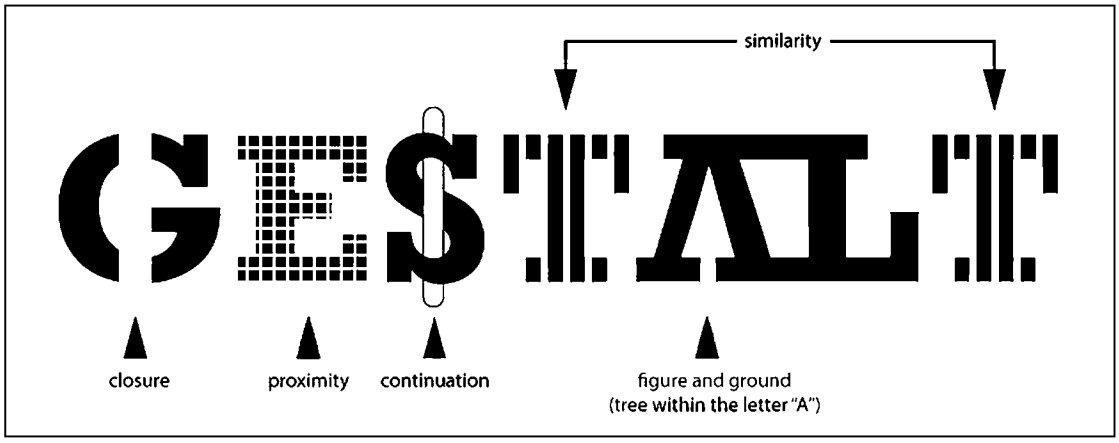


Figure 5.31 The Elements of Gestatlt Theory

Source: Ahmadi (2020)

Through the integration of these Gestalt principles into the pattern of design representation, the sketch or drawing was assessed not only for its visual communication of sustainability but also for its aesthetic coherence. In this case, the design sketch embodied an integrated approach to sustainability, where the visual components (shape, structure, and material depiction) collaborated to elicit a strong message of environmental responsibility, attributable to the fusion of ecodesign identity. Similar to Gestalt theory, which held that the whole was greater than the sum of its parts, the analysis used HQR to hunt for patterns that point to this fusion and provide proof of it. Thus, to create the greyscale colour, black and white pigment was needed – the application of artistic effect developed by "MS Word of picture tools". Because they produced the greatest contrast for those two colours when positioned parallel to one another. The research study can sometimes refer to complementary colours as "opposite colours".

On the other hand, the plane-X axis and the plane-Y axis, which were positioned concurrently, served as the foundation for the HQR analysis's structure. The creation of horizontal continuum, which denotes the change in object features between the plane-X axis (semantics order) and the plane-Y axis (levelling order), is essentially made possible by the extraction of the semiotics sign. Each axis was graded using a 5-point rating system (Chumiran & Abidin, 2019). Using this framework, semiotic indicators

related to ecodesign, including symbols for energy efficiency, sustainability, or green technology, could be retrieved and graded on the X-axis according to how well they convey these environmentally friendly principles. The degree to which these design features are leveled or arranged with respect to other design aspects is the simultaneous basis for evaluating the design on the Y-axis. This two-axis rating methodology in HQR analysis offered a reliable way to evaluate how a design expresses its identity, whether it was via functional elements, green features, or aesthetic depictions. The evaluation guaranteed that the design's hierarchy (leveling) and meaning (semantics) were in harmony to provide a logical and useful representational pattern.

To establish a connection between the data display and reduction flow processing of Stage 1 and Stage 2, the research study must adhere to the DRM framework orientation, as outlined in an earlier table titled "The Methodological Context of Mixed Method Strategy for Reliability and Validity" in the Stage 3 referred to concluding. Four different kinds of assessment techniques were found to examine the pattern of design representations within the following categories such as (1) design scheme, (2) artefact categorisation, (3) new product development, and (4) design manuscript. This process started with the contextual qualitative testing approach. Thus, the use of the evaluation techniques that were specifically addressed by the following three methods namely (1) think-aloud; (2) heuristic; and (3) analytic rubric evaluation. This situation could lead to the generation of convergence thinking across datasets in terms of credibility and transferability. However, the heuristic evaluation based on two techniques—artifact categorization and new product development—was unable to sufficiently address the research objectives. To assess design manuscripts or sketches, an additional evaluation method is called the analytic rubric assessment (ARE) method. This method, as supported by research, examined how well a design integrated sustainable, harmonious, and functional elements of the ecodesign identity.

Table 5.20
HQR Analysis for The Butterfly - A6

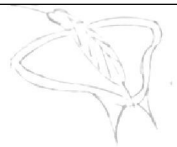
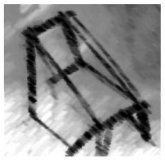
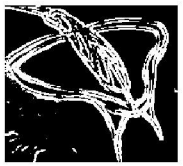
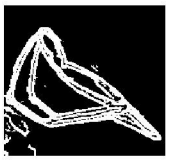
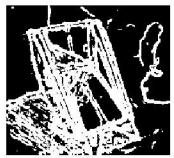
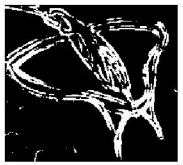
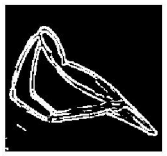
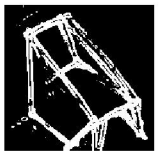
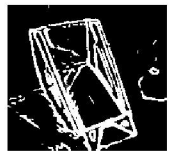
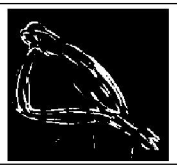
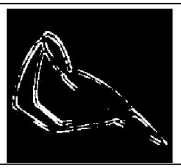
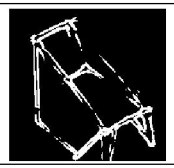
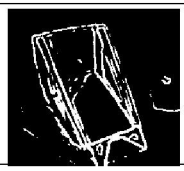
Artistic Effects (Leveling)	Subject Matter	Transitional of Mimicry Process			Product Design
Photocopy (Level 5)					
Chalk Sketch (Level 4)					
Glow Edges (Level 3)					
Glow Edges (-40%) (Level 2)					
Glow Edges (-50%) (Level 1)					

Table 5.21
HQR Analysis for The Butterfly – C7

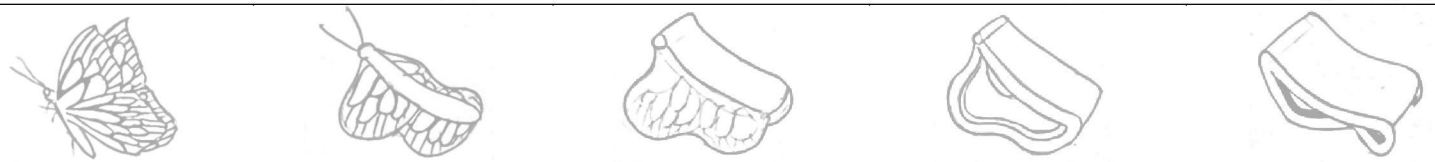
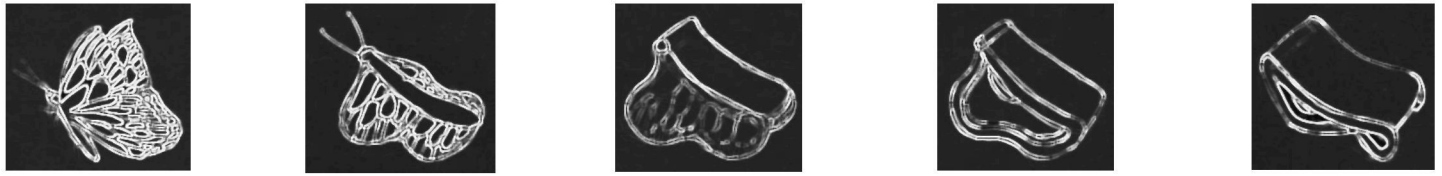
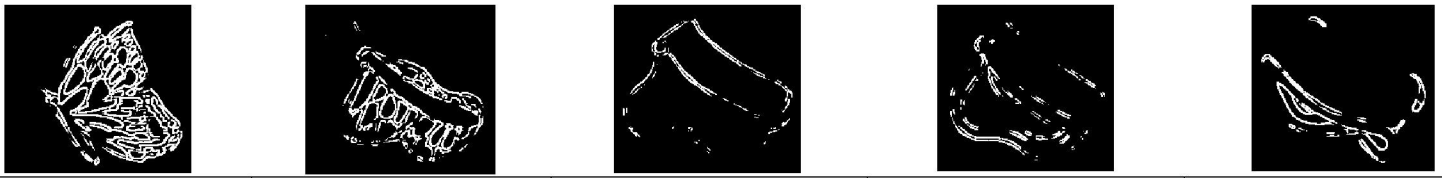
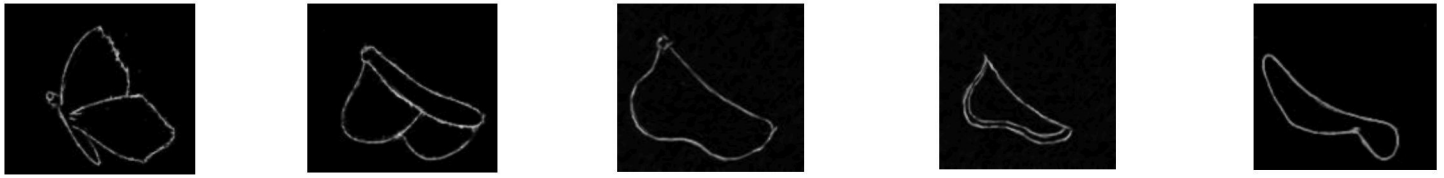
Artistic Effects (Leveling)	Subject Matter	Transitional of Mimicry Process			Product Design
Photocopy (Level 5)					
Chalk Sketch (Level 4)					
Glow Edges (Level 3)					
Glow Edges (-40%) (Level 2)					
Glow Edges (-50%) (Level 1)					

Table 5.22
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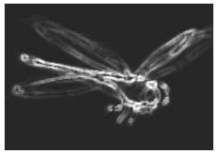
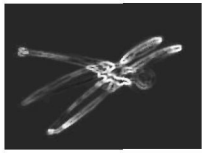
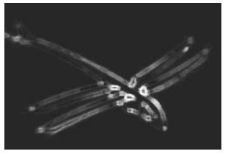
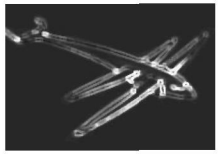
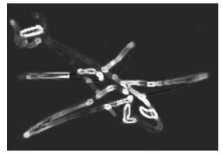
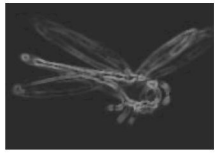
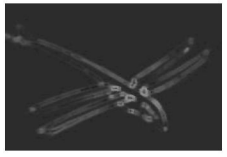
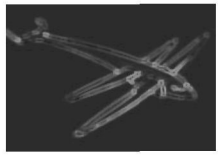
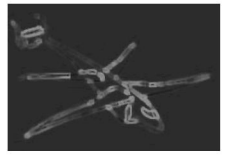
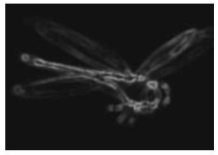
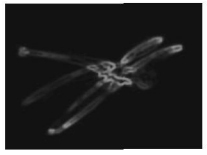
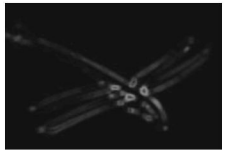
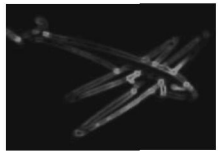
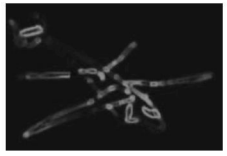
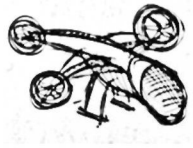
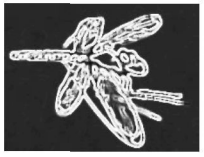
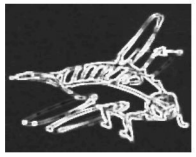
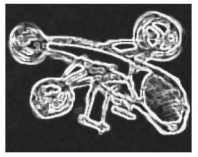
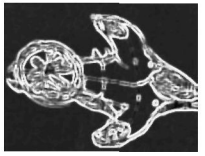
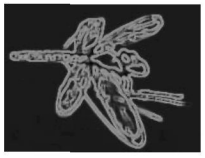
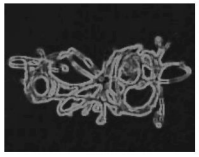
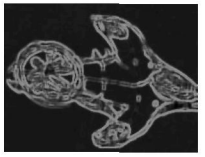
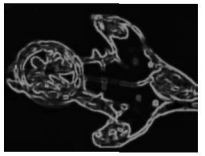
Artistic Effects (Leveling)	Subject Matter	Transitional of Mimicry Process			Product Design
Photocopy (Level 5)					
Chalk Sketch (Level 4)					
Glow Edges (Level 3)					
Glow Edges (-40%) (Level 2)					
Glow Edges (-50%) (Level 1)					

Table 5.23
HQR Analysis for The Dragonfly – B6

Artistic Effects (Leveling)	Subject Matter	Transitional of Mimicry Process			Product Design
Photocopy (Level 5)					
Chalk Sketch (Level 4)					
Glow Edges (Level 3)					
Glow Edges (-40%) (Level 2)					
Glow Edges (-50%) (Level 1)					

Consequently, the horizontal continuum formed by the X and Y axes suggested a change in the object characteristics of the design in terms of both meaning (represented by the X-axis by semantics) and structure (represented by the Y-axis by hierarchy). This continuum made it possible to conduct an integrated analysis in which the significance of characteristics and their clarity of meaning were assessed together to provide a coherent picture of the design's effectiveness. Hence, the research study consistently found the evidences from the Table 5.20, 5.21, 5.22, and 5.23, that the unification of design object had morphed a proper transitional of mimicry process via "figure and ground" comprehensively following,

i) Visual elements (VE) are the primary means by which a continuum of evidence of form integration was generated in design cognition with zoomorphism (subject matter to a product design).
ii) The VE is made up of four fundamental properties such as (1) point, (3) line, (4) plane, and (5) volume. These properties stimulated the production of the composition's natural tone and texture.

Once the HQR analysis was finished, another round of research was conducted to reach a result. This study used the ARE method, allowing the design manuscript to be recognised within the context of credibility and transferability datasets. The four shortlisted participants who were assessed and provided by HQR analysis were required to exhibit high-quality performance, according to the ARE approach of roles' function. To arrive at the research study's concluding conclusions, the results of the HQR analysis were critical to the ARE approach. These dataset's properties were transferable.

The research study used the contextual self-assessment of rubrics to initiate the ARE method. Within the framework of self-evaluation using rubrics, the fundamentals of student pedagogy revealed that the "Feedback" provided by teachers as well as ongoing work are vital in promoting students' development, self-awareness, and enhancement of their learning tasks (Andrade 2008; Panadero, Alonso-Tapia, & Reche, 2013; Miknis, Davies & Johnson, 2020; Karaman, 2024). Students can better grasp how their work fits the criteria of the rubric by using the teachers' constructive input. This enables them to assess their position with various performance levels. On the other hand, the concept of "Work-in-Progress" referred to assessing students' work at

different periods as opposed to concentrating only on the finished product. Including self-evaluation at various points during a project or assignment can aid in students' development of metacognitive abilities, or the ability to reflect on their own learning and thought processes. They get more skillful at determining what works and what doesn't as they evaluate their developing work. Therefore, Work-in-Progress assessments in self-assessment rubrics and instructor feedback are effective tools that helped students develop into reflective, self-regulated learners. While Work-in-Progress evaluation guarantees that students are continuously improving their skills throughout the learning process, feedback assists students in understanding how to improve. When combined, these strategies foster resilience, progress, and a better comprehension of the individual's learning trajectory. The meaning of teachers' feedback in the context of rubrics' self-assessment referred to the instructor's and/or researcher's feedback (Andrade 2008; Panadero, Alonso-Tapia, & Reche, 2013; Miknis, Davies & Johnson, 2020; Karaman, 2024). Dividing the assessment into distinct parts and criteria is an ARE approach for a drawing manuscript that applies the heuristic method. Every component of the drawing was assessed by the rubric based on predetermined performance levels that were established by the teacher and/or researcher's feedback, which was derived from teaching and learning experiences. This methodology, like the HQR method, guarantees an objective and methodical manner in which to assess drawings, especially those that were meant to depict cognitive or problem-solving processes.

Table 5.24
Rules of Thumbs Using for Orb Web of Spider Net Analysis Within Radar Chart

Instructors' Feedback: Spider orb web		**Work in Progress: Radar chart**
Value of Marks	Level of Proficient	% of Weight Leveling (Multiply 5)
0–40	Very poor	0 % - 24% (0)
41–55	Poor	25% - 49% (5)
56–70	Good	50% - 74% (10)
71–85	Very good	75% - 99% (15)
86-100	Excellent	100% (20)

Next, precisely establishing the performance standards for instructors' feedback as Spider orb web category was necessary in creating the "Proficient" level marks in an ARE approach. Although there was still space for development, it reflected a strong, competent level of success that satisfies the fundamental requirements. Within an ARE

technique, the Proficient level consisted of semantically constructed descriptors within the value of marks that are (1) Very poor, (2) Poor, (3) Good, (4) Very good, and (5) Excellent. These descriptors correlates with learning objectives and set this level apart from both lower and higher performance categories under the Radar chart within multiple 5. Although it showed that students have fulfilled the essential prerequisites, it is still a respectable accomplishment that offered an opportunity for the progression development referred to Work-in-Progress: % of Weight Levelling. Thus, Table 5.24 provided an approximate summary of the Radar chart categorised Proficient level that was visualised by orb web of Spider net analysis.

Table 5.25
Output Matrix for The HQR Analysis Via Four Design Manuscripts

No.	Coding Criterion	A6	C7	A13	B6	Overall		
						Averages' Marks	Total of Average %	Ranks
1	Duration	20	20	20	16	61	76.25	1st
2	Quality	16	16	12	16	48	60.0	4th
3	Elements	20	20	16	20	61	76.25	1st
4	Pattern	20	20	16	12	53	66.25	3rd
5	Semantics	16	20	20	16	60	75.0	2nd
Total of Marks		92	96	84	80	56.6	70.75	n/a
Proficient		Excellent	Excellent	Very Good	Very Good	Good < Very Good		

Further, Table 5.25 presented the results of a matrix analysis of four design manuscript coding systems (A6, C7, A13, and B6) according to five attributes: (1) Duration, (2) Quality, (3) Elements, (4) Pattern, and (5) Semantics. The ARE evaluation's matrix analysis, which was derived from the earlier pilot study and showed Strength of Association as Good to Excellent, was referred to as CA value A & B with.778 ~.937, while standardised items of CA reached with.767 ~ 942, n = 12 (Chumiran, Abidin, & Kamil, 2020). Since the approach had undergone reliability testing, the research study purposefully recycled the ARE form sheet. As a result, C7, which received the highest overall score and was rated Excellent, was a clear choice, closely followed by A6 and A13. Even though B6 received the lowest overall score (80), it was still rated as Very Good. As for code attributes, Duration ranked in the first

place with a 76.25% rating, closely trailed by Elements with a similar number. At 75% and 66.25%, respectively, Semantics and Pattern accounted for the two and third positions. Subsequently, the final 60% indicated the design manuscript's quality in its entirety as fourth. Manuscripts were prepared with A6: 92 (Excellent), C7: 96 (Excellent), A13: 88 (Very Good), and B6: 80 (Very Good) coding systems, specifically for the proficient subjects' participants. To receive the 20-mark weighting, C7 received the highest number of marks, which is somewhat close to perfect.

Consequently, the spider net analysis will be engaged per the radar chart's coding criterion. The goal was to see the consistency of the results, allowing the context of the work-in-progress to be visually represented through the tabulation of tables into a visual interpretation. A radar chart, also known as a spider chart, was especially useful in studying the different types of spider silk (net) and their functions because it showed the different performance attributes of each type, like toughness, elasticity, and tensile strength, in a way that emphasised its unique function (Doblhofer, Heidebrecht & Scheibel, 2015). The shape and reach of each net type's plotted region in the radar map revealed its specific function, which aided in the analysis of how spiders maximised web design using specialised silks, as seen in Figure 5.32. The effectiveness and deliberate selection found in nature's designs were made clearer by this visual parallel. Therefore, the research study used the rules of thumb to interpret the percentage of weight leveling of students' activity/progress through the visualisation of a radar chart in order to provide an overview of the location of work-in-progress.

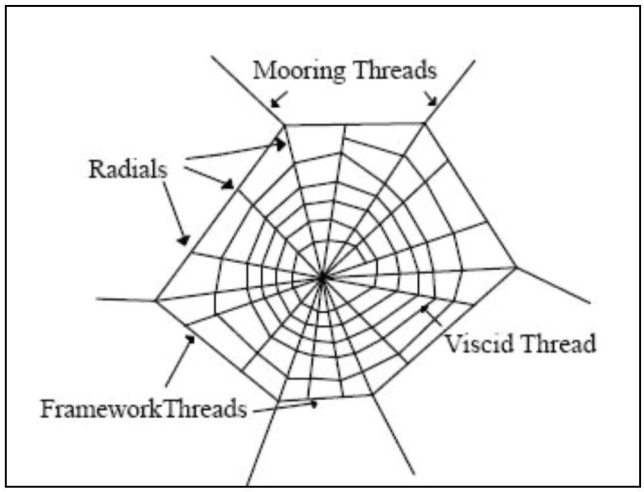


Figure 5.32 Different Parts of The Spider Silk Web - Orb Web

Source: Singha et al. (2012)

Two forms of radar charts, quadrilateral (balanced) and pentagonal (imbalanced), can be used in spider net orb-web analysis to provide useful visualisations of the functions of various web structures and silk qualities. The two were related in the following way: Different perspectives on orb-web analysis were provided by pentagon (imbalanced) and quadrilateral (balanced) radar plots. While the pentagon chart highlights the trade-offs in web design by revealing specialised features over more properties, the quadrilateral chart is excellent for visualising balanced traits across less important properties. When used in tandem, these visual aids enabled us to comprehend how various web components were tailored to their distinct functions in prey capture, stability, and survival. (Wang, Du, & He, 2020)

In Figure 5.33, a quadrilateral radar chart can also be used to visually represent an orb-web analysis, particularly when the analysis focussed on four important mechanical or functional characteristics of the spider silk or web structure. To graphically illustrated whether the orb web achieved a balanced integration of these features across its structure, the analysis research employed a quadrilateral radar chart. A symmetrical shape, or one that was almost symmetrical, indicated a web that successfully balanced these characteristics. The design of the web may exhibit trade-offs if one axis was significantly longer than the others, indicating specialisation in one attribute at the price of others.

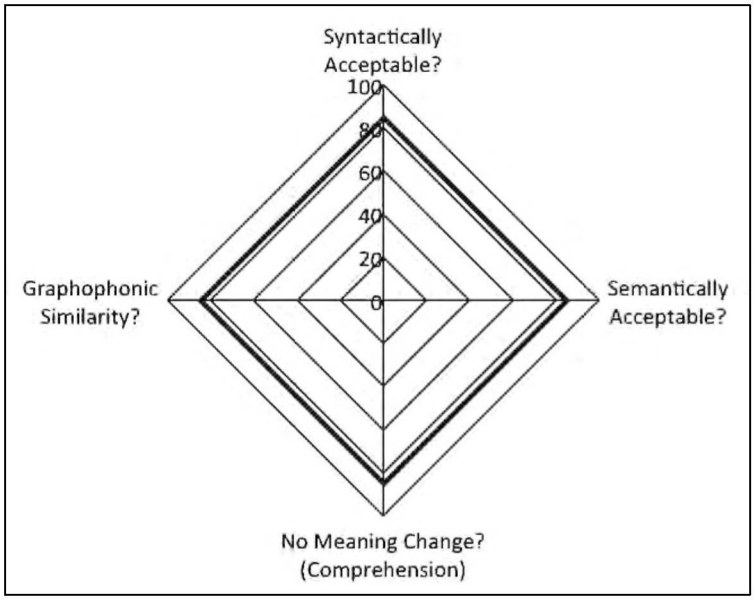


Figure 5.33 A Spider Chart Showing Balanced Use of Cueing Systems

Source: Wohlwend (2012)

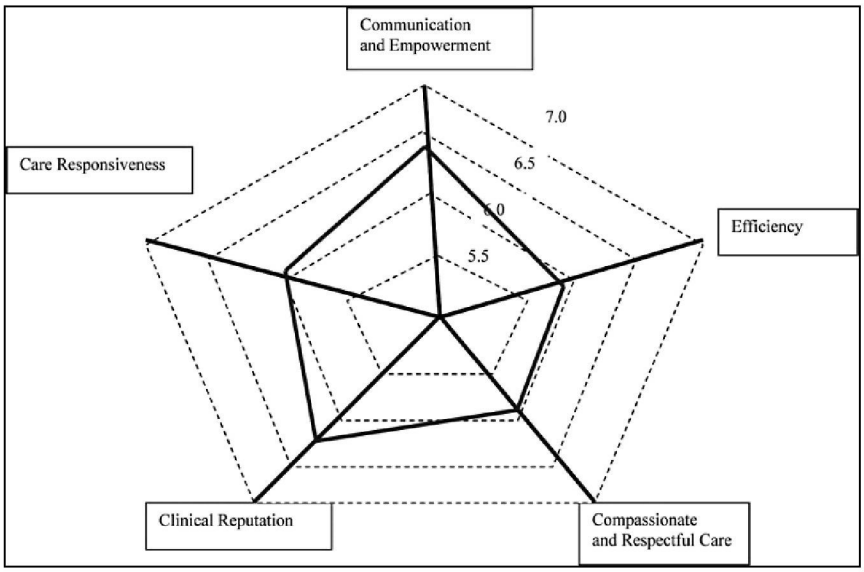
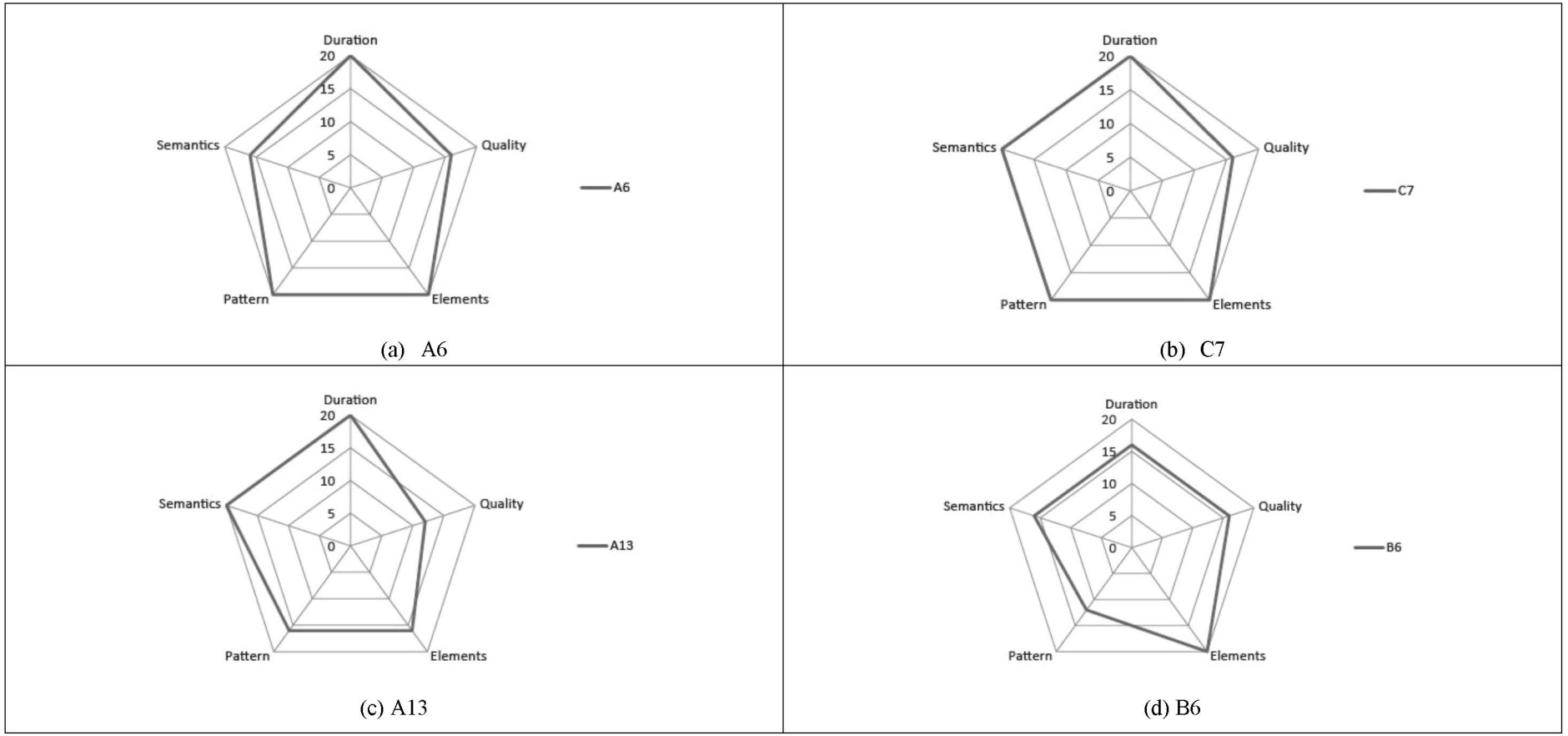


Figure 5.34 Spider-web Diagram Based on The Unweighted Scores

Source: Liu et al. (2010)

In Figure 5.34, the five functional qualities could be compared across the web using the pentagon radar graphic. The ranking of a specific web component (frame, radial, spiral, hub, etc.) on each property would be displayed on each axis. The total mechanical function of the web may be visually compared if the analysis studies gave each web component its own pentagon. The study results show trade-offs where some axes were short (poor strength, for example) and places where other qualities are maximised, showing that the silk is specialised in that area. The roles that different orb web components played in resilience, stability, and prey capture were succinctly and comparably understood thanks to this method.

The requirement of interpreting four types led to the use of spider net analysis in the final methodological research of generating conclusions, as shown in Figure 5.35. For the radar chart to reliably displayed the equilibrium interaction of coding schemes attribution, it must be visualised. The spider net analysis classification that the netting proportion of the orb leveling pattern represented the structural firm of consistency was naturally inspired by the scientific case study on the orb silk spider. The two patterned types of spider net analysis (1) the Orb Web and (2) the Orb Weaver approaches were the study's main findings. Hence, the dominant C7, indicated by the closest Orb Web, is superior to the Orb Weaver that were represented A6, A13, and B6 as Figure 5.36. Together, the consistency to support the accuracy of validity came from the crucial main findings.



(a) A6 (b) C7

(c) A13 (d) B6

Figure 5.35 Interpretation of Four Types Resulted with C7 Revealed The Nearest Orb Web of Spider Net Analysis

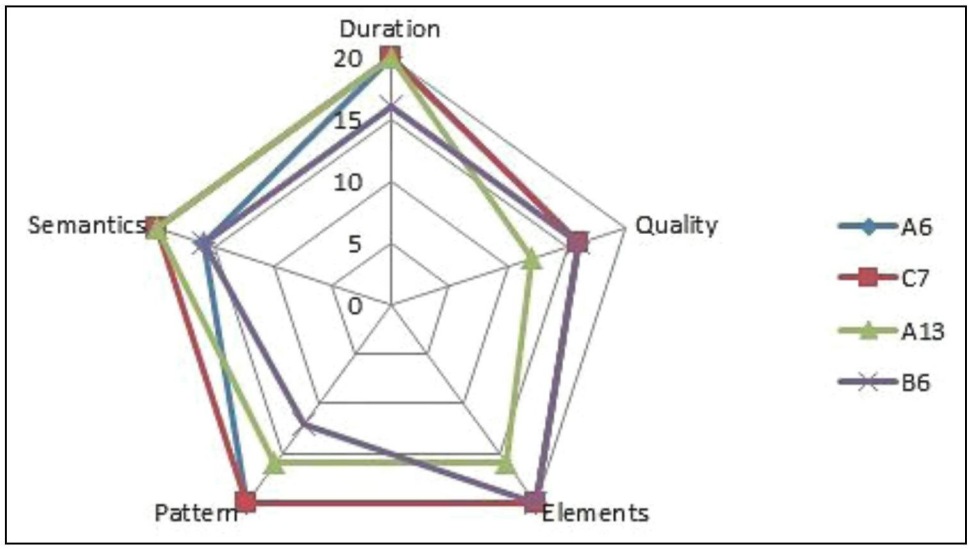


Figure 5.36 Comparison of Spider Chart Analysis: to See The Dominant C7 as The Closest Orb Web is Greater to The Orb Weaver-represented A6, A13, and B6

Finally, to ensure consistency and dependability in the data collection process, the study pairs two raters (the computation of statistical measures of reliability, such as Cohen's Kappa or Krippendorff's Alpha to assess design papers in the context of the given research findings. The goal of this pairing method was to determine the degree of agreement among raters and evaluate the accuracy of their assessments, both of which were essential for guaranteeing the validity of the coding scheme employed in the study. Therefore, the pairing rate conclusion is as follows:

a) The raters' successful matching produced a high degree of agreement (80%) in their coding decisions, guaranteeing the validity of the study's dataset. The high degree of agreement indicated that the coding procedure was generally dependable, even though 20% of the data can be regarded as erroneous because of rater disagreement.
b) Reliability was important when reporting to external stakeholders because it showed that the research findings were supported by a thorough coding procedure with a uniform degree of rater judgment.

In context with this, the high rater agreement (80%) guaranteed the validity of the coding method employed in this design manuscript study, disregarding a 20% degree of disagreement. Eight codes were used to specify the strong agreement of

coding content: (1) visual elements interpretation; (2) ecodesign identity quality; (3) heuristic procedural step; (4) exceeding level > 3-quality review; (5) line quality; (6) ecodesign identity; (7) product form identity; and (8) Level 3-Proficiency. The remaining two codes of agreement, such as the Cantilever principle and the Cantilever design understanding, were then not categorised, and thus were not accepted.

However, the ARE method allowed for the confident reporting of the data's overall reliability, which supported the study's findings.

i) The drawing conclusion that was presented focused on how Gestalt Theory (GT) concepts were applied in the Heuristic Quality Review (HQR) analysis to assess a design sketch or drawing's ecodesign identity, namely through its zoomorphic influences and visual elements (VE).
ii) A thorough grasp of how the different design components (VE) worked together to produce a cohesive design vision was made possible by the application of Gestalt Theory (GT) in HQR analysis. Gestalt principles like figure-ground, closure, similarity, proximity, and continuity were applied to make sure the design was understood holistically.
iii) The main means of combining these aspects into a cohesive design were visual elements (VE), especially when they were inspired by zoomorphic forms. The design strengthened its ecodesign identity by using zoomorphism to evoke natural features.
iv) The natural tone and texture of a design were greatly influenced by the four basic VE properties: point, line, plane, and volume. These qualities support the overarching objectives of the ecodesign brand by fostering a feeling of cohesion and connection to nature.

Overall, by combining Gestalt and VE principles, the design successfully conveys its ecodesign identity. Form integration gives the design coherence, and the organic, natural elements that were essential to its ecodesign identity focus were reinforced by the manipulation of VE characteristics – referred to as unified and uniformed.

5.7 DS-2 Data Analysis: Descriptive Statistics (Designing Clinical Survey)

Descriptive statistics II (DS-2) offered a core comprehension of the data, which is essential for supporting prescriptive investigations in fundamental research. The goal of the DS-2 study was to highlight the techniques for statistical testing that made use of appropriate theory constructions, which was related to the variables modeling that corresponded to a specific source and serve as a guide for the analysis and interpretation of datasets. The DS-2, which often denotes more sophisticated descriptive approaches, usually aids in this process by providing a summary of the mean, median, mode, standard deviation, variance, skewness, and kurtosis of datasets. It offered information on the distribution of the data's shape, central tendency, and dispersion.

The DS-2 study evaluated the scale measurement variables (nominal, ordinal, ratio, and interval) to identify patterns and relationships. By examining relationships between variables via correlation and cross-tabulation, researchers can identify patterns and dependencies within the data. These insights can help to create prescriptive models and strategies. Using a particular testing methodology, the methods of reflecting and directing the formation of hypotheses resulted in the emergence of hypotheses by spotting significant patterns or anomalies in the data that need further analysis. This was an important stage before moving on to prescriptive analysis, which was frequently based on well-formulated hypotheses. Understanding the distribution and relationships within the data was made easier by using visual tools such as (1) histograms, (2) box plots, (3) scatter plots, and (4) bar charts, which were all based on the data visualisation method. In prescriptive studies, decision-making processes are supported and findings were communicated more easily with the use of clear visuals.

Conversely, the DS-2 study has the benefit of baseline comparisons, meaning that prescriptive advice may be tested for efficacy against metrics provided by statistical testing methods. This facilitated the evaluation of whether the tactics used were yielding the intended results. It will, therefore, be simple to build the supporting model assumptions since many prescriptive models depended on certain data assumptions (e.g., normality, independence).

In addition to confirming the models' correctness in the prescriptive intended conclusions, descriptive statistics aid in the verification of these assumptions. Finally, the DS-2 study helped improve the quality of the data according to the specific datasets. Descriptive statistics aid in the identification of mistakes, missing values, and

discrepancies by offering a thorough analysis of the data. Before beginning any prescriptive analysis, the data must be cleaned and prepared. Nevertheless, DS-2 facilitates prescriptive research by providing in-depth analyses of the data that served as the foundation for creating, approving, and putting into practice prescriptive models and methodologies in basic research.

5.7.1 Preliminary Data Analysis: Normality Test

Preliminary data analysis involved analysing missing values, verifying for normality and outliers, and transforming the data to ensure it was ready for analysis. The normality test is a crucial preliminary study that must be performed before undertaking any multivariate analysis. Normality tests enabled researchers to assess the dataset's distributional assumption, allowing them to select relevant statistical techniques for data analysis. When choosing statistical tests, there was a notable understanding of the importance of data collection. Reviewing the population scale impacted data analysis based on the datasets.

If the research study data was not normally distributed, the researcher needed to examine alternate statistical procedures that were resistant to violations of normality assumptions. Because of the two statistical testing methods used in the use of SPSS software, it was typically split into two categories: (1) parametric statistics and (2) nonparametric statistics. Parametric statistics depended on assumptions about the distribution of the population from which the sample was drawn. Meanwhile, non-parametric statistics is independent of assumptions.

Therefore, data can be acquired from a sample that did not follow a predefined distribution. For Example, when data was not normally distributed, nonparametric tests such as the Wilcoxon signed-rank test or the Mann-Whitney U test can be employed in place of t-tests. When comparing two independent samples whose outcomes were not normally distributed and the samples were tiny, a non-parametric test was acceptable. The three main focuses of SPSS Statistics interpretation were as follows: (1) how to interpret numerical values; The p-value was either less or larger than 0.05. If the p-value was less than 0.05, it indicated a significant divergence from the normal distribution and can be considered that the data was not normally distributed. (2) how to interpret statistical tests where the analysis study must test for normality; It was easy to interpret a Q-Q plot by observing that the residuals were approximately normally distributed if

they fall on a relatively straight line at a 45-degree angle or diagonal angle. A Q-Q plot provided a simple visual meant to determine if the residuals were normally distributed, even if it isn't a rigorous statistical test. The deviation (or vertical distance) between the observation and the expected regression line was known as the residual. Predicted values were points that fell on the expected line for a given x-axis position and (3), how to handle scenarios in which research study data deviated from the assumption of normality; The study datasets, along with their range, quartiles, and median, was shown in a box plot. When analysing a box plot, consider the length of the box to comprehend the data's spread and the median to determine the data's central tendency. Any points outside of the data's range were considered outliers, and the whiskers show the data range. In Figure 5.27, the higher and lower whiskers represent scores that fell outside the middle 50%. Whiskers typically (but not always) covered a broader range of scores than middle quartile groups. The subsequent explanation of box plot disciplines was provided here.

a) *Make sure the outlier is not a data entry error* − Sometimes, data values were recorded incorrectly. If an outlier is present, first verify that the value was entered correctly and was not an error.
b) *Assign a new value to the outlier* − If the outlier turned out to be a result of a data entry error, the study may decide to assign a new value to it such as of the dataset.
c) *Remove the outlier* − If the value was a true outlier, the study may choose to remove it if it had insignificant impact on our overall analysis. It then needed to be mentioned in the final report or analysis that the study removed an outlier.

Thus, to run the datasets of Scenario 1 and Scenario 2 analysis simultaneously, the data analysis research would be presented the SPSS Output with (1) Test of normality → (2) Normal Q-Q Plots → (3) Box Plots. The research projects' benefits of projecting and providing appropriate testing methods through a systematic approach were demonstrated by this data analysis exercise. Furthermore, to discuss a suitable SPSS Statistics testing strategy in support of the concurrent prescriptive analysis research, this was one programme under the DRM framework. Then, the normality test datasets would be evaluated using the prior recommendation of descriptive statistics in

Scenario 1 for the pilot survey and Scenario 2 for the datasets of the fieldwork survey separately.

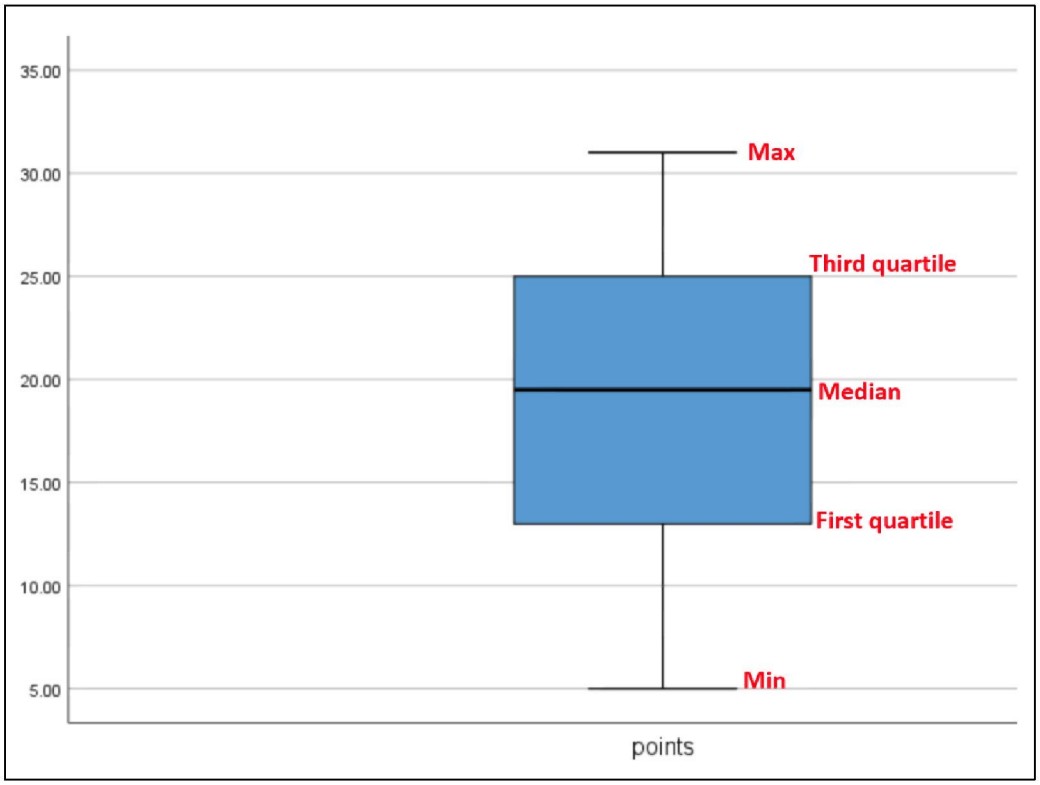


Figure 5.37 How to Interpret: A Single Box Plot in SPSS

Source: Scale (2023)

In this SPSS output study, the normality test of SPSS Statistics methods in Figures 5.38, 5.39, and 5.40 demonstrated that the dataset analysis process from 16 people of respondents was well computed. Due to the dataset content of the independent variable about the C9. Manual Mode of Heuristic Method for the Heuristics Design Tool and the dependent variable represented by C6. Product Form Identity under the ecological form of ecodesign identity. Understanding where to position the dependent variables was mandatory, as it emerged from the prior theoretical frameworks recognised in Chapter 3 under the "theoretical framework for the ecological form of ecodesign identity. Therefore, using proper techniques when creating clinical surveys will produce the desired results.

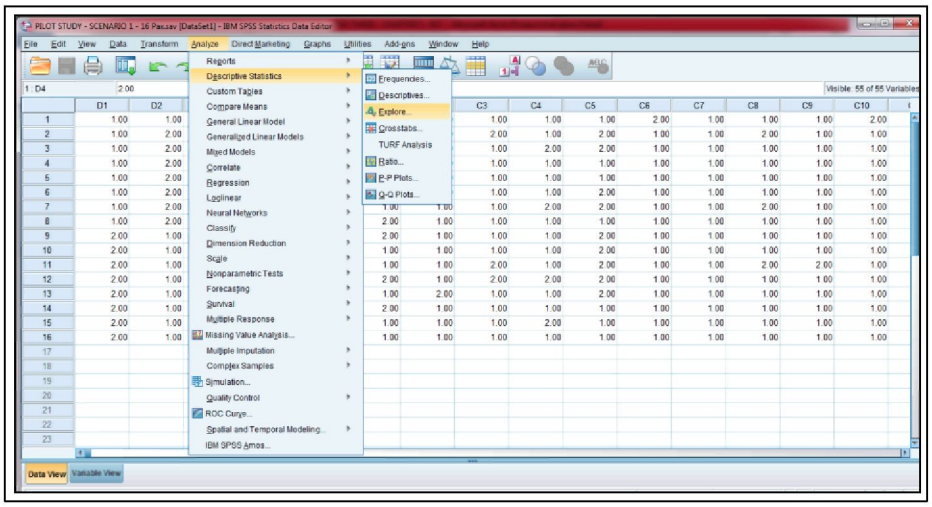


Figure 5.38 Normality Test SPSS for Scenario 1 - Click Analyze > Descriptive Statistics > Explore

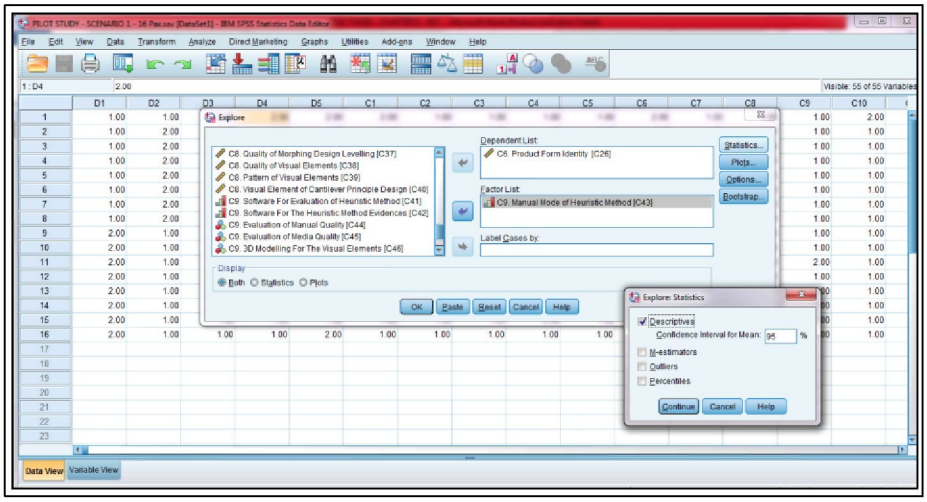


Figure 5.39 Normality Test SPSS for Scenario 1 - Explore: Statistics

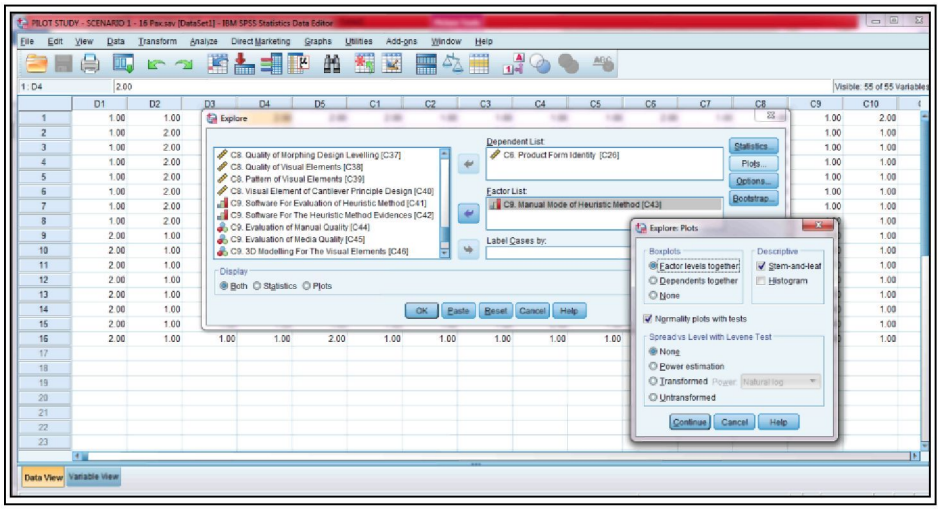


Figure 5.40 Normality Test SPSS for Scenario 1 - Explore: Plot

Table 5.26
Case Processing for Scenario 1 – Pilot Survey

Case Processing Summary

		Cases					
	C9. Manual Mode of	Valid		Missing		Total	
	Heuristic Method	N	Per cent	N	Per cent	N	Per cent
C6. Product Form	Tracing paper	7	100.0%	0	0.0%	7	100.0%
Identity	Layering paper	3	100.0%	0	0.0%	3	100.0%
	Dotted drawing	3	100.0%	0	0.0%	3	100.0%
	All answers stated	3	100.0%	0	0.0%	3	100.0%

Table 5.26 provided information about the number of genuine cases on which the statistics were based, and the report table contained the descriptive statistics themselves. For data entry, N=0 indicatesd "no missing data". As an outcome, all respondents (N=16 people of students) completed the desired clinical survey entirely.

Table 5.27
Shapiro-Wilk Test of Normality for Scenario 1 – Pilot Survey

Tests of Normality

	C9. Manual Mode of	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Heuristic Method	Statistic	df	Sig.	Statistic	df	Sig.
C6. Product Form	Tracing paper	.316	7	.034	.772	7	.021
Identity	Layering paper	.175	3	.	1.000	3	1.000
	Dotted drawing	.385	3	.	.750	3	.000
	All answers stated	.385	3	.	.750	3	.000

a. Lilliefors Significance Correction

In the SPSS output of Scenario 1, the table showed the results of normality tests using the Shapiro-Wilk tests for the variable "C9. Manual Mode of Heuristic Method" across different levels of "C6. Product Form Identity". Here was an explanation of the Shapiro-Wilk test results provided in Table 5.27,

i) *Tracing Paper* – A significance level of 0.021 was assigned to the Shapiro-Wilk statistic, which came out as 0.772. Therefore, the data for the "Tracing Paper" group did not follow a normal distribution, as the significance value was less than 0.05, and we rejected the null hypothesis.
ii) *Layering Paper* – The Shapiro-Wilk statistic was 1.000, indicating a

significance level of 1.000. Because the significance level was greater than 0.05, we cannot reject the null hypothesis, implying that the data for the "Layering Paper" group has a normal distribution.

iii) *Dotted Drawing* − At the 0.000 significance level, the Shapiro-Wilk value was 0.750. We rejected the null hypothesis, indicating that the data for the "Dotted Drawing" group did not follow a normal distribution because the significance value is less than 0.05.

iv) *All Answers Stated* − At the 0.000 significance level, the Shapiro-Wilk value was 0.750. We rejected the null hypothesis, indicating that the data for the "All Answers Stated" group did not follow a normal distribution because the significance value was less than 0.05.

However, the inconsistent finding was analysed from a significant *p*-value representing a dependent variable. Hence, the Shapiro-Wilk test examined the normality of "C6. Product Form Identity" concerning the data of the individuals categorised as three independent variables: "tracing paper", "layering paper", "dotted drawing", and "all answers stated" under the "Manual Mode of Heuristics Method." The analysis study indicated that "C6. Product Form Identity" for this specific subset of persons was non-normally distributed because the Sig. *p*-value 0.021 and 0.000 under the Shapiro-Wilk column was less than 0.05. But in the middle of the SPSS output, an inconsistency significant *p*-value of 1.000 was discovered. By using Normal Q-Q Plots and Box Plots for analysis visualisation, verification was possible.

For the Normal Q-Q Plots throughout Scenario 1 in Figure 5.41, Figure 5.42, Figure 5.43, and Figure 5.44, all of the answers indicated three kinds of independent variables under "Manual Mode of Heuristics Method", namely "tracing paper," "layering paper," "dotted drawing," and "all answers stated." The remaining patterns did not fall neatly along the diagonal straight line. As a result, the dotted line deviated significantly from the straight line.

Last but not least, Box Plots within Scenario 1 in Figure 5.45 showed that the data entry for the value of outliers for case number 3 from the Tracing Paper was inaccurate. As a result, the output summarised Scenario 1 of Preliminary Data Analysis inside the Normality Test, which is not normally distributed. As a result, incremental non-parametric tests employing the static testing method were temporarily necessary.

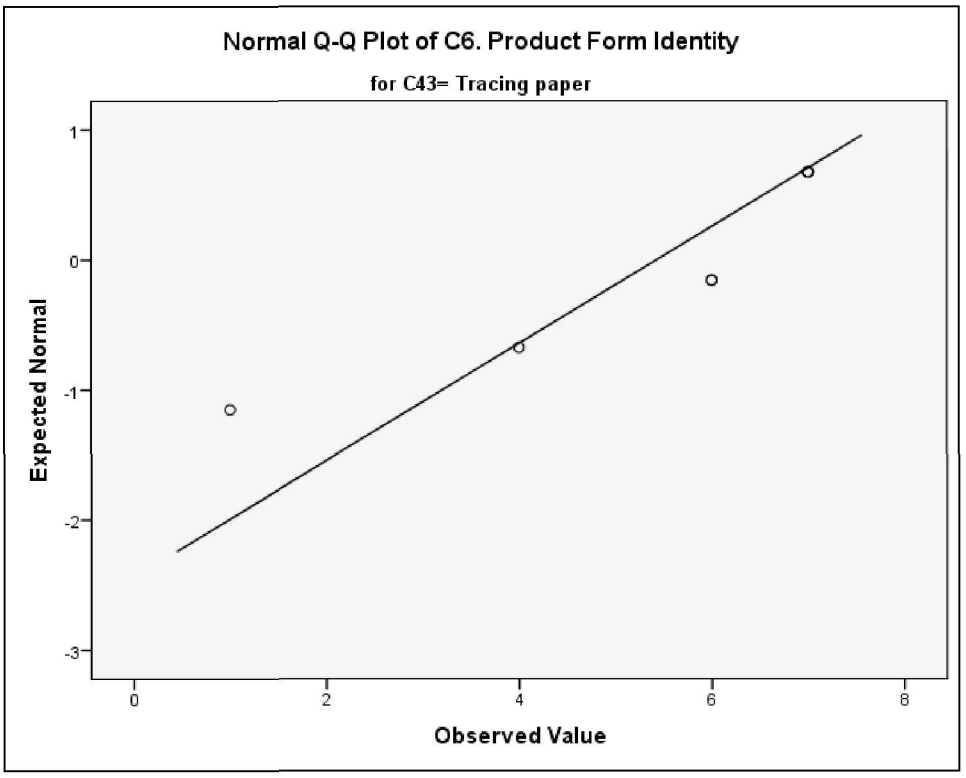


Figure 5.41 Normal Q-Q Plots for Scenario 1 for Tracing Paper – Dotted Dispersed From The Straight Line

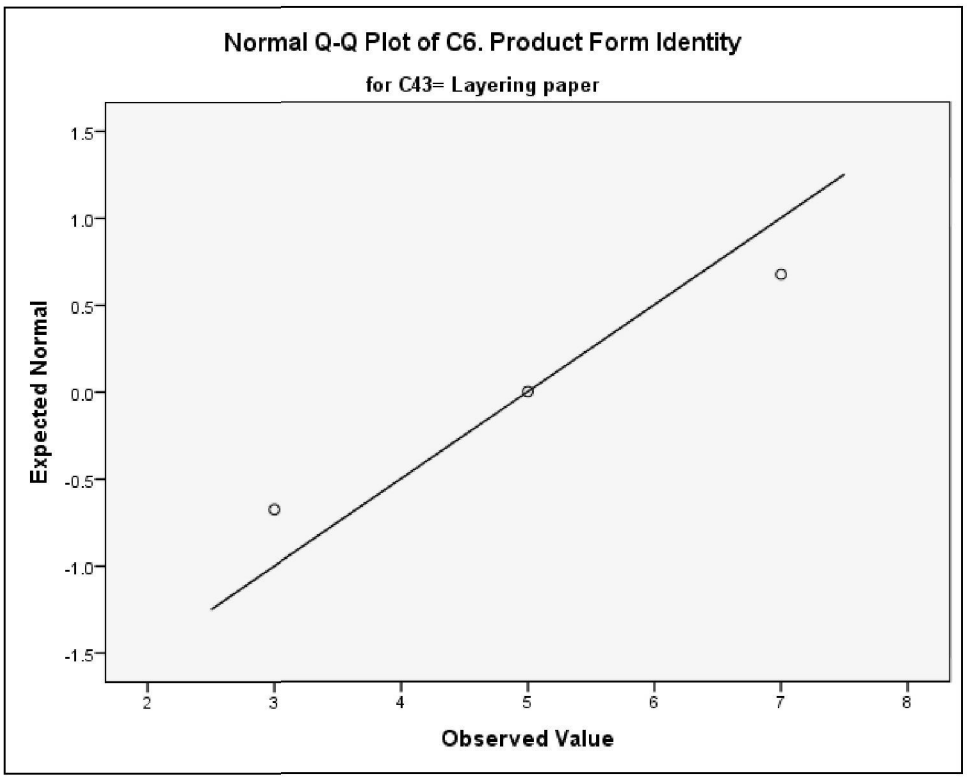


Figure 5.42 Normal Q-Q Plots for Scenario 1 for Layering Paper – Dotted Dispersed From The Straight Line

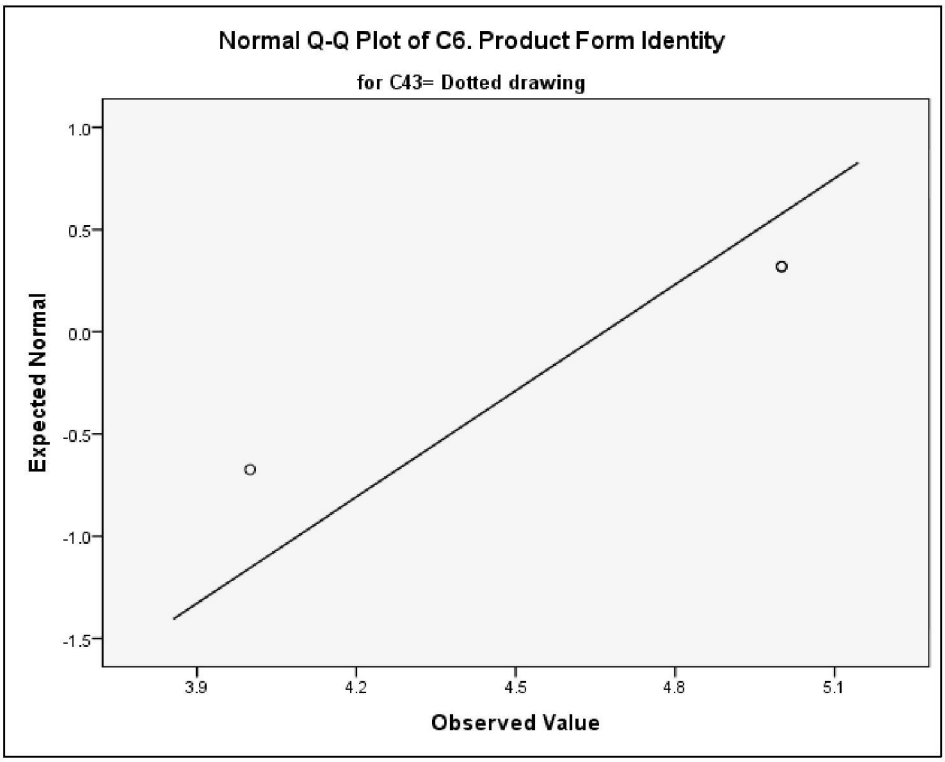


Figure 5.43 Normal Q-Q Plots for Scenario 1 for Dotted drawing – Dotted Dispersed From The Straight Line

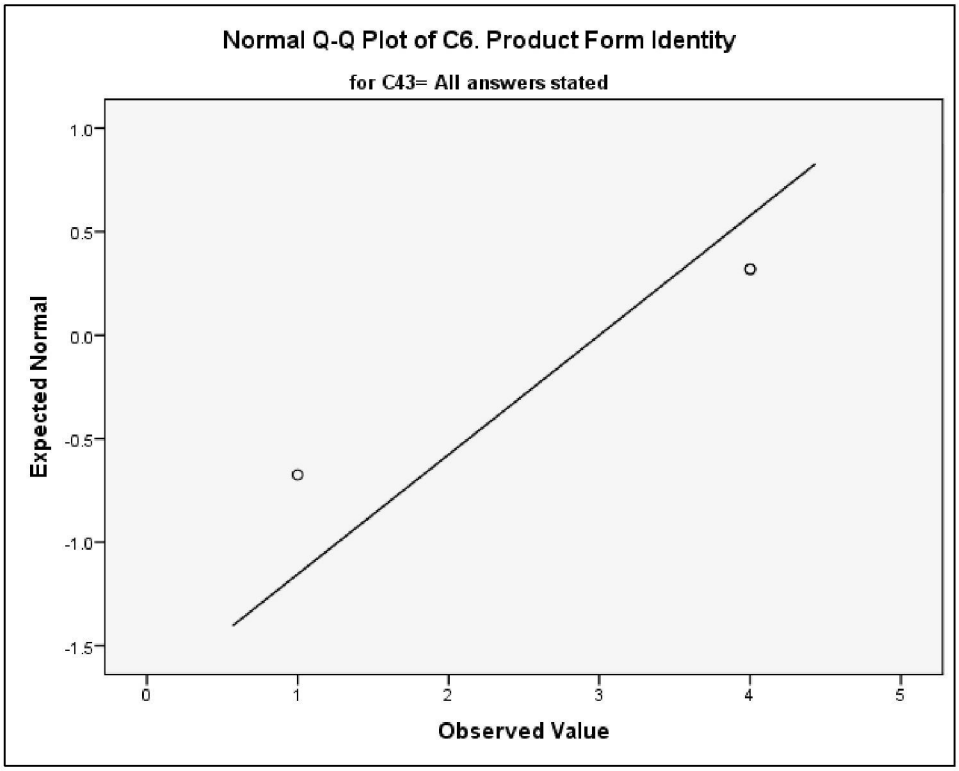


Figure 5.44 Normal Q-Q Plots for Scenario 1 for All answers stated – Dotted Dispersed From The Straight Line

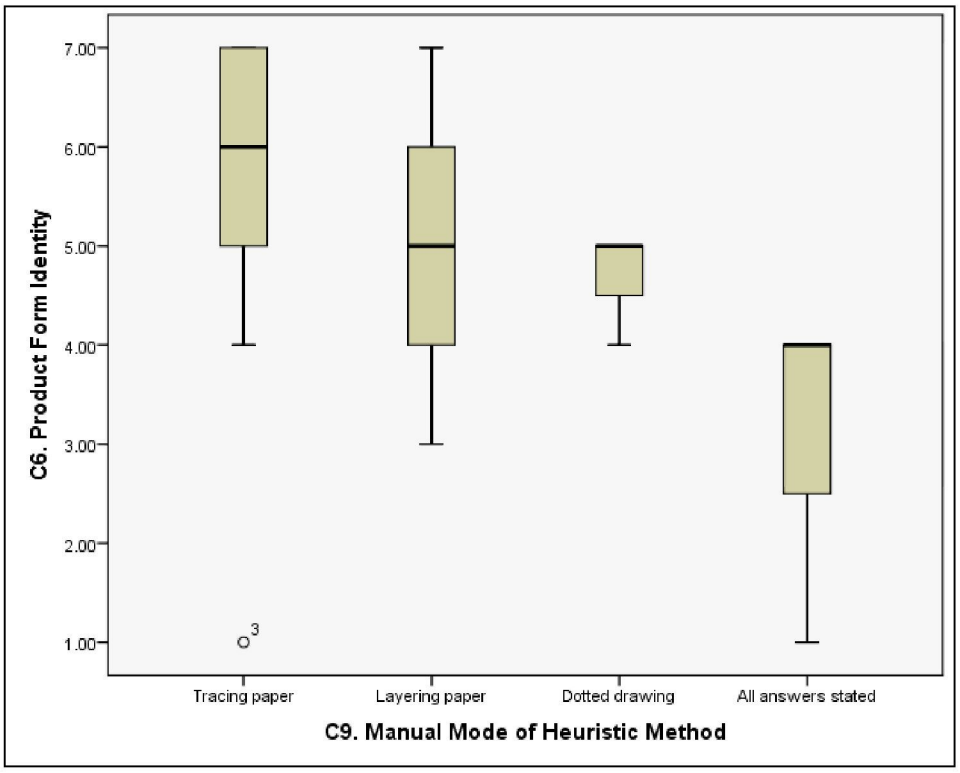


Figure 5.45 Box Plots for Scenario 1 – The Value of Outliers for Case Number 3 From the Tracing Paper Was Incorrect, and All Box Plots Were Invalidated Via Error Data Entry

In Scenario 2 of the SPSS output study, the normality test of SPSS Statistics methods in Figures 5.46, 5.47, and 5.48 demonstrated that the dataset analysis process was well computed for the fieldwork survey. Due to the dataset content of the independent variable refered to the "Q16-Heuristic procedural step" for the "Heuristics Design Tool" and the dependent variable represented by the "C6. Product Form Identity" under "Ecological Form of Ecodesign Identity." The theory building of quantitative structure to enable the projection of two variables in the normality test of SPSS Statistics methods. It streamlined the process of dataset screening and statistical test selection within the SPSS environment.

Forty-five students participated in the clinical survey design. Respondents, representing each of the three groups' institutions, shared their insights following the evaluation of the VPA method. A quick response from each participant particularly contributed to the appropriate answer where the ideation of the designing process must be coordinated together upon the evaluation of the events' session.

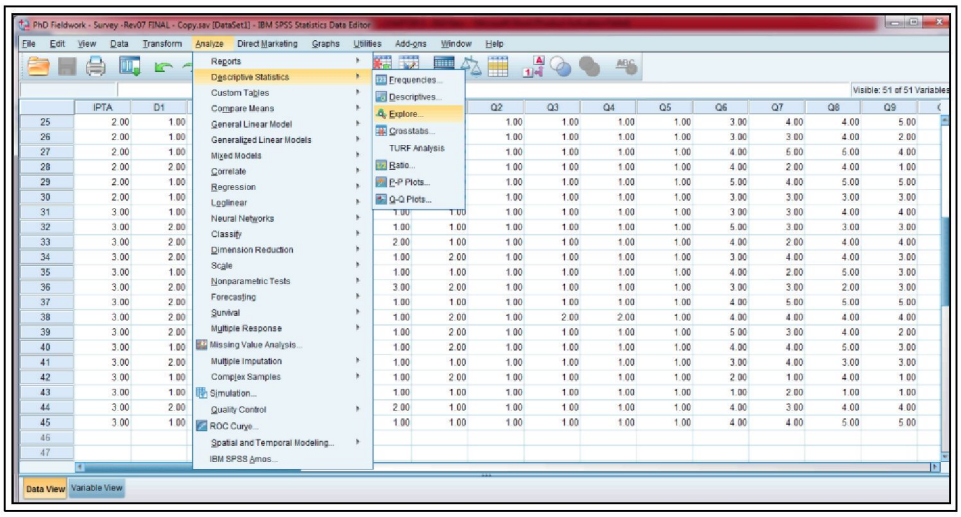


Figure 5.46 Normality Test SPSS for Scenario 2 - Click Analyze > Descriptive Statistics > Explore

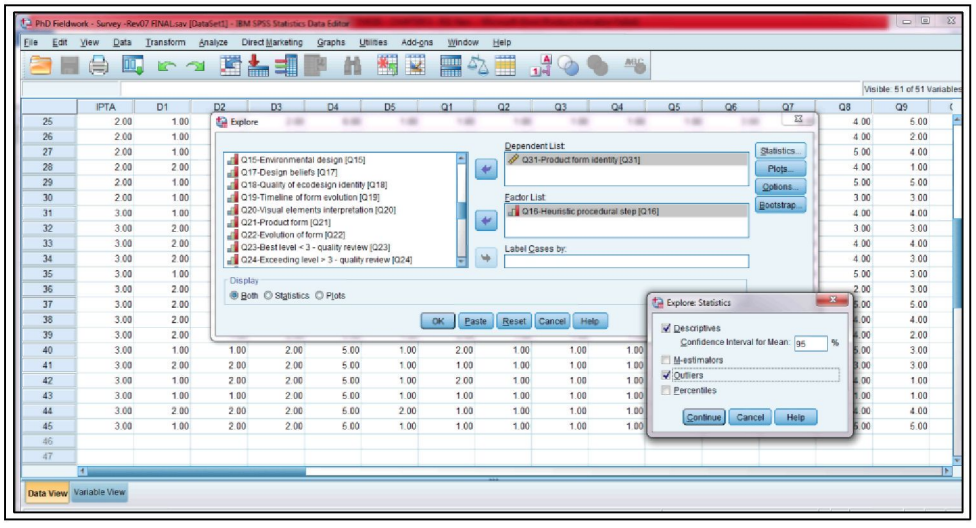


Figure 5.47 Normality Test SPSS for Scenario 2 - Explore: Statistics

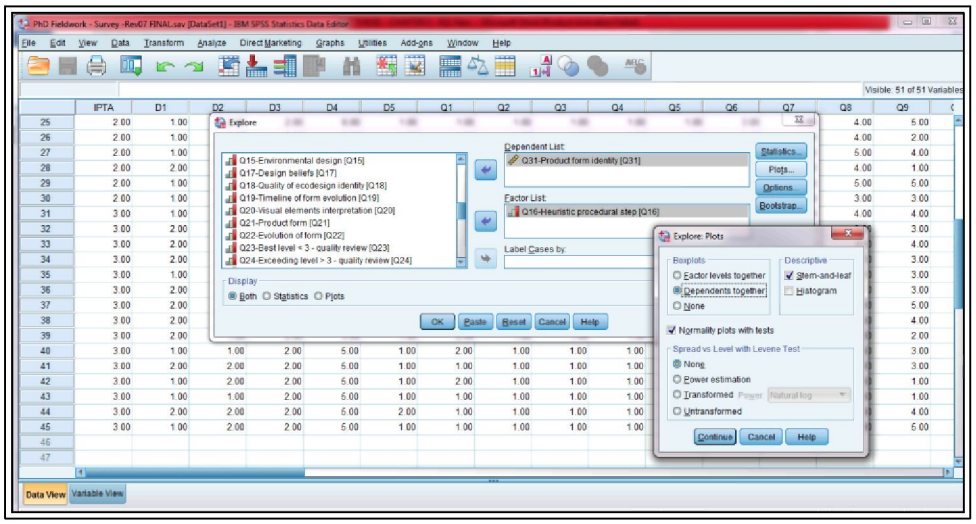


Figure 5.48 Normality Test SPSS for Scenario 2 - Explore: Plot

Table 5.28
Case Processing Summary for Scenario 2 – Fieldwork Survey

Case Processing Summary

		Cases					
	Q16-Heuristic procedural step	Valid		Missing		Total	
		N	Per cent	N	Per cent	N	Per cent
Q31-Product form identity	Neutral	7	100.0%	0	0.0%	7	100.0%
	Agree	28	100.0%	0	0.0%	28	100.0%
	Extremely agree	10	100.0%	0	0.0%	10	100.0%

Table 5.28 indicated the number of true cases on which the statistics are based, whereas the report table contained the descriptive statistics. For data entry, N=0 meant "no missing data". As a result, all respondents (N=45 people students) completed the targeted clinical survey thoroughly.

Table 5.29
Test of Normality for Scenario 2 – Fieldwork Survey

Tests of Normality

	Q16-Heuristic procedural step	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
		Statistic	df	Sig.	Statistic	df	Sig.
Q31-Product form identity	Neutral	.357	7	.007	.777	7	.024
	Agree	.172	28	.033	.909	28	.019
	Extremely agree	.229	10	.148	.859	10	.074

a. Lilliefors Significance Correction

The normality tests for the variable "Q16-Heuristic procedural step" at various levels of "Q31-Product form identity" were presented in Table 5.29, utilising Shapiro-Wilk tests. The following is an explanation of the Shapiro-Wilk test results,

a) *Neutral* – At a significance level of 0.024, the Shapiro-Wilk statistic was 0.777. We rejected the null hypothesis since the significance value was less than 0.05, indicating that the "Neutral" group's data may not have followed a normal distribution.
b) *Agree* – At the 0.019 significance level, the Shapiro-Wilk value was 0.990. We rejected the null hypothesis, indicating that the data for the "Agree" group did not follow a normal distribution because the significance value was less than 0.05.
c) *Extremely Agree* – At the 0.074 significance level, the Shapiro-Wilk value was 0.859. Given that the significance value exceeded 0.05, the null hypothesis cannot be rejected, indicating that the distribution of the data for the "Extremely Agree" group was normal.

In the Normal Q-Q Plots for Scenario 2 in Figures 5.49, 5.50, and 5.51, every response listed three different types of independent variables under "Q16-Heuristic procedural step": "neutral," "agree," and "extremely agree." The remaining patterns did not align perfectly with the straight diagonal line. Consequently, there was a notable deviation of the dotted line from the straight line.

Finally, Box Plots in Scenario 2 (Figure 5. 52) demonstrated that missing values were entered for the outlier values for Case 41 in the Neutral. The manner in which outliers were depicted in the two combined box plots was inconsistent Therefore, Scenario 2 of the Preliminary Data Analysis inside the Normality Test was summarised in the output, which followed an irregular distribution. Hence, it was temporarily necessary to perform incremental non-parametric tests utilising the static testing approach.

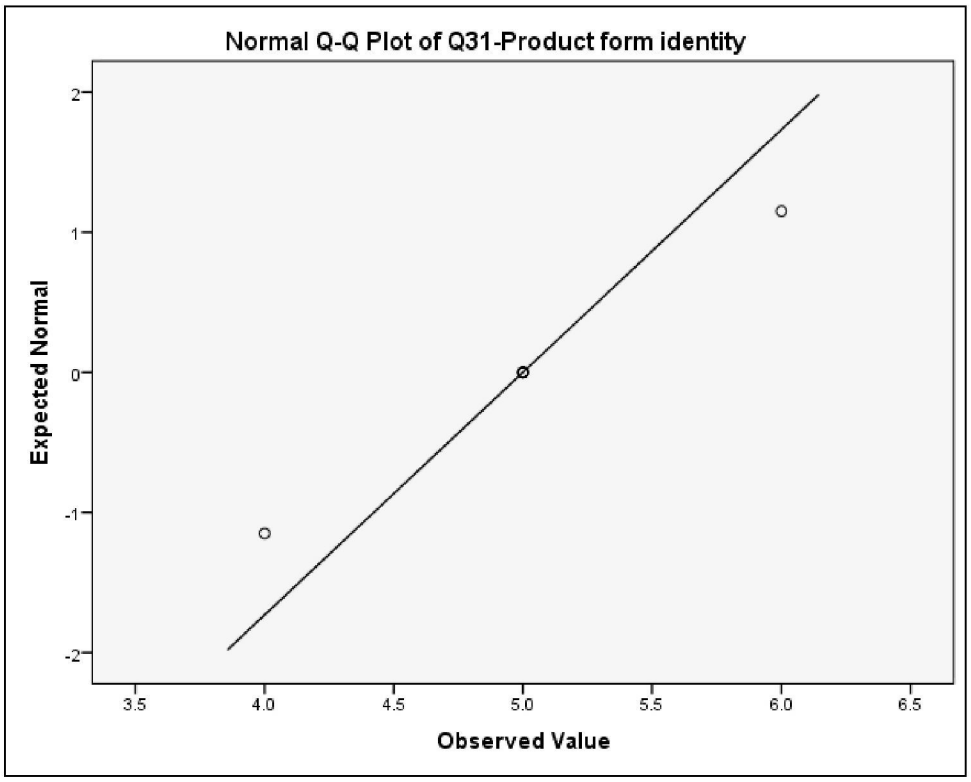


Figure 5.49 Normal Q-Q Plot SPSS for Scenario 2 - Neutral

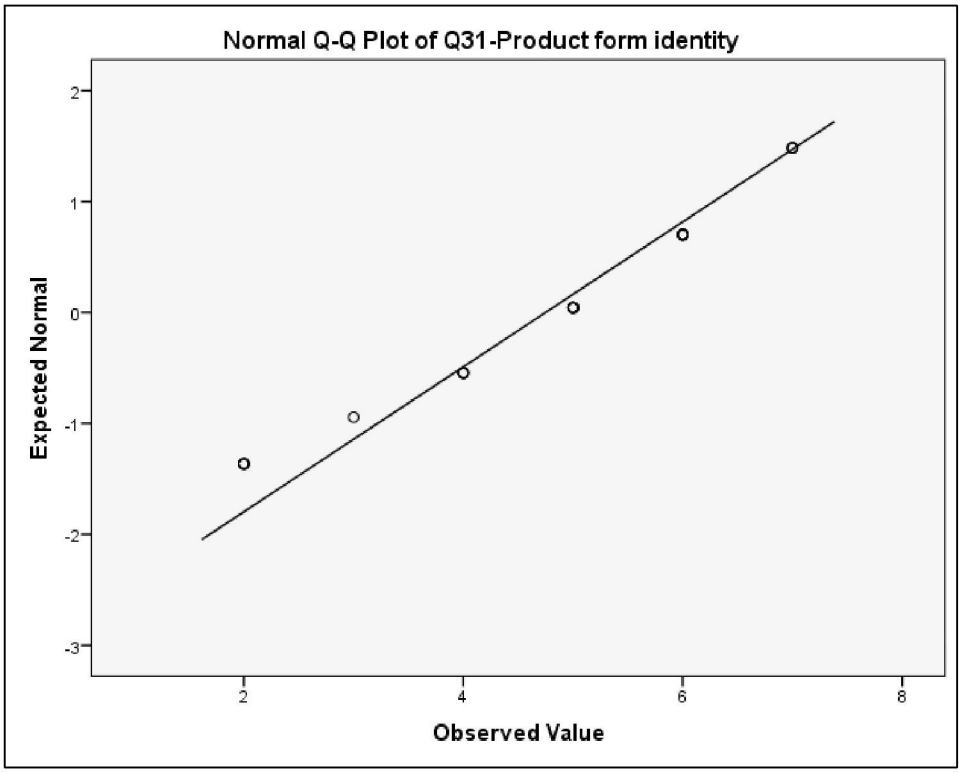


Figure 5.50 Normal Q-Q Plot SPSS for Scenario 2 - Agree

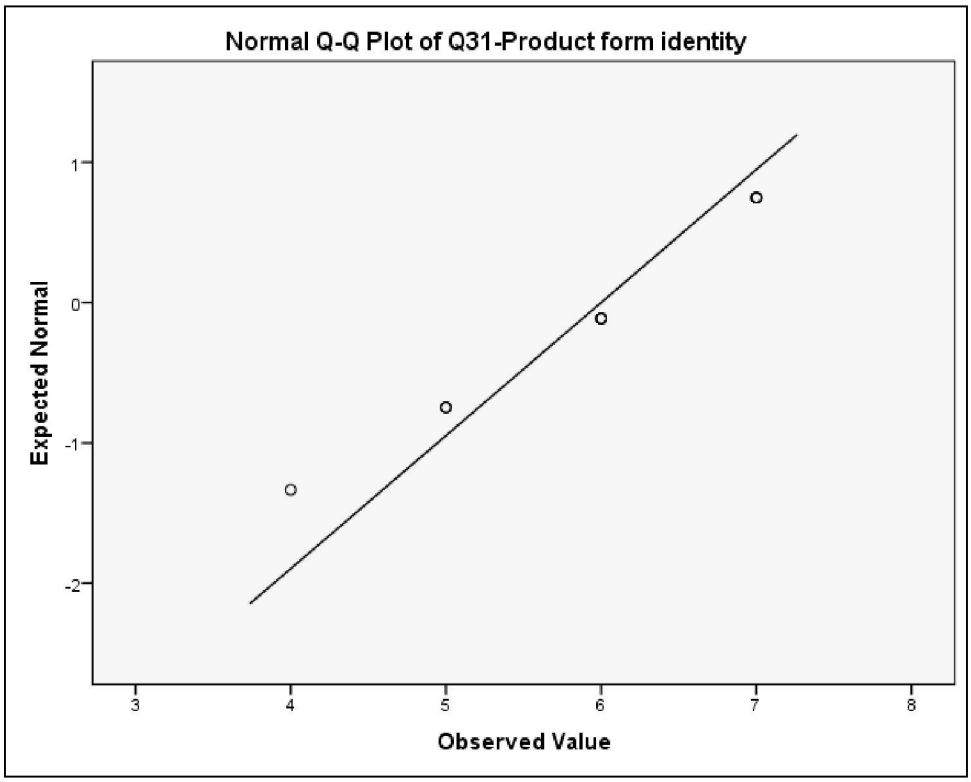


Figure 5.51 Normal Q-Q Plot SPSS for Scenario 2 – Extremely Agree

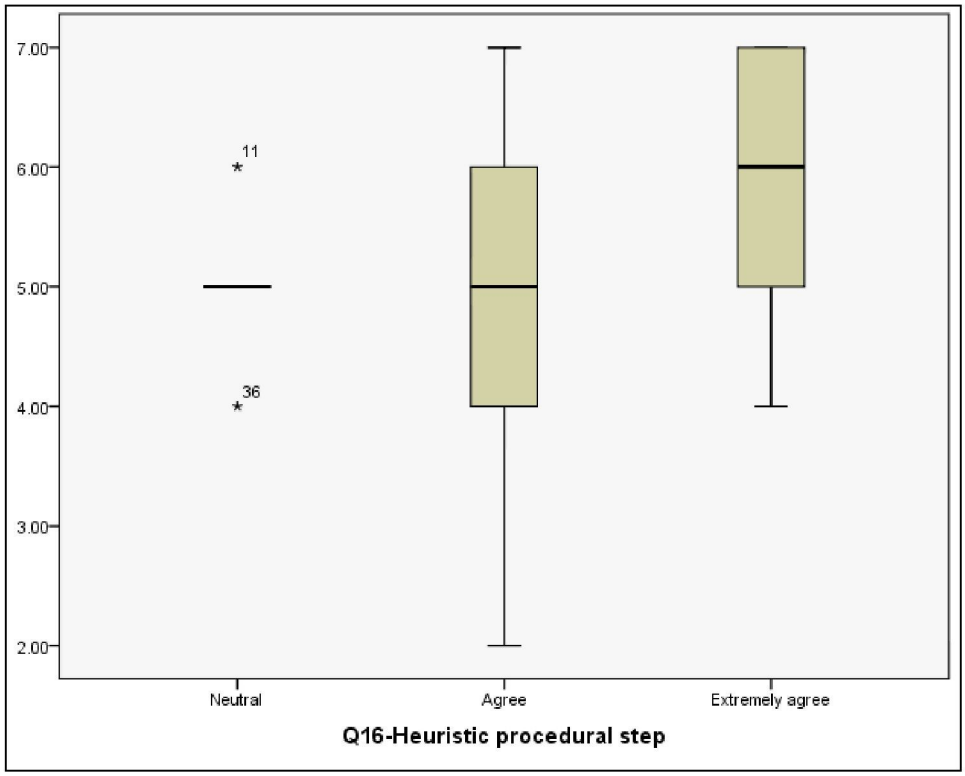


Figure 5.52 Box Plots SPSS for Scenario 2 – Neutral, Agree and Extremely Agree

The labelling of the case number may have been traced using the Outliers Descriptives of Box Plots for Scenario 2 in Table 5.30. To determine the value case number, the study needed to look at the following: (1) Extremely Agreed - Maximum value of 7.00; (2) Agree - Maximum value of 7.00; and (3) Neutral - Maximum value of 6.00. In light of this, Table 5.41 - which refered to (1) Neutral Highest Value = 11 Case Number, (2) Agree Highest Value = 12 Case Number, and (3) Extremely Agree Highest Value = 2 Case Number—was necessary for the Extreme Value table. Each case number specifically reflected each group's total of 45 students.

Table 5.30
Outliers Descriptives of Box Plots for Scenario 2 – Fieldwork Survey

Descriptives

Q16-Heuristic procedural step			Statistic	Std. Error
Neutral	Mean		5.0000	.21822
	95% Confidence Interval for Mean	Lower Bound	4.4660	
		Upper Bound	5.5340	
	5% Trimmed Mean		5.0000	
	Median		5.0000	
	Variance		.333	
	Std. Deviation		.57735	
	Minimum		4.00	
	Maximum		6.00	
	Range		2.00	
	Interquartile Range		.00	
	Skewness		.000	.794
	Kurtosis		3.000	1.587
Agree	Mean		4.7500	.28925
	95% Confidence Interval for Mean	Lower Bound	4.1565	
		Upper Bound	5.3435	
	5% Trimmed Mean		4.7778	
	Median		5.0000	
	Variance		2.343	
	Std. Deviation		1.53055	
	Minimum		2.00	
	Maximum		7.00	
	Range		5.00	
	Interquartile Range		2.00	
	Skewness		-.480	.441
	Kurtosis		-.548	.858
Extremely agree	Mean		6.0000	.33333
	95% Confidence Interval for Mean	Lower Bound	5.2459	

	Upper Bound	6.7541	
5% Trimmed Mean		6.0556	
Median		6.0000	
Variance		1.111	
Std. Deviation		1.05409	
Minimum		4.00	
Maximum		7.00	
Range		3.00	
Interquartile Range		2.00	
Skewness		-.712	.687
Kurtosis		-.450	1.334

Table 5.31
Extreme Value Outliers of Box Plots for Scenario 2 – Fieldwork Survey

	Extreme Values				
	Q16-Heuristic procedural step			Case Number	Value
Q31-Product form identity	Neutral	Highest	1	11	6.00
			2	3	5.00
			3	20	5.00[b]
		Lowest	1	36	4.00
			2	41	5.00
			3	34	5.00[c]
	Agree	Highest	1	12	7.00
			2	17	7.00
			3	28	7.00
			4	4	6.00
			5	10	6.00[d]
		Lowest	1	39	2.00
			2	8	2.00
			3	7	2.00
			4	5	2.00
			5	16	3.00
	Extremely agree	Highest	1	2	7.00
			2	9	7.00
			3	21	7.00
			4	37	7.00
			5	1	6.00[d]
		Lowest	1	43	4.00
			2	24	5.00
			3	22	5.00
			4	45	6.00
			5	42	6.00[e]

a. The requested number of extreme values exceeds the number of data points. A smaller number of extremes is displayed.

b. Only a partial list of cases with the value 5.00 is shown in the table of upper extremes.

c. Only a partial list of cases with the value 5.00 are shown in the table of lower extremes.

d. Only a partial list of cases with the value 6.00 is shown in the table of upper extremes.

e. Only a partial list of cases with the value 6.00 is shown in the table of lower extremes.

Lastly, the bar graph displayed the number of answers to the "Q21-Product form" at each of the "Q18-Quality of ecodesign identity" levels in Figure 5.53. The answers were divided into five categories, namely "Extremely disagree," "Disagree," "Neutral," "Agree," and "Extremely agree." In the bar chart, the category "Agree" under "Q18-Quality of ecodesign identity" had the greatest count for the response "Agree." With 12 responses, this category's bar has the greatest count. The data for the "Agree" group did not follow a normal distribution, as indicated by the rejection of the null hypothesis due to the significance value being less than 0.05. According to the results of the normality test, this category did not have a normal distribution ($p < 0.05$).

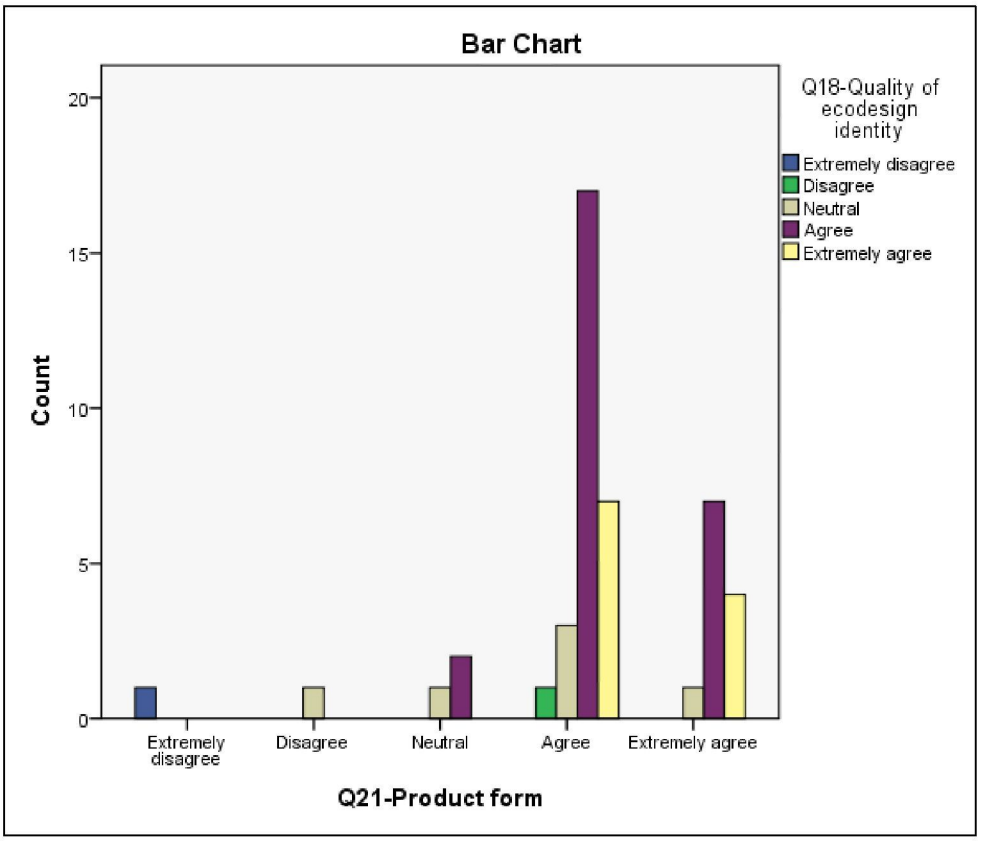


Figure 5.53 Bar Chart SPSS for Scenario 2 – Frequent Answered by Agree to the Q21. Product Form

5.7.2 Spearman's Rho Correlation: Significant p-Value

The direction and intensity of the relationship between two ranked variables were evaluated using Spearman's Rho correlation. Since it was non-parametric, it did not make any assumptions about the data's distribution. Spearman's Rho was a non-parametric test that could be used with ordinal data or data that did not fit the

requirements of parametric tests like Pearson's correlation since it did not assume that the data was regularly distributed.

Spearman's Rho evaluated monotonic associations that were initially based on the tendency of the variables to move in the same direction, though perhaps not at a constant rate. When there was a steady increase or decrease in the variables rather than a linear relationship, it was acceptable. There were various benefits to visualising monotonic correlations in Spearman's Rho correlation, which improved data interpretation and understanding. The intuitive understanding of the relationship between variables was aided by visualisation. It facilitated the quick observation of patterns, trends, and the association's strength.

The research may rapidly determine whether the relationship was rising or decreasing and whether it was monotonic (variables move in the same direction) by charting the data in SPSS. When conveying results to a wider audience—including individuals who might not be familiar with statistical measures—graphical representations worked better. Results can be made more readable and interesting by using graphics like scatter plots. To evaluate theories on the relationship between two variables, however, one could employ Spearman's Rho hypothesis testing. For example, scientists may propose that two variables have a strong positive (increasing) or negative (decreasing) correlation in Figure 5.54

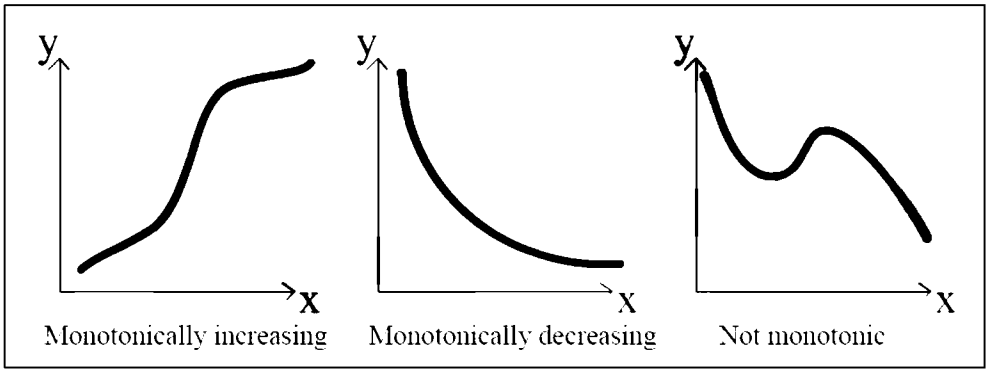


Figure 5.54 Types of Monotonic Pattern in Spearman's Rho Correlation

In Table 5.32, the correlation coefficient of Spearman Rho falls between -1 and 1. A perfect positive correlation was represented by a value of 1, a perfect negative correlation was represented by a value of -1, and no correlation was represented by a value of 0. The statistical significance of the correlation wase ascertained by referring to the significance level (p-value), rho (ρ), and r_s.

Table 5.32
Spearman Rho Correlation Coefficient Index

rho (ρ) or r_s	Interpretation of Relationship Category
0 < 0.19 positive (0 < - 0.19 negative)	Very weak
0.20 < 0.39 positive (- 0.20 < - 0.39 negative)	Weak
0.40 < 0.59 positive (- 0.40 < - 0.59 negative)	Moderate
0.60 < 0.79 positive (- 0.60 < - 0.79 negative)	Strong
0.80 < 1.00 positive (- 0.80 < - 1.00 negative)	Very strong

Source: Sugiyono (2010) and Brainkart (2025)

When a research project decided to analyse a dataset using Spearman's correlation, part of the procedure which included ensuring that the data required for analysis can be analysed using Spearman's correlation. Here, Leard (2023) stated the notification of testing method following,

> *"Spearman's correlation determines the degree to which a relationship is monotonic. Put another way, it determines whether there is a monotonic component of association between two continuous or ordinal variables. As such, monotonicity is not actually an assumption of Spearman's correlation. However, you would not normally want to pursue a Spearman's correlation to determine the strength and direction of a monotonic relationship when you already know the relationship between your two variables is not monotonic. Instead, the relationship between your two variables might be better described by another statistical measure of association. For this reason, it is not uncommon to view the relationship between your two variables in a scatterplot to see if running a Spearman's correlation is the best choice as a measure of association or whether another measure would be better (Leard, 2023)."*

In Figure 5.55 and Figure 5.46, Using the Click Analyze > Correlate > Bivariate menu, the research study ran SPSS to produce its output. The significance of the association was evident at the 2-tailed 0.01 level for all variables were carefully chosen, and this was where the SPSS output screening step be presented.

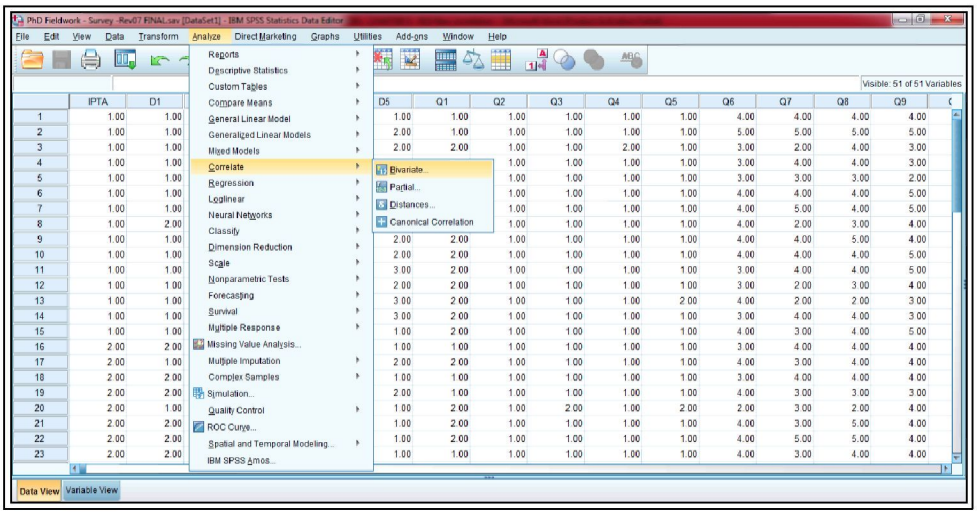


Figure 5.55 Spearman Rho SPSS for Scenario 2: Click Analyse> Correlate > Bivariate

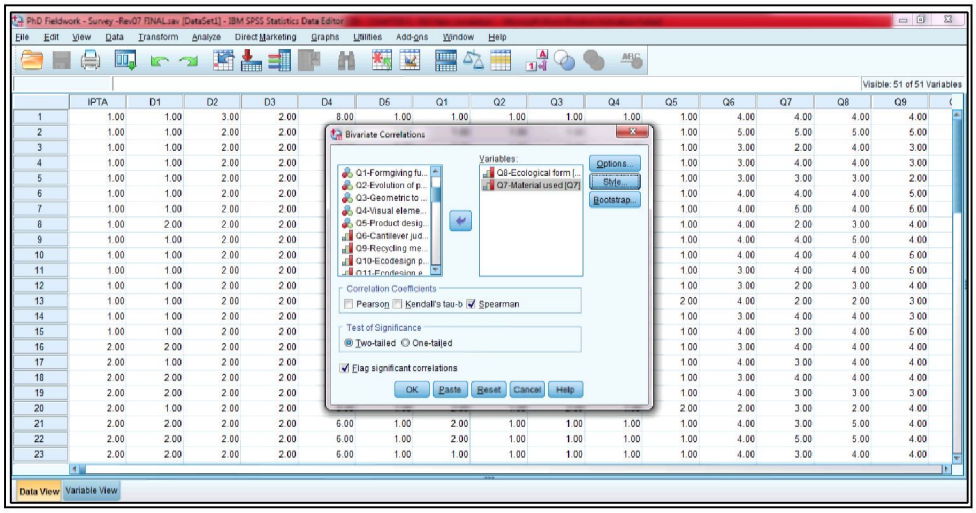


Figure 5.56 Spearman Rho SPSS for Scenario 2: Click Spearman Rho

In descriptive statistics, the role of item measurement mapping was crucial for the identification and interpretation of variables. There were two pinpoints for defining variables, namely (1) identification of variables and (2) operationalisation. Items measurement mapping helped define the variables as Table 5.33. It involved determining how the items (questions, statements, or observations) related to the constructs measured and offered to the identification of the variables.

Meanwhile, an operationalisation understanding described with each variable must be operationalised, meaning it should be defined in measurable terms. Items helped convert theoretical concepts into measurable variables. Accurate mapping of items to constructs is crucial for ensuring measurement validity. Consistent mapping across items contributes to increased measurement reliability, thereby ensuring that

repeated measurements produce similar results. Therefore, item measurement mapping was essential for effectively identifying, measuring, and interpreting variables in descriptive statistics. It helped ensure that researchers collect reliable and valid data, ultimately leading to accurate conclusions and insights.

As part of the correlation analysis investigation, the SPSS output of nonparametric correlations was managed in three phases of categorisation, denoted as (1) i-DS-2 stage, (2) ii-DS-2 stage, and (3) iii-DS-2 stage as shown in Table 5.34. The classification process was used to organise the supporting evaluation of the primary output stage (DS-2) for the DRM framework. A thorough description of the DRM framework's processes for the flows was provided in the previous Chapter 3. Therefore, an explanation of the knowledge domain hierarchy consistently will define and source an appropriate answer to each research question. This enabled content synchronising, which eventually made it easier to grasp the correlation analysis summaries from Appendix 16. Consequently, generating the specific variable relationship after the SPSS testing procedure was a supplementary research effort.

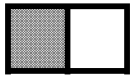
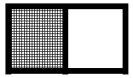
Table 5.33
Items Measurement Mapping to Screen the Variables Operationalisation

Sectional	Items (Variables)	Aims	Visual aid approach
SECTION C1: Nominal Questionnaire	Q1 - Q5	To label the variables of product category towards an intangible ecological form identity	Figure 1: Design continuum - The evolution of form (EoF)
SECTION C2: Semantic Differential Scale	Q6 - Q10	To recognise some **visual elements** of product design following the design thinking.	Table 1: Addressing the Design Thinking
SECTION C3: Semantic Differential Scale	Q11 - Q15		Table 2: The heuristic of transitional form
SECTION C4: Likert Scale	Q16 - Q20	To measure the **perception** of design belief (axis X&Y), using a 5-point Likert scale design to validate the intangible ecological form of ecodesign.	Table 3: Horizontal Axis - The Heuristic Procedural Step
SECTION C5: Likert Scale	Q21 - Q25		Table 4: Vertical axis - The level of quality review
SECTION C6: Numerical Scale	Q26 - Q30	To seek the **emotion** of a product's form quality (axis X&Y), using a 7-point numerical scale design in the heuristic procedural step.	Table 5: Horizontal axis - The heuristic procedural step
SECTION C7: Numerical Scale	Q31 - Q35		Table 6: Vertical axis - The level of quality review

SECTION C8: Ratio - Multiple Choice Questionnaire	Q36 - Q40	To elaborate an intangible ecological form for ecodesign using the level of ratio scales following the product's form and its functional unit.	Table 7: Horizontal axis - The theory of extrapolative semantics design thinking
SECTION C9: Ratio - Multiple Choice Questionnaire	Q41 - Q45		Table 8: Vertical axis - The level of visual elements

Table 5.34
Correlations Mapping to Screen the Variables of Research Answers for the Research Questions

Sectional	Items (Variables)	Q7-Material used	Q8-Ecological form	Q16-Heuristic procedural step	Q18-Quality of ecodesign identity	Q20-Visual elements interpretation	Q23-Best level < 3 - quality review	Q25-Quality of lines	Q27-Product form transformation	Q28-Ecodesign identity	Q30-Cantilever principle	Q31-Product form identity	Q32-Visual elements understanding
SEC. C2	Q8-Ecological form	.510** (.000)											
	Q9-Recycling methodology	.548** (.000)	.407** (.006)										
SEC. C4	Q16-Heuristic procedural step		.424** (.004)										
	Q18-Quality of ecodesign identity		.440** (.002)	.682** (.000)									
	Q20-Visual elements interpretation			.497** (.001)									
SEC. C5	Q24-Exceeding level > 3 - quality review						.500** (.000)						
	Q25-Quality of lines				.419** (.004)	.573** (.000)							
SEC. C6	Q28-Ecodesign identity			.431** (.003)	.549** (.000)			.391** (.008)	.397** (.007)				
	Q30-Cantilever principle								.389** (.008)			.439** (.003)	
SEC. C7	Q31-Product form identity		.449** (.002)		.405** (.006)						.537** (.000)		
	Q32-Visual elements understanding								.576** (.000)		.439** (.003)	.488** (.001)	
	Q33-< Level 3 - Proficiency			.505** (.000)	.494** (.001)			.413** (.005)		.442** (.002)	.519** (.000)		
	Q35-Cantilever design understanding					.454** (.002)							.525** (.000)

Legends:  i-DS-2 Stage  ii-DS-2 Stage  iii-DS-2 Stage

First, in the i-DS-2 stage two variables of correlations from Section C2 were found and examined following (1) Table 5.35 and (2) Table 5.36.

a) The result of Table 5.35 associated the pairs of variables between Q8-Ecological form and Q7-Material used indexed with a "positive moderate relationship" value of r_s = .510, and was positioned under two-tailed correlations significant at the 0.01 level ** (n = 45, p < .000).
b) Meanwhile, the result of Table 5.36 associated the pairs of variables between Q9-Recycling methodology and Q7-Material used indexed with "positive moderate relationship" value of r_s = .510, and it was positioned under two-tailed correlations significant at the 0.01 level ** (n = 45, p < .000).

Table 5.35
Q8-Ecological Form and Q7-Material Used

Correlations

			Q8-Ecological form	Q7-Material used
Spearman's rho	Q8-Ecological form	Correlation Coefficient	1.000	.510**
		Sig. (2-tailed)	.	.000
		N	45	45
	Q7-Material used	Correlation Coefficient	.510**	1.000
		Sig. (2-tailed)	.000	.
		N	45	45

**. Correlation is significant at the 0.01 level (2-tailed).

Table 5.36
Q9-Recycling Methodology and Q7-Material Used

Correlations

			Q9-Recycling methodology	Q7-Material used
Spearman's rho	Q9-Recycling methodology	Correlation Coefficient	1.000	.548**
		Sig. (2-tailed)	.	.000
		N	45	45
	Q7-Material used	Correlation Coefficient	.548**	1.000
		Sig. (2-tailed)	.000	.
		N	45	45

**. Correlation is significant at the 0.01 level (2-tailed).

Second, in the ii-DS-2 stage, four variables of correlations from Section C4 and C5 were examined: (1) Table 5.37, (2) Table 5.38, (3) Table 5.39 and (4) Table 5.40.

a) The result of Table 5.37 associated the pairs of variables between Q18-Quality of ecodesign identity and Q8-Ecological form indexed with "positive moderate relationship" value of r_s = .440, and it was positioned under two-tailed correlations significant at the 0.01 level ** (n = 45, p < .002).
b) The result of Table 5.38 associated the pairs of variables between Q18-Quality of ecodesign identity and Q16-Heuristic procedural step indexed with "positive strong relationship" value of r_s = .682, and it was positioned under two-tailed correlations significant at the 0.01 level ** (n = 45, p < .000).
c) The result of Table 5.39 associated the pairs of variables between Q25-Quality of lines and Q18-Quality of ecodesign identity indexed with "positive moderate relationship" value of r_s = .419, and it was positioned under two-tailed correlations significant at the 0.01 level ** (n = 45, p < .004).
d) The result of Table 5.40 associated the pairs of variables between Q25-Quality of lines and Q20-Visual elements interpretation indexed with a "positive moderate relationship" value of r_s = .573, and it was positioned under two-tailed correlations significant at the 0.01 level ** (n = 45, p < .000).

Table 5.37
Q18-Quality of Ecodesign Identity and Q8-Ecological Form

Correlations

			Q18-Quality of ecodesign identity	Q8-Ecological form
Spearman's rho	Q18-Quality of ecodesign identity	Correlation Coefficient	1.000	.440**
		Sig. (2-tailed)	.	.002
		N	45	45
	Q8-Ecological form	Correlation Coefficient	.440**	1.000
		Sig. (2-tailed)	.002	.
		N	45	45

**. Correlation is significant at the 0.01 level (2-tailed).

Table 5.38
Q18-Quality of Ecodesign Identity and Q16-Heuristic Procedural Step

Correlations

			Q18-Quality of ecodesign identity	Q16-Heuristic procedural step
Spearman's rho	Q18-Quality of ecodesign identity	Correlation Coefficient	1.000	.682**
		Sig. (2-tailed)	.	.000
		N	45	45
	Q16-Heuristic procedural step	Correlation Coefficient	.682**	1.000
		Sig. (2-tailed)	.000	.
		N	45	45

**. Correlation is significant at the 0.01 level (2-tailed).

Table 5.39
Q25-Quality of Lines and Q18-Quality of Ecodesign Identity

Correlations

			Q25-Quality of lines	Q18-Quality of ecodesign identity
Spearman's rho	Q25-Quality of lines	Correlation Coefficient	1.000	.419**
		Sig. (2-tailed)	.	.004
		N	45	45
	Q18-Quality of ecodesign identity	Correlation Coefficient	.419**	1.000
		Sig. (2-tailed)	.004	.
		N	45	45

**. Correlation is significant at the 0.01 level (2-tailed).

Table 5.40
Q25-Quality of Lines and Q20-Visual Elements Interpretation

Correlations

			Q25-Quality of lines	Q20-Visual elements interpretation
Spearman's rho	Q25-Quality of lines	Correlation Coefficient	1.000	.573**
		Sig. (2-tailed)	.	.000
		N	45	45
	Q20-Visual elements interpretation	Correlation Coefficient	.573**	1.000
		Sig. (2-tailed)	.000	.
		N	45	45

**. Correlation is significant at the 0.01 level (2-tailed).

Third, in the iii-DS-3 stage, four variables of correlations from Section C6 and C7 were examined following (1) Table 5.41, (2) Table 5.42, (3) Table 5.43, (4) Table 5.44, (5) Table 5.45, (6) Table 5.46, (7) Table 5.47, (8) Table 5.48 and (9) Table 5.49.

a) The result of Table 5.41 associated the pairs of variables between Q28-Ecodesign identity and Q16-Heuristic procedural step indexed with a "positive moderate relationship" value of $r_s = .431$, and it was positioned under two-tailed correlations significant at the 0.01 level ** ($n = 45$, $p < .003$).
b) The result of Table 5.42 associated the pairs of variables between Q28-Ecodesign identity and Q18-Quality of ecodesign identity indexed with "positive moderate relationship" value of $r_s = .549$, and it was positioned under two-tailed correlations significant at the 0.01 level ** ($n = 45$, $p < .000$).
c) The result of Table 5.43 associated the pairs of variables between Q28-Ecodesign identity and Q25-Quality of lines indexed with "positive moderate relationship" value of $r_s = .391$, and it was positioned under two-tailed correlations significant at the 0.01 level ** ($n = 45$, $p < .008$).
d) The result of Table 5.44 associated the pairs of variables between Q28-Ecodesign identity and Q27-Product form transformation indexed with "positive moderate relationship" value of $r_s = .397$, and it was positioned under two-tailed correlations significant at the 0.01 level ** ($n = 45$, $p < .007$).
e) The result of Table 5.45 associated the pairs of variables between Q33-< Level 3 – Proficiency and Q16-Heuristic procedural step indexed with "positive moderate relationship" value of $r_s = .505$, and it was positioned under two-tailed correlations significant at the 0.01 level ** ($n = 45$, $p < .000$).
f) The result of Table 5.46 associated the pairs of variables between Q33-< Level 3 – Proficiency and Q18-Quality of ecodesign identity indexed with "positive moderate relationship" value of $r_s = .494$, and it was positioned under two-tailed correlations significant at the 0.01 level ** ($n = 45$, $p < .001$).
g) The result of Table 5.47 associated the pairs of variables between Q33-< Level 3 – Proficiency and Q25-Quality of lines indexed with "positive moderate relationship" value of $r_s = .413$, and it was positioned under two-tailed correlations significant at the 0.01 level ** ($n = 45$, $p < .005$).
h) The result of Table 5.48 associated the pairs of variables between Q33-< Level

3 – Proficiency and Q28-Ecodesign identity indexed with "positive moderate relationship" value of r_s = .442, and it was positioned under two-tailed correlations significant at the 0.01 level ** (n = 45, p < .002).

i) The result of Table 5.49 associated the pairs of variables between Q33-< Level 3 – Proficiency and Q30-Cantilever principle indexed with "positive moderate relationship" value of r_s = .519, and it was positioned under two-tailed correlations significant at the 0.01 level ** (n = 45, p < .000).

Table 5.41
Q28-Ecodesign Identity and Q16-Heuristic Procedural Step

Correlations

			Q28-Ecodesign identity	Q16-Heuristic procedural step
Spearman's rho	Q28-Ecodesign identity	Correlation Coefficient	1.000	.431**
		Sig. (2-tailed)	.	.003
		N	45	45
	Q16-Heuristic procedural step	Correlation Coefficient	.431**	1.000
		Sig. (2-tailed)	.003	.
		N	45	45

**. Correlation is significant at the 0.01 level (2-tailed).

Table 5.42
Q28-Ecodesign Identity and Q18-Quality of Ecodesign Identity

Correlations

			Q28-Ecodesign identity	Q18-Quality of ecodesign identity
Spearman's rho	Q28-Ecodesign identity	Correlation Coefficient	1.000	.549**
		Sig. (2-tailed)	.	.000
		N	45	45
	Q18-Quality of ecodesign identity	Correlation Coefficient	.549**	1.000
		Sig. (2-tailed)	.000	.
		N	45	45

**. Correlation is significant at the 0.01 level (2-tailed).

Table 5.43
Q28-Ecodesign Identity and Q25-Quality of Lines

Correlations

			Q28-Ecodesign identity	Q25-Quality of lines
Spearman's rho	Q28-Ecodesign identity	Correlation Coefficient	1.000	.391**
		Sig. (2-tailed)	.	.008
		N	45	45
	Q25-Quality of lines	Correlation Coefficient	.391**	1.000
		Sig. (2-tailed)	.008	.
		N	45	45

**. Correlation is significant at the 0.01 level (2-tailed).

Table 5.44
Q28-Ecodesign Identity and Q27-Product Form Transformation

Correlations

			Q28-Ecodesign identity	Q27-Product form transformation
Spearman's rho	Q28-Ecodesign identity	Correlation Coefficient	1.000	.397**
		Sig. (2-tailed)	.	.007
		N	45	45
	Q27-Product form transformation	Correlation Coefficient	.397**	1.000
		Sig. (2-tailed)	.007	.
		N	45	45

**. Correlation is significant at the 0.01 level (2-tailed).

Table 5.45
Q33-< Level 3 – Proficiency and Q16-Heuristic Procedural Step

Correlations

			Q33-< Level 3 - Proficiency	Q16-Heuristic procedural step
Spearman's rho	Q33-< Level 3 - Proficiency	Correlation Coefficient	1.000	.505**
		Sig. (2-tailed)	.	.000
		N	45	45
	Q16-Heuristic procedural step	Correlation Coefficient	.505**	1.000
		Sig. (2-tailed)	.000	.
		N	45	45

**. Correlation is significant at the 0.01 level (2-tailed).

Table 5.46
Q33-< Level 3 – Proficiency and Q18-Quality of Ecodesign Identity

Correlations

			Q33-< Level 3 - Proficiency	Q18-Quality of ecodesign identity
Spearman's rho	Q33-< Level 3 - Proficiency	Correlation Coefficient	1.000	.494**
		Sig. (2-tailed)	.	.001
		N	45	45
	Q18-Quality of ecodesign identity	Correlation Coefficient	.494**	1.000
		Sig. (2-tailed)	.001	.
		N	45	45

**. Correlation is significant at the 0.01 level (2-tailed).

Table 5.47
Q33-< Level 3 – Proficiency and Q25-Quality of Lines

Correlations

			Q33-< Level 3 - Proficiency	Q25-Quality of lines
Spearman's rho	Q33-< Level 3 - Proficiency	Correlation Coefficient	1.000	.413**
		Sig. (2-tailed)	.	.005
		N	45	45
	Q25-Quality of lines	Correlation Coefficient	.413**	1.000
		Sig. (2-tailed)	.005	.
		N	45	45

**. Correlation is significant at the 0.01 level (2-tailed).

Table 5.48
Q33-< Level 3 – Proficiency and Q28-Ecodesign Identity

Correlations

			Q33-< Level 3 - Proficiency	Q28-Ecodesign identity
Spearman's rho	Q33-< Level 3 - Proficiency	Correlation Coefficient	1.000	.442**
		Sig. (2-tailed)	.	.002
		N	45	45
	Q28-Ecodesign identity	Correlation Coefficient	.442**	1.000
		Sig. (2-tailed)	.002	.
		N	45	45

**. Correlation is significant at the 0.01 level (2-tailed).

Table 5.49
Q33-< Level 3 – Proficiency and Q30-Cantilever Principle

Correlations

			Q33-< Level 3 - Proficiency	Q30-Cantilever principle
Spearman's rho	Q33-< Level 3 - Proficiency	Correlation Coefficient	1.000	.519**
		Sig. (2-tailed)	.	.000
		N	45	45
	Q30-Cantilever principle	Correlation Coefficient	.519**	1.000
		Sig. (2-tailed)	.000	.
		N	45	45

**. Correlation is significant at the 0.01 level (2-tailed).

Overall, the fieldwork survey's three out of five major objectives were identified from the data analysis study. The respondents, who were young industrial designers involved in the process of producing clinical surveys for product clinical adoption, approved three portions of the goals' fieldwork: (1) visual elements: Section 2, (2) perception: portions 4 and 5, and (3) emotion: Sections 6 and 7.

5.7.3 Chi-Square Test: X^2 Independence Test

The Independence Test is a type of nonparametric test. The function is to reject the null hypothesis and then allow for the "correlation" or "association" of significant findings based on the contingency table findings. The use of nominal and ordinal data in this study allows for the types of observation procedures outlined in the H0 and H1

hypothesis statements. Two hypotheses' statements were described as (1) null hypothesis, no link between two variables, and (2) alternative hypothesis, an association between two variables. The examination of statistical X2 calculation was a critical step in interpreting the square table based on the degree of freedom. The values r and c for the basic statistical X2 meaning were calculated using the same row and column counts. As a result, the analysis study employed the formal equation shown below:

$$df = (r - 1)(c - 1) \tag{5.1}$$

Since the SPSS statistics had been performed, the provided formula clarified the "symmetrically square table". In this testing method understanding, the analysis study aimed the "availability of two variables relationship" from an existing SPSS data collection to confirm the research questions, whether the significant finding falls under the independent (null hypothesis) or dependent (alternative hypothesis). There were two analytical methodologies phases of formal objectives as study advice supplied as follows:

i) Determine the optimal nominal scale measurement for dichotomous or multiple variables using a 2 x 2 contingency table and Chi-Square X2 statistical analysis.
ii) Identify symmetrical square tables in frequency distributions (greater than two-by-two) and use degrees of freedom (df) to evaluate paired cell combinations. The ordinal data scale might present Chi Square X2 ranking scores based on the observed and expected frequencies between two variables.

Lastly, based on the outcomes from the prior nominal and ordinal scale tests, two significant test results were shown in Table 5.50. Two symmetric measure tables, such as (1) nominal by nominal using Pearson's r Coefficient Index and (2) ordinal by ordinal using Gamma γ Coefficient Index separately, have been used in the research study to expound on the data analysis and interpretation. This was an interpretation of the strength of association based on the criteria as follows.

Table 5.50
Pearson's *r* and Gamma *γ* Coefficient Index (The Rules of Thumb)

Strength of Association	**(*r*) and (*γ*) Coefficient**
None	0.00
Weak Association	Between ± 0.01 to ± 0.09
Moderate Association	Between ± 0.10 to ± 0.29
Strong Association	Between ± 0.30 to ± 0.99
Perfect Association	± 1.00

Source: A Brief Guidebook - SPSS eTutor (Britton, 2011)

In the first analytical methodology phase, an output SPSS report table contains the descriptive statistics itself, while Table 5.51 displayed the number of true cases on which the statistics were based. N=0 in data entry meant "no missing data". As a result, each respondent completed the target with N=45 students in the entire.

Table 5.51
Nominal Case Processing Summary for Crosstabs

Case Processing Summary

	Cases					
	Valid		Missing		Total	
	N	Per cent	N	Per cent	N	Per cent
Q3-Geometric to organic * Q5-Product design timeline	45	100.0%	0	0.0%	45	100.0%

Table 5.52
Nominal Crosstabulation for Geometric to Organic and Product Design Timeline

Q3-Geometric to organic * Q5-Product design timeline Crosstabulation

			Q5-Product design timeline		
			Yes	No	Total
Q3-Geometric to organic	Yes	Count	42	1	43
		Expected Count	41.1	1.9	43.0
		% Within Q3-Geometric to organic	97.7%	2.3%	100.0%
	No	Count	1	1	2
		Expected Count	1.9	.1	2.0
		% Within Q3-Geometric to organic	50.0%	50.0%	100.0%
Total		Count	43	2	45
		Expected Count	43.0	2.0	45.0
		% Within Q3-Geometric to organic	95.6%	4.4%	100.0%

The expected frequency value with H0 41.1 has been projected by the nominal association between two variables, as explained in Table 5.52, where the variables were "Q3-Geometric to organic * Q5-Product design timeline." The purpose of this anticipated frequency value was to determine which three types of intuition contributed to the most common answer. To make the study more convenient, the researcher highlighted all tables in grey to make the analytical study easier to grasp for observational purposes.

Table 5.53
Chi-Square Tests for Geometric to organic and Product design timeline

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	10.228[a]	1	.001		
Continuity Correction	2.082	1	.149		
Likelihood Ratio	4.092	1	.043		
Fisher's Exact Test				.088	.088
Linear-by-Linear Association	10.001	1	.002		
N of Valid Cases	45				

a. 3 cells (75.0%) have an expected count of less than 5. The minimum expected count is .09.

b. Computed only for a 2x2 table

The nominal dataset of the chi-square statistic has counted the value of 10.228, as shown in Table 5.53. The following equation has been used to count degrees of freedom (df): df = (r – 1) (c – 1) = (2-1) (2-1) = (1) (1) = 1. The SPSS output comment that read, "2 cells (50.0%) have expected count less than 5," was followed by the Sig. Two-tailed p-value counted with 001, which then explained this alpha value. Since the quantity of the p-value (.001) was less than the alpha value of.05., the chi-square statistic's significant value assumption has been met for the significant value evaluation.

Table 5.54
Symmetric Measures of Chi-Square Tests for Geometric to organic and Product design timeline

Symmetric Measures					
		Value	Asymptotic Standardized Error	Approximate T[b]	Approximate Significance
Nominal by Nominal	Phi	.477			.001
	Cramer's V	.477			.001
Interval by Interval	Pearson's R	.477	.316	3.556	.001[c]
Ordinal by Ordinal	Spearman Correlation	.477	.316	3.556	.001[c]
N of Valid Cases		45			

a. Not assuming the null hypothesis.

b. Using the asymptotic standard error assuming the null hypothesis.

c. Based on normal approximation.

The nominal values were in Table 5.54 were selected using one of three methods for measuring coefficients. The knowledge of the SPSS technique is intended to aid in decision-making through analysis and study; among the three rules of thumb, the opinion approach practice could only be ascertained by one coefficient measurement. So, the chi-square 2 × 2 square tables tradition chooses the Phi value. As a result, a Phi value of **.477** was chosen, and it described the "**positive strong association**" that was related between "Q3-Geometric to organic * Q5-Product design timeline" in this strength of association, with $r = > + 0.30 < + 0.99$. Here, with the recognition of the hypothesis statements were followed:

a) The Nominal Chi-square Test of Independence:
   Is there a valid statistical relationship between "Geometric to organic and Product design timeline"?
b) H0 Statement or Null Hypothesis (**Independent**):
   There was **no association** between Geometric to organic and Product design timelines in the design representativeness of the Malaysian young industrial designers' population.
c) H1 Statement or Alternative Hypothesis (**Dependent**):
   There was **an association** between Geometric to organic and Product design timelines in the design representativeness of the Malaysian young industrial designers' population.

Nominal Scales - Significant Test Result:

The analysis investigation discovered that the value of P(X2> 10.228), **Pearson's *r* Coefficient as .477 (positive strong association)**, together with the quantity of one degree of freedom (df). Then, Sig. Two-tailed numbered 0.001 of p-value accomplished the lower amount, which was smaller than the alpha value rule's 0.05. As a consequence, the analysis study rejected the H0 statement or null hypothesis (independent) because the association was true and occurred in the H1 statement or alternative hypothesis. As an outcome, the association between geometric to organic and product design timelines suggested that the H1 statement (dependant) happened within a representative sample of Malaysia's young industrial designers. As a result, the chi-square testing procedure yields the result **"dependent".**

Table 5.55
Ordinal Case Processing Summary for Crosstabs

Case Processing Summary

	Cases					
	Valid		**Missing**		**Total**	
	N	Per cent	N	Per cent	N	Per cent
Q21-Product form * Q18-Quality of ecodesign identity	45	100.0%	0	0.0%	45	100.0%

Table 5.56
Ordinal Crosstabulation for Product Form and Quality of Ecodesign Identity

Q21-Product form * Q18-Quality of ecodesign identity Crosstabulation

			Q18-Quality of ecodesign identity					
			Extremely disagree	Disagree	Neutral	Agree	Extremely agree	Total
Q21-Product form	Extremely disagree	Count	1	0	0	0	0	1
		Expected Count	.0	.0	.1	.6	.2	1.0
		% Within Q18-Quality of ecodesign identity	100.0%	0.0%	0.0%	0.0%	0.0%	2.2%
	Disagree	Count	0	0	1	0	0	1
		Expected Count	.0	.0	.1	.6	.2	1.0
		% Within Q18-Quality of ecodesign identity	0.0%	0.0%	16.7%	0.0%	0.0%	2.2%
	Neutral	Count	0	0	1	2	0	3
		Expected Count	.1	.1	.4	1.7	.7	3.0

		% Within Q18-Quality of ecodesign identity	0.0%	0.0%	16.7%	7.7%	0.0%	6.7%
	Agree	Count	0	1	3	17	7	28
		Expected Count	.6	.6	3.7	16.2	6.8	28.0
		% Within Q18-Quality of ecodesign identity	0.0%	100.0%	50.0%	65.4%	63.6%	62.2%
	Extremely agree	Count	0	0	1	7	4	12
		Expected Count	.3	.3	1.6	6.9	2.9	12.0
		% Within Q18-Quality of ecodesign identity	0.0%	0.0%	16.7%	26.9%	36.4%	26.7%
Total		Count	1	1	6	26	11	45
		Expected Count	1.0	1.0	6.0	26.0	11.0	45.0
		% Within Q18-Quality of ecodesign identity	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

In the second analytical methodology phase, while the report table includes the descriptive statistics themselves, Table 5.55 showed the number of real cases that the statistics are based on Ordinal Datasets Case Processing. “No missing data” was what N=0 in data entry refers to. As a consequence, every responder finished the target with N=45 students in its entirety.

The ordinal scale association in Table 5.56 showed the fifth cell’s ranking scales for “Q21. Product Form by Q18. Quality of Ecodesign Identity” based on expected frequency values: 16.2 with 65.45%. Based on the most common answer, the analysis study was able to visualize that every subject had an equal chance of answering all surveys within the 5 x 5 contingency tables and that this quantification of sample size had explained all replies. Thus, it contributed to the probability sampling. To prevent bias in data collection, the type of sampling selection was determined by using the ordinal testing method, specifically designed for the square table’s measurement. It also demonstrated the sample size’s representativeness.

Table 5.57
Chi-Square Tests for Product Form and Quality of Ecodesign Identity

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	54.496[a]	16	.000
Likelihood Ratio	17.360	16	.363
Linear-by-Linear Association	11.937	1	.001
N of Valid Cases	45		

a. 22 cells (88.0%) have an expected count of less than 5. The minimum expected count is .02.

Table 5.58
Symmetric Measures of Chi-Square Tests for Product Form and Quality of Ecodesign Identity

Symmetric Measures

	Value	Asymptotic Standardized Error	Approximate T[b]	Approximate Significance
Ordinal by Ordinal Gamma	.494	.195	2.052	.040
Spearman Correlation	.315	.141	2.179	.035[c]
Interval by Interval Pearson's R	.521	.174	4.001	.000[c]
N of Valid Cases	45			

a. Not assuming the null hypothesis.

b. Using the asymptotic standard error assuming the null hypothesis.

c. Based on normal approximation.

A 54.496 chi-square statistical value, as shown in Table 5.67, yielded the equation df= (r – 1) (c – 1) = (5-1) (5-1) = (4) (4) = 16. A two-tailed p-value of.000 for Sig was then obtained, indicating that "25 cells (100.0%) have expected count less than 5." Because of this, the p-value of.001 is less than the alpha value of .05.

The square term's equilibrium (pair observation) was demonstrated and indicated in Table 5.68, which also showed how ordinal values followed one another to create ordinal symmetrical tables. Once more, using Table 5.56 as a guide, the research investigation utilised the Gamma γ Coefficient value, which produced a result of **.494** with a significant level of **.040**. Following the "**positive strong association**" that both variable associations between "Q21. Product Form *Q18. Quality of Ecodesign Identity" had been tied in this strength of association, it then fell between ± 0.30 and ± 0.99. Therefore, the output of ordinal descriptivism described a "positive strong

association" generated from the pair of ranking scales with 5 x 5 contingency tables (exceeding 2 x 2 contingency tables) were needed for the Chi-square Test of Independence. Here, with the recognition of the hypothesis statements following,

a) The Ordinal Chi-square Test of Independence:
   Is there a valid statistical relationship between "Product Form and Quality of Ecodesign Identity"?
b) H0 Statement or Null Hypothesis (**Independent**):
   There was **no association** between Product Form and the Quality of Ecodesign Identity in the design representativeness of the young Malaysian industrial designer population.
c) H1 Statement or Alternative Hypothesis (**Dependent**):
   There is **an association** between Product Form and the Quality of Ecodesign's Identity in the design representativeness of the young Malaysian industrial designer population.

Ordinal Scales - Significant Test Result:

The study's findings indicated that P(X2> 54.496), **Gamma γ Coefficient as .494 (positive strong association)** has 16 degrees of freedom (df). A 0.001 Sig. P-value (weak association) was identified to reject the H0 statement or independent null hypothesis resulting to an alpha value of less than 0.05. As a result, the H1 statement or alternative hypothesis placed beneath the "**dependent**" was accepted as the official result of the chi-square testing procedure.

5.8 Thematic Co-Occurrence Analysis

Thematic co-occurrence analysis (TCA) was an important tool analysis in pragmatic research for ecodesign identity products. It helped to steer the design and development process towards more sustainable and user-centered solutions by illuminating the connections between various themes or concepts. For example, when topics such as "user satisfaction" and "sustainability" co-occur, TCA can show whether environmentally friendly features matched what customers value in a product. This made the product more appealing and sustainable by assisting industrial designers in striking a balance between customer preferences and environmental concerns. Research

studies guaranteed that ecodesign concept strategies were thorough, addressing environmental implications at every stage, from raw material extraction to disposal or recycling, by looking at the co-occurrence of themes throughout a product's full lifecycle. Again, TCA played a crucial role in pragmatic research for ecodesign identity products by helping to comprehend the intricate relationship (cause-effect of predictive relationship model) that exists between sustainability, user needs, and market expectations. It contributed to the development of creative, sustainable goods by informing design strategies, optimising lifecycle analysis, and improving decision-making processes. This technique helped to ensure that ecodesign goods were not only ecologically friendly but also commercially feasible and marketable.

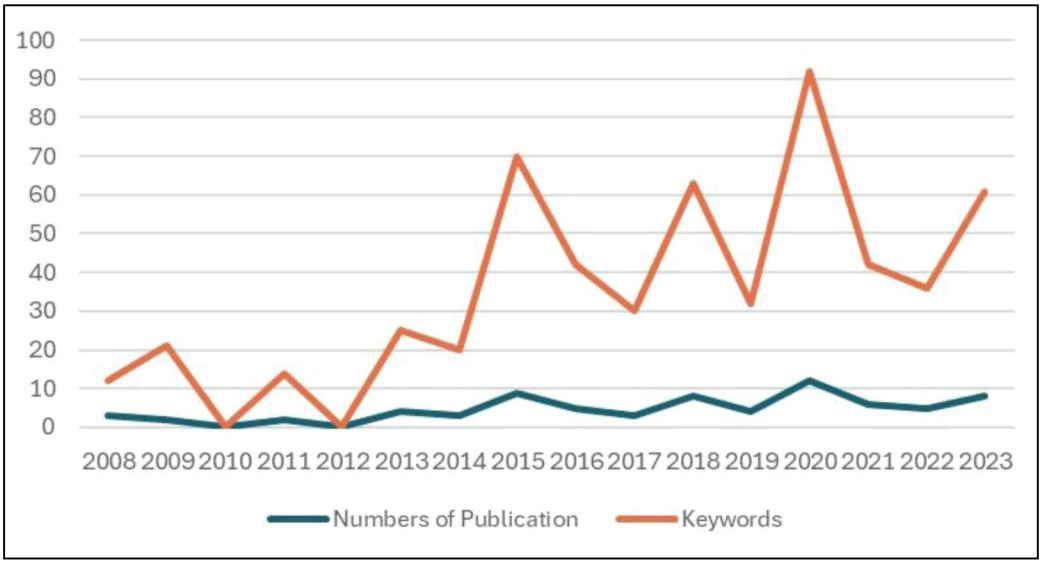


Figure 5.57 Publications and Keywords Performance Chart

Therefore, coding keywords in TCA involved a systematic process to identify, categorise, and analyse the relationships between themes and coding within a qualitative dataset in the cause-effect of predictive relationship model. In Figure 5.57, the chart titled "Publications and Keywords Performance Chart" visually represented the number of publications and associated keywords over a period from 2008 to 2023. For the blue line (Numbers of Publication), this line showed the number of publications each year. The line remained relatively flat, indicating a low and steady number of publications throughout the period, with slight increased in certain years. The number of publications remained consistently low, with only slight increased observed in certain years, such as

around 2014 and 2019. So, the number of publications has remained consistently low, with only slight increases observed in certain years, such as around 2014 and 2019.

Meanwhile, the orange line (keywords) refered to the line representing the number of keywords used in the publications each year. It fluctuated significantly, showing spikes and drops across the years. There was a significant fluctuation in the number of keywords used. The number of keywords spiked sharply in 2015 and 2020, indicating periods of a high concentration of diverse topics or themes within the publications. Next, there were noticeable drops in the number of keywords following the peaks, such as in 2016 and 2021.

Table 5.59
Publications and Keywords Performance Chart

Year(s)	Numbers of Publication	Keywords
2008	3	12
2009	2	21
2010	0	0
2011	2	14
2012	0	0
2013	4	25
2014	3	20
2015	9	70
2016	5	42
2017	3	30
2018	8	63
2019	4	32
2020	12	92
2021	6	42
2022	5	36
2023	8	61
Total	74	560

Further, the cumulative performance explanation is as follows:

a) *Keywords Growth* − The overall performance of keywords showed a trend of increasing diversity or complexity in the topics covered by the publications. Despite the fluctuations, there was a general upward trend in the number of keywords, suggesting that more themes were explored or publications that

became more detailed over time.

b) *Publication Stability* − The number of publications remained low and steady. This suggested that while the quantity of publications did not increase significantly, the diversity of topics within those publications has expanded, as indicated by the rising number of keywords.

c) *Peaks and Drops* − The peaks in keyword performance (e.g., 2015 and 2020) indicate years where there was a significant focus on emerging or diverse topics within the field, potentially driven by new research trends or external factors influencing the subject matter of the publications. Overall, the chart indicated that while the field may not have seen a dramatic increase in the number of publications, there has been a substantial increase in the diversity or focus areas within those publications over the years.

Further, the critical literature review (CLR) approach of methodological review was used to identify the total number of publications, which the research study was addressed in Table XO. Once more, it was noted in the previous chapter that it was related to CLR, which should involve a thorough analysis and evaluation of the body of existing literature (a grounded theory heuristically), frequently with a particular theoretical or methodological focus. That meant assessing the calibre of the research, looking into underlying presumptions, and questioning conventional wisdom. Since it could be realistically engaged with the contextual of conceptual framework in Chapter 3 and 4 consistently, the research study identified to position a cause-effect named similarly same such as "designing-output." Labeling was done is to clarify the relationship between the methodological assumption that it sought to address the availability source abstraction (synthesising articles of literature review) and real-world phenomena where reality engaged from the chronological order essentially. The outcomes of the research study's use of explanatory approaches to find the findings will be triangulated to answer the research questions.

However, to cover an acceptable application of TCA's data analysis, the procedural analysis framing is necessary. The research study wisely focused on the CLR process of methodological review using the hypothetical form after the identification → screening → eligibility → inclusion as the main direction of the structural TCA method because the CLR approach was chosen to analyse the qualitative datasets orientated by grounded theory study. The research study examined all 74 publications

from the article databases maintained by the Universiti Teknologi MARA (UiTM) College of Creative Arts (CCA) and Formgiving Design Research Group (FDRG) in Table 5.59 and Table 5.60. FDRG-CCA intends to guarantee that the industrial design research discipline, which concentrates on artifacts and/or product systems in the industrial design area holistically, is orientated towards similar domains and concepts to Design Society United Kingdom (DSUK). The DSUK may have a great deal of experience and credibility in the field of design education.

Once more, the TCA abstraction showed the notable publications that it thoroughly discussed and linked to the open-cycle coding process study topic. By applying the labeling of the designing-output (cause-effect) method, the levelling process of the methodological review could be systematically focused. It is important to remember that the tabulation table still contains the methodological explanations. In actuality, the research study continued to employ the non-linear procedure for the qualitative CLR research, with the tabulation table referring to the context of the iterative process (Williams and Moser, 2019). Next, the 3T's Coding Scheme Strategy within the TCC and TCA employed the axial cycle coding procedure to determine the number of co-occurrence keywords that were intended to be aligned with theme clustering methodologies.

Finally, the decrease in the quantity of co-occurring keywords needed to specify the precise response to research questions from the iteration of the selected cycle coding scheme. The pattern and classification of the design representation was based on the predicted findings. As a result, the study's final report illustrated using the thematic cluster pattern of (1) tree map and (2) Sankey chart. The complete data analysis expectation was simulated by these visualising functions, which served as proof for the cause-and-effect forecast of the predictive connection model.

Table 5.60
Abstraction of Thematic Co-occurrence Analysis (TCA)

ID# No.	Years	Title(s)	Keyword(s)	Legends	Index	Abstraction of TCA					
						*DESIGNING (Process)			*OUTPUT		
						Design	Protocol	Metaphor	Form	Product	Identity
1.	2008	The "Old Masters" Of Engineering Design and The Modern Form Development Process of Automobiles	Aesthetics, engineering design, form development	/	Scopus	✓	-	-	✓	-	-
2.	2008	On The Role of Formgiving in Design	Aesthetics, design, formgiving, shaping	/	Scopus	✓	-	-	✓	-	-
3.	2008	The Embodied Mind in Relation to Thinking About Form Development	Form, tactility, thinking		Scopus	-	-	-	-	-	-
4.	2009	Designers' Perceptions of Typical Characteristics of Form Treatment in Automobile Styling	Automobile styling, car components, designer perceptions, form elements, form features	/ (=)	Scopus	✓	-	-	✓	-	-
5.	2009	Thinking And Re-Thinking Verbal Protocol Analysis in Design Research	Appropriateness, cognition, ethics, meta- verbal protocol analysis, methodology, verbal protocol analysis		Scopus	-	✓	-	-	-	
6.	2011	The Significance of Form Elements: A Study of Representational Content of Design Sketches	Aesthetics, categorization, form, perception, visual		Scopus	-	-	-	✓	-	-

ID# No.	Years	Title(s)	Keyword(s)	Legends	Index	Abstraction of TCA					
						*DESIGNING (Process)			*OUTPUT		
						Design	Protocol	Metaphor	Form	Product	Identity
7.	2011	Understanding Styling Activity of AutomotiveDesigners: A Study of Manual Interpolative Morphing Through Freehand Sketching	Automotive design, form composition, morphing techniques, perception, styling process	/	Scopus	✓	-	-	✓	-	-
8.	2013	Unconscious Human Behavior at VisceralLevel of Emotional Design	Unconscious human behaviour, behavioural science, emotional design, visceral level		Scopus	✓	-	-	-	-	-
9.	2013	Upcycling: Re-Use and Recreate Functional Interior Space Using Waste Materials	Interior space, upcycling, waste materials		Scopus	-	-	-	-	-	-
10.	2013	The Interaction of Product Noise and Form Design in Evoking Users' Responses	Noisy product, product form, users' responses		Scopus	-	-	-	✓	✓	-
11.	2013	The Characteristics of Form in Relation to Product Emotion	Design, emotion, form, product characteristics		Scopus	-	-	-	✓	✓	-
12.	2014	The Challenges of Developing Styling DNA	Algorithmic, car design, design methodologies,		Scopus	✓	-	-	-	-	-

ID# No.	Years	Title(s)	Keyword(s)	Legends	Index	Abstraction of TCA					
						*DESIGNING (Process)			*OUTPUT		
						Design	Protocol	Metaphor	Form	Product	Identity
		Design Methodologies for Car Design	manual, styling dna								
13.	2014	The Value of Unconscious Human Behavior in Product Design Innovation	Design thinking, product design, unconscious human behaviour		Scopus	✓	-	-	-	✓	-
14.	2014	The Environmental-Driven Elements Towards Ecological Systems of Furniture Design	Design, ecological, economics, standard, technology		Scopus	-	-	-	-	-	-
15.	2015	Function Means Analysis for Ablution Concept Solution	Design, practice, principle-solution, product design		Scopus	✓	-	-	-	✓	-
16.	2015	A Practical Guideline to Quantifying Qualitative Analyses of Design Cognition	Design research methodology, empirical, think-aloud, verbal protocol analysis		Scopus	-	✓	-	-	-	-
17.	2015	Work In Progress: Mapping the Development of Quality Sensuous Response Through Blind and Visually Impaired Group (BVIG) Touch Interaction	Component, formatting, insert, style, styling		Scopus	-	-	-	✓	-	-
18.	2015	On The Role of Police Car Graphic Stripe in Design	Brand image and identity, graphic stripe design, police car, public perception, semantic		Scopus	✓	-	-	-	-	✓

ID# No.	Years	Title(s)	Keyword(s)	Legends	Index	Abstraction of TCA					
						*DESIGNING (Process)			*OUTPUT		
						Design	Protocol	Metaphor	Form	Product	Identity
19.	2015	Understanding Methodological Solution in Design Situation of Novice Designer	Design issues, design experience, design strategies, principle-solution		Scopus	✓	-	-	-	-	-
20.	2015	Theoretical Framework for Ceramic Design Studies Facing Advanced Mathematical Educational Research	Design challenge, design thinking, industrial ceramic, mathematical principle		Scopus	✓	-	-	-	-	-
21.	2015	Theoretical Framework for Ceramic Design Studies Facing Advanced Mathematical Educational Research	Design challenge, design thinking, industrial ceramic, mathematical principle		Scopus	✓	-	-	-	-	-
22.	2015	A Pattern in Formgiving Design: Giving Priority to A Principal Solution in Industrial Design Situation	Abulation tub, aesthetic, ceramic, formgiving, pattern		Scopus	-	-	-	✓	-	-
23.	2015	Unconscious Interaction Between Human Cognition and Behaviour in Everyday Product: A Study of Product Form Entities Through Freehand Sketching Using Design Syntactic Analysis	Design syntactic analysis, interaction in design, methodology, product design, unconscious human behaviour		Scopus	✓	-	-	-	✓	-
24.	2015	Role Of DNA Styling: The Creation of Local Brand Identity Recognition Framework	Design research methodology, brand identity, design levels		Scopus	✓	-	-	-	-	✓
25.	2016	Malaysian Product Design Identity:	Agreement, culture and heritage, ethic, identity,	/	Scopus	✓	-	-	-	✓	✓

ID# No.	Years	Title(s)	Keyword(s)	Legends	Index	Abstraction of TCA					
						*DESIGNING (Process)			*OUTPUT		
						Design	Protocol	Metaphor	Form	Product	Identity
		Issues, Transformation, And Challenges	product design								
26.	2016	A Framework of Empirical Study Through Design Practice for Industrial Ceramic Sanitary Ware Design	Ceramic sanitary ware design, design practice, formgiving, verbal protocol analysis		Scopus	✓	✓	-	✓	-	-
27.	2016	In-Vitro Design Protocol: Artificial Situation Strategy Uses to Comprehend Designers' Thought	Aesthetic, design activities, in-vitro design protocol (ivdp)	/	Scopus	✓	✓	-		-	-
28.	2016	The Concept of Formgiving for Color and Trim in Car Design	Car design, color and trim, formgiving		Scopus	✓	-	-	✓	-	-
29.	2016	Practice-Based Design Metaphor in Design Problem-Solving: Cultural Implication for Form Development	Cultural identity, design metaphor elements, product design development, verbal protocol analysis		Scopus	✓	✓	✓	-	✓	✓
30.	2017	Verbal Protocol Analysis Strategy for Product Design Cognition: Preliminary Study on Metaphorical Form Element	Cognitive dimension, metaphor abstraction, metaphorical elements, verbal protocol stategy		Scopus	-	✓	✓	-	-	-
31.	2017	Designer Activity Experience: Blind User-Designer Activity Model in Knowing Product Influence Through	Blind user, design association, design audit, design experience, design factors,		Scopus	✓	-	-	-	-	-

ID# No.	Years	Title(s)	Keyword(s)	Legends	Index	Abstraction of TCA					
						*DESIGNING (Process)			*OUTPUT		
						Design	Protocol	Metaphor	Form	Product	Identity
		Blind User Perspective	designer								
32.	2018	Blind User Experience Audit: Revealing Underlying Invisible Factors in Design Experience	Blind user, contextual, design audit, design experience, design factors, protocol analysis		Scopus	✓	✓	-	-	-	-
33.	2018	Elderly Usability Interaction Design Model for Home Appliances: Theoretical Framework	Elderly, interaction design model, product interface, usability		Scopus	✓	-	-	-	✓	-
34.	2018	Design Elements: The Interaction of Elderly People on Product Interfaces	Elderly, interaction, product interface		Scopus	-	-	-	-	✓	-
35.	2018	Service Design: Issues and Opportunities	Business model, ecosystem innovation, entrepreneurship, myra score, service design		Scopus	✓	-	-	-	-	-
36.	2018	Islamic Art Element in Modern Furniture Design Based on Three Types of Design Thinking Approaches	Furniture design, hermeneutic, Islamic art element, normative, reflective		Scopus	✓	-	-	-	-	-
37.	2018	Historical Analysis on Product Form Structure Establishment in Malaysian Industrial Design Practices	Design heritage, design practice, design timeline, visual form characteristic	/	Scopus	✓	-	-	✓	-	-
38.	2018	Escalating Product Identity Through Emphasizing Metaphorical Form	Design metaphor, form elements, metaphor mapping,		Scopus	-	-	✓	✓	✓	-

ID# No.	Years	Title(s)	Keyword(s)	Legends	Index	Abstraction of TCA					
						*DESIGNING (Process)			*OUTPUT		
						Design	Protocol	Metaphor	Form	Product	Identity
		Element Principles	product metaphor								
39.	2018	The Investigation of Designers' Reflective Practice Activity Using Verbal Protocol Analysis	Product design, reflective practice, verbal protocol analysis		Scopus	✓	✓	-	-		-
40.	2019	Assessing Designers' Perception, Analysis, And Reflective Using Verbal Protocol Analysis	Methodology, product design, verbal protocol analysis	/	Scopus	✓	✓	-	-	✓	-
41.	2019	A Preliminary Study on Identifying the Potential Core Values for Product Branding Based on Malaysian Keris Characteristics	Dna, formgiving, Malaysian keris, nostalgic sentimental values, visual branding characteristic		Scopus	-	-	-	✓	-	-
42.	2019	Assessing The Attributes of Unconscious Interaction Between Human Cognition and Behavior in Everyday Product Using Image-Based Research Analysis	Image-based research analysis, methodology, product design		Scopus	✓	-	-	-	✓	-
43.	2019	The Design, Development and Evaluation of TPSACK Courseware to Facilitate the Art and Design Education Students Artistic Skills Knowledge	Artistic skills, development, dick and carey model, tpsack courseware 70		Scopus	-	-	-	-	-	-
44.	2020	Knowledge, Attitude, And Practice of Malaysian Residence Toward Prevalent Of COVID-19 Pandemic in The Early	Attitude, covid-19, knowledge, Malaysia, practice		Scopus	-	-	-	-	-	-

ID# No.	Years	Title(s)	Keyword(s)	Legends	Index	Abstraction of TCA					
						*DESIGNING (Process)			*OUTPUT		
						Design	Protocol	Metaphor	Form	Product	Identity
		Period of Outbreak: A Cross-Sectional Study									
45.	2020	The Influence of Reference Material for Sketching Strategies and Form Establishment at The Embodiment Design Level	Design elements, design thinking process, form embodiment, interaction	/ (=)	WoS	✓	-	-	✓	-	-
46.	2020	Design Focus Group as A Controlled-Experiment Setting	Controlled experiment, design intuition, design research, focus group study		WoS	✓	-	-	-	-	-
47.	2020	3R Evokes Ecodesign Identity in Ecological System of Green Manufacturing	Design methodology, ecodesign, industrial design, industry 40, innovation		Scopus	✓	-	-	-	-	-
48.	2020	The Presence of Fibonacci Sequence in Malaysia Keris Design Related to Elements of Art and Principles of Design	Elements of art, fibonacci sequence, keris, principles of design		WoS	✓	-	-	-	-	-
49.	2020	The TPSACK Framework Implementation in Measuring the Technological, Pedagogical, Skills and Content Knowledge by Using Courseware	Tpack framework, tpsack framework, artistic skills		WoS	-	-	-	-	-	-
50.	2020	Pre-Post Observation Research Fosters a Preliminary Study in Product Form	Design education, ethics, form, preliminary study,		WoS	-	✓	-	✓	-	-

ID# No.	Years	Title(s)	Keyword(s)	Legends	Index	Abstraction of TCA					
						*DESIGNING (Process)			*OUTPUT		
						Design	Protocol	Metaphor	Form	Product	Identity
		Identity	verbal protocol analysis								
51.	2020	Making 4.0: Developing an Official Master Degree for Adapting the Curricula of Future Workers and Managers of Wood and Furniture Sector to The Skills Required by The Industry 4.0	Eu project, he, icts, industry 40, master, furniture, wood		WoS	-	-	-	-	-	-
52.	2020	Assessing The Awareness and Readiness of The Malaysian Furniture Industry for Industry 4.0	Automation; furniture; industry 4.0; cost benefit; productivity		Scopus	-	-	-	-	✓	-
53.	2020	Value In Exchange: The Importance of User Interaction as The Center of User Experiences	Co-creation method, co-creation, co-creation framework, co-production		Scopus	-	-	-	-	✓	-
54.	2020	Extrapolative Morph Design Thinking as An Intangible Ecological Form to Encode the Ecodesign Identity	Form, heuristic method, industrial design, intangible ecological form	/	WoS	✓	-	-	✓	-	-
55.	2020	The Challenges of Developing a Validation Protocol for The New Curriculum of Making 4.0: Between Malaysian and European Education Systems	Education systems, industry40, making40, new curriculum, validation protocol		ERA	-	✓	-	-	-	-
56.	2021	Data Collection Instrument in Designerly	Design thinking, designerly, intuition, research		WoS	✓	-	-	-	-	-

ID# No.	Years	Title(s)	Keyword(s)	Legends	Index	Abstraction of TCA					
						*DESIGNING (Process)			*OUTPUT		
						Design	Protocol	Metaphor	Form	Product	Identity
		Intuition Study	instrumentation								
57.	2021	Ways And Challenges of Product Labelling for The Visually Impaired	Braille, labelling tool., tactile, visually impaired		WoS	-	-	-	-	-	-
58.	2021	Analysing The Malaysian Higher Education Training Offer for Furniture Design and Woodworking Industry 4.0 As an Input Towards Joint Curriculum Validation Protocol	Industry 4.0, joint curriculum, malaysian higher education, validation, wood and furniture		Scopus	-	-	-	-	-	-
59.	2021	International Virtual Colloquium on Multi-Disciplinary Research Impact (2 Nd Series) Design Thinking in Learning and Innovation Towards Design Process in IR 4.0	Design thinking, industrial revolution, learning		WoS	-	-	-	-	-	-
60.	2021	Cognitive Ergonomics of Formgiving as Unstructured Approaches in Furniture Design Practice	Cognitive ergonomics, formgiving, furniture design, visual protocol	/	WoS	✓	✓	-	✓	-	-
61.	2021	A Case for Intuition-Driven Design Expertise	Design decision making, design expertise, design intuition		Scopus	✓	-	-	-	-	-
62.	2022	Design And Synthesis of A 3D Graphene-Enhanced Electrode for Fast	3d graphene-enhanced electrode, design, hierarchical,		Scopus	✓	-	-	-	-	-

ID# No.	Years	Title(s)	Keyword(s)	Legends	Index	Abstraction of TCA					
						*DESIGNING (Process)			*OUTPUT		
						Design	Protocol	Metaphor	Form	Product	Identity
		Charge/Ion Transport for Lithium Storage	synthesis								
63.	2022	Bioactivity And Pharmacological Potential of Date Palm (Phoenix Dactylifera L.) Against Pandemic COVID-19: A Comprehensive Review	Bioactivity, covid-19, coronavirus, date palm, nutraceutical, phoenix dactylifera, sars-cov-2		Scopus	-	-	-	-	-	-
64.	2022	Sustainability Of Malay Traditional Silverware in The East Coast Region of Malaysia	Malay traditional craft, silverware, sustainability		WoS	-	-	-	-	-	-
65.	2022	The Value of Unintended Human Behaviour in Everyday Product Design	Unintended human behaviour, everyday product, interaction design, user experience		Scopus	✓	-	-	-	✓	-
66.	2022	Knowledge, Attitute and Practices (KAP) Theory Towards Preventive Measures Among Malaysians in Early Outbreak of Covid-19	Attitude, awareness, covid-19, knowledge, practice, preventive measures		Scopus	-	-	-	-	-	-
67.	2023	Artistic Characteristics of Moire in Qin Ind Han Tiles: A Review	Artistic, characteristics of moire, design, literature review, tiles		Scopus	✓	-	-	-	-	-
68.	2023	How Can Virtual Simulation Be Used in Ceramic Product Design Classes in The	Ceramics design, fujian ancient house, virtual		Scopus	✓	-	-	-	-	-

ID# No.	Years	Title(s)	Keyword(s)	Legends	Index	Abstraction of TCA					
						*DESIGNING (Process)			*OUTPUT		
						Design	Protocol	Metaphor	Form	Product	Identity
		Republic of China									
69.	2023	Research On the Dissemination and Application of Computer 3D Technology in The Process of Intangible Cultural Heritage Display	Intangible cultural heritage, computer 3d technology, culture art, display dissemination		Scopus	-	-	-	-	-	-
70.	2023	Understanding Online-Merge-Offline Teaching Mode Based on Metaverse	Metaverse, online-merge-offline, teaching model		Scopus	-	-	-	-	-	-
71.	2023	Analysis Of the Application of Synaesthesia Concept in Modern Product Design	Communication, emotional design, multisensory product experience		Scopus	✓	-	-	-	✓	-
72.	2023	Design Of an Interactive Educational Information System Based on The SECI Model	Informatization, interactive education, seci model, system design	/	Scopus	✓	-	-	✓	-	-
73.	2023	Understanding Interface Design of Health Apps for The Elderly Based on User Experience	Health app, interface design, senior citizen, user experience		Scopus	✓	-	-	-	-	-
74.	2023	Recent Advances, Challenges, Opportunities, Product Development and Sustainability of Main Agricultural Wastes for The Aquaculture Feed Industry - A Review	Animal-based protein, aquaculture feed, environmental stress, immunostimulator, plant-based protein, protein		Scopus	-	-	-	-	-	-

ID# No.	Years	Title(s)	Keyword(s)	Legends	Index	Abstraction of TCA					
						*DESIGNING (Process)			*OUTPUT		
						Design	Protocol	Metaphor	Form	Product	Identity
			replacement, sustainability								
		Abstraction Numbers of Keywords in Publication				43	12	3	19	16	4
		Total Numbers of Co-occurrences Keywords Counted				59	13	6	20	17	4
		Percentage of Co-occurrences Keywords Counted (%)				75%	17%	8%	49%	41%	10%

*Note:
The conceptual framework oriented by cause-effect of predictive relationship model: Chapter 3, Phase 3 - Conceptual framework through the "Support" and "Evaluation" for the DRM framework outcome using a comprehensive study following the interpretation provided:

i) DESIGNING: Refers to the term "process," which is assessed by the VPA study's observation of the grounded task, which is the essence of behaviour. – evaluating the themes of design → design representation.

ii) OUTPUT: Measurement of "output" performance will be carried out via statistical descriptive research in order to interpret the foundational research's validity and dependability – defines to address / categorize the operational of uncontrolled variables → correlate the variables consistency.

Legends:

a) CLR process of methodological review (refer to Chapter 4 –page xx):

Screening Stage: 16 Numbers of Excluded Publication.

/ Eligibility Stage: 12 Numbers of Availability Publication

b) Overview of coding process (refer to Chapter 4 –page xx)

(=) Selective Coding Process: two resource abstractions were identified. Refer to further TCA method.

Figure 5.58 showed a bar chart that illustrated the abstraction numbers of keywords in publications that the articles tallied according to the matching keywords' availability throughout the research study's conceptual framework. Two bars, designated as Series 1 (solid grey, indicating article numbers) and Series 2 (dotted pattern, indicating percentages achieved), corresponded to each term counted. Hence, out of the 74 total articles, 97 keywords were found, and during the screening stage, the pertinent information was processed in relation to the particular "designing" and "output" codes of the prescriptive conceptual framework (cause-effect of predictive relationship model) in the articles' research study requirements. The bar chart's level for the marked "designing" was (1) Design: 74.1% (n = 43), (2) Protocol: 20.7% (n = 12), and (3) Metaphor: 5.2% (n = 3). Nevertheless, the "output" label was referenced by three additional codes: (1) Form: 48.7% (n = 19), (2) Product: 41.0% (n = 16), and (3) Identity: 10.3% (n = 4). The existent source literature assessment, which confirmed that the theme study's synthesising data were legitimate and readily available, was greatly impacted by the frequent keyword counts. It was apparent that the grounded theory investigation needed the datasets that were obtained from the literature review.

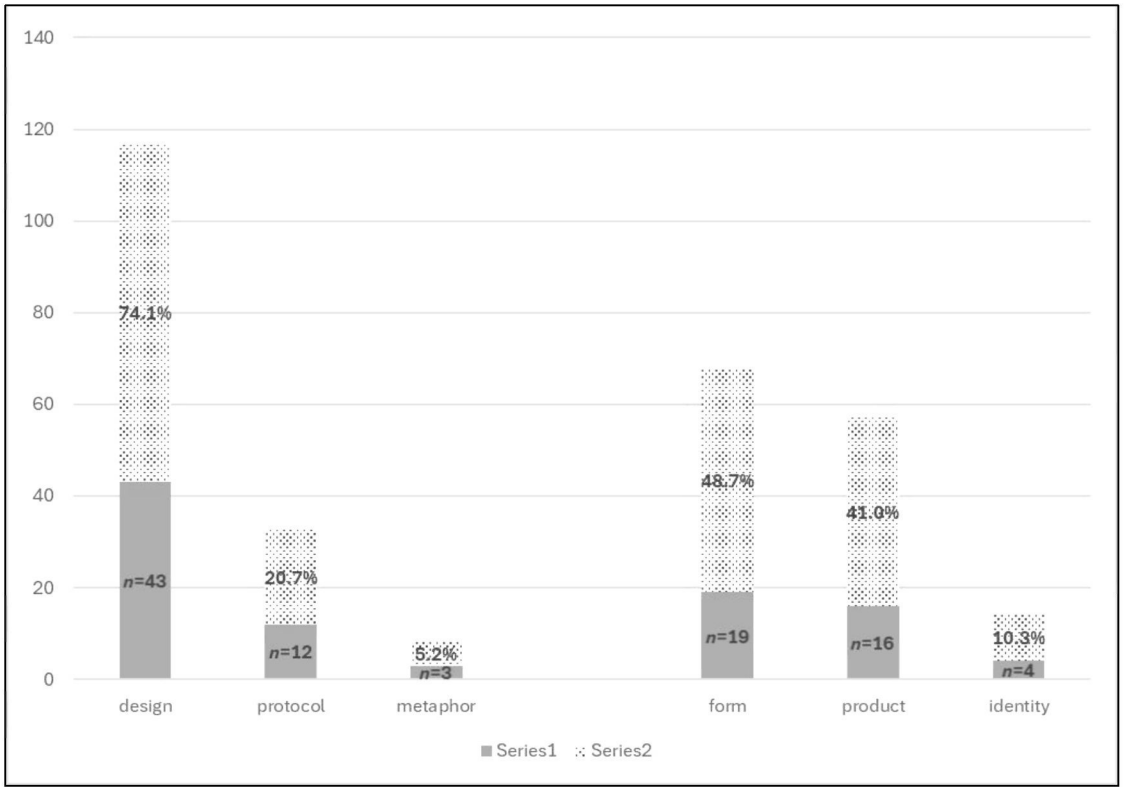


Figure 5.58 Abstraction Numbers of Keywords in Publications

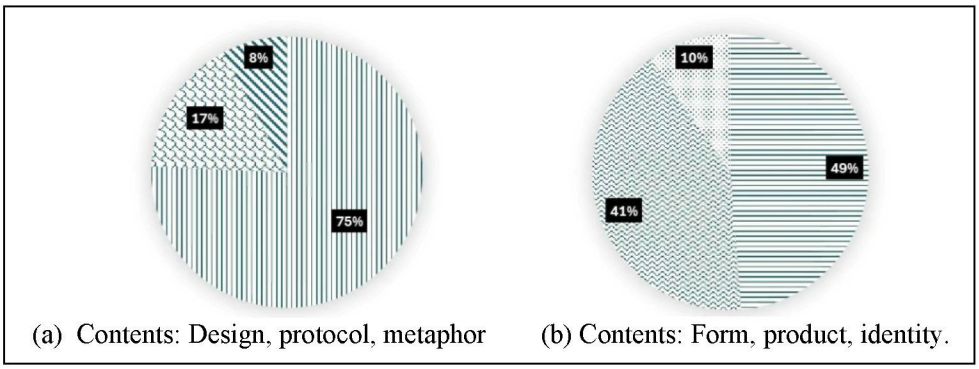


Figure 5.59 Percentage of Co-occurrences Keywords Counted: (a) Designing and (b) Output

The pie chart presented in Figure 5.59 displayed the percentage of co-occurrences keywords. The distribution of the pie chart indicated a predominance or focus on the variable or factor represented by the 75% segment, with the remaining two categories comprising a smaller portion of the dataset in the TCA method abstraction. First, the largest component was referred to as the "75% segment of design" and was represented by vertical stripes in the "Designing" contents. The dominance over the pie chart showed that this category had the highest percentage or frequency in the data. Second, a denser diagonal striped pattern was used in the 17% protocol segment to indicate that it is a lesser but yet substantial portion of the section when compared to the 75% segment. Third, among the categories given, the 8% metaphor segment, the smallest slice denoted by a lighter diagonal stripe pattern, shows the lowest share. The analysis followed in the "Output" contents, where the pie chart indicated that the distribution of the top two categories is more balanced than that of the third, which was significantly smaller. These charts were useful for displaying the relative importance or incidence of each category and comparing various outputs or components within a dataset. Despite not being a majority, the fourth and largest segment in the chart was the 49% segment of the form, indicated by vertical stripes. It demonstrated that while this category is the most common, it did not entirely control the dataset. In terms of share, the fifth product group, which accounts for 41% of the total, indicated that a considerable amount of it uses a tightly packed zigzag pattern. This indicated that it was almost as common as the 49% category. Finally, the lowest portion of the pie chart represented the 10% identity segment, represented by a dotted pattern, and suggested that this category was the least common in the data.

Table 5.61
The Key Groups Analysis for Open Cycle Codes

Item#	Scope Analysis	Abstraction Contents				Memoing 1 (Thematic Area)
		Designing Phase	Occurrences	Output Phase	Occurrences	
1	ID01	n/a	0	n/a	0	n/a
		n/a	0	n/a	0	
2	ID02	design	7	form	10	1) Pattern of Tangible
		solution	1	aesthetics	2	2) Pattern of Intangible
3	ID04	design	7	form	8	1) Extrapolative thinking
		morphing	1	element	4	2) Interpolative thinking
4	ID07	process	5	morphing	9	1) Extrapolative thinking
		sketch	4	characteristic	2	2) Interpolative thinking
5	ID25	design	14	product	4	1) Pattern of Tangible
		practice	3	artificial	1	2) Pattern of Intangible
6	ID27	design	7	form	3	1) Experience
		method	1	aesthetics	1	2) Knowledge
7	ID37	design	6	form	7	1) Experience
		identify	2	artefact	3	2) Knowledge
8	ID40	design	4	product	2	1) Experience
		interact	4	behavior	4	2) Knowledge
9	ID45	design	8	form	1	1) Pattern of Tangible
		interact	2	pattern	1	2) Pattern of Intangible
10	ID54	design	6	form	5	1) Pattern of Tangible
		digitize	3	image	2	2) Pattern of Intangible
11	ID60	design	7	form	5	1) Experience
		method	2	visual	3	2) Knowledge
12	ID70	teaching	7	form	6	1) Pattern of Tangible
		interact	2	model	2	2) Pattern of Intangible

In Table 5.61, TCA employed the key groups analysis for open cycle codes from the eligibility stage, which was referred to as the 12 numbers of availability publication. Next, the cause-effect selecting keywords were found using the following categories: (1) design (designing) categorised by cause; and (2) form fallen by an effect category, resulting in a shortlist of all 12 publications' articles that was thoroughly covered by the abstract contents. The precise co-occurrences that may be adopted and/or aligned with the predictive connection model were specifically screened when choosing the abstraction content. Appropriate for utilising open cycle coding in conjunction with the abstract contents of papers published, Memoing 1 aided in the interpretation of the coding scheme by particularly classifying co-occurrence keywords. The name and/or labeling categorisation by Memoing 1 was necessary to address the proper coding as

one of the main findings of the study. Therefore, in the following summary, the important essence of behaviour in the context of designerly method thinking was identified.

Table 5.62
Summary for The Key Groups of Open Cycle Coding for Thematic Clustering Context

Scope Analysis	Abstraction Contents			
	Theme of Designing Phase	Occurrences	Theme of Output Phase	Occurrences
Group 1	design	66	form	45
	interact	6	element	4
	behavior	4	aesthetic	3
	practice	3	artefact	3
	method	3	visual	3
	digitize	3	model	2
	identify	2	image	2
	solution	1	pattern	1
	morphing	1		
Group 2	teaching	7	morphing	9
	interact	2	characteristic	2
Group 3	process	5	product	6
	sketch	4	behavior	4
			artificial	1

The important groups of open cycle coding summary for the context of theme clustering have been determined as Table 5.62. Three sets of scope analysis showed that the coding method has systematically classified and established newly coded taxonomy tabulations. Following the overview of the coding process (open, axial, and selective cycle coding), a reduction of codes is then necessary. Hence, the conclusion contents of the axial cycle coding was approached by triangulating datasets from which the key findings of the axial coding for thematic clustering context are specifically derived. Simultaneously, Memoring 2 considerably approached a further essence of behaviour that could help evaluate and analyse datasets to address the study concerned. The CLR iteration approach facilitated a difficult dissertation writing in the publications picked for the articles since the co-occurrence keywords of Memoing 1 and 2 were consistent.

Table 5.63
The Key Findings Analysis for Axial Cycle Codes

Item#	Scope Analysis	Conclusion Contents				Memoing 2 (Thematic Area)
		Designing Phase	Occurrences	Output Phase	Occurrences	
1	ID01	design	4	form	3	1) Pattern of Tangible
		structure	4	aesthetic	1	2) Pattern of Intangible
2	ID02	phase	5	form	10	1) Pattern of Tangible
		structure	2	aesthetic	2	2) Pattern of Intangible
3	ID04	design	5	form	1	1) Pattern of Tangible
		visualize	2	characteristic	3	2) Pattern of Intangible
4	ID07	sketch	2	form	9	1) Extrapolative thinking
		characteristic	2	theme	2	2) Interpolative thinking
5	ID25	design	13	product	3	1) Pattern of Tangible
		method	5	artificial	2	2) Pattern of Intangible
6	ID27	process	2	form	3	1) Experience
		study	5	emotion	2	2) Knowledge
7	ID37	n/a	0	n/a	0	n/a
		n/a	0	n/a	0	
8	ID40	design	7	product	2	1) Experience
		attributes	2	idea	2	2) Knowledge
9	ID45	design	5	form	5	1) Experience
		function	2	quality	1	2) Knowledge
10	ID54	design	21	metaphor	3	1) Extrapolative thinking
		function	2	identity	4	2) Interpolative thinking
11	ID60	plan	7	form	3	1) Experience
		perform	2	shape	1	2) Knowledge
12	ID70	manage	6	module	8	1) Pattern of Tangible
		learning	4	system	3	2) Pattern of Intangible

The conclusion began by outlining the selective coding procedure, which emphasized the most salient themes or categories discovered during axial coding and analyzed their interconnections. Examining these core themes in greater detail and coming up with solutions that have implications for the research questions and goals is the insight phase as Table 5.63. This explanation of the selected cycle coding study was covered in the previous Chapter 4. Thus, the comprehension of research information into a formal data analysis method of qualitative research that approached the phases of abstraction and interpretation was trustworthy and reliable (Chai et al., 2021). The research study might have served to select or narrow down the interpretation that was ultimately employed. In the part that follows, Taylor and Francis (2024) defined interpretation as follows: "...your conclusion should be an interpretation of your results,

where you summarise all of the concepts that you introduced in the main body of the text in order of most to least important. This section shouldn't introduce any new ideas." To guarantee that conclusions were reached using solid reasoning, logical thought is therefore necessary. By ensuring that the conclusions flow naturally from the evidence, it guards against data misinterpretation such as Table 5.74. It's crucial to assess if the results support the ideas that already existed or if new ones need to be developed. Bias and incorrect presumptions can be avoided with the aid of logic.

Table 5.64
Summary for The Key Findings of Axial Coding for Thematic Clustering Context

Scope Analysis	**Conclusion Contents**			
	Theme of Designing Phase	Occurrences	Theme of Output Phase	Occurrences
Level 1	design	55	Form	31
	method	5	aesthetic	3
	function	4	characteristic	3
	structure	4	theme	2
	visualize	2	emotion	2
	attributes	2	quality	1
			shape	1
Level 2	plan	7	Product	5
	perform	2	artificial	2
			idea	2
Level 3	manage	6	Module	8
	learning	4	system	3
Level 4	phase	5	Metaphor	3
	structure	2	identity	4
Level 5	process	2	n/a	-
	study	5	n/a	-
Level 6	sketch	2	n/a	-
	characteristic	2	n/a	-

Selective cycle coding and the contextual application of thematic clustering were related procedures in qualitative data analysis, particularly in grounded theory, thematic analysis, and related methodologies. The research study refined initial codes into more conceptual and detailed categories when topic clusters were created. This data refinement offered an easy-to-read map in Table 5.65.

Table 5.65
The Key Findings Shortlisted Using The Selective Cycle Coding Mapping

Item#	Scope Analysis	Abstraction Contents				Memoing 1 (Thematic Area)	Conclusion Contents				Memoring 2 (Thematic Area)
		Designing Phase	Occurrences	Output Phase	Occurrences		Designing Phase	Occurrences	Output Phase	Occurrences	
3	ID04	design	7	form	8	1) Extrapolative thinking 2) Interpolative thinking	design	5	form	1	1) Pattern of Tangible 2) Pattern of Intangible
		morphing	1	element	4		visualize	2	characteristic	3	
9	ID45	design	8	form	1	1) Pattern of Tangible 2) Pattern of Intangible	design	5	form	5	1) Experience 2) Knowledge
		interact	2	pattern	1		function	2	quality	1	

The outcome of the selective cycle coding in the position grouping validation was Level 1:

i) DESIGNING: The tagging of "visualise and function" terms had achieved the essence of behaviour in the VPA research observation process and/or activities, as shown by a cause's dataset. Thus, the hypothetical form pattern is as follows: "Designing" (as design themes) → "visualise and function" (as design representation).

ii) OUTPUT: The essence of behaviour in statistical descriptive research was established by an effect dataset that evaluated how "characteristic and quality" terms were categorised. As therefore, forecasting the "Form" (operational of uncontrolled variables) leads to a link between the variables' "characteristic and quality."

Result of the Conclusion Contents Mapping:

The word "cause" was used to denote the tagging name of the "visualise and function" codes. In the meantime, the word "effect" was used to classify the tagging name of the "characteristic and quality" codes. However, the Memoings 1 and 2 showed how two participants, ID04 and ID45, engaged with the body of knowledge. Two article sources that provided a differentiated knowledge led to additional opinions based on two significant statement discoveries. These two important claims led to the emergence of two theories for the conceptual framework statements that developed correspondingly.

- If the ecological form of product design is approached with an extrapolative and /or interpolative thinking understanding. The fusions' ecodesign identity will then be produced using the pattern of tangible and intangible elements.
- If the ecological form of product design is exposed to a pattern of tangible and / or intangible aspects. Then the fusions' ecodesign identity will be built using their ecodesign experience and knowledge.

Finally, it should be noted that the conclusion of 3T's Coding Scheme Strategy within the TCC and TCA greatly aided in the conceptual framework's development within the research. Through the literature review sources and thorough explanation of the grounded theory phenomenon, this method established a body of knowledge that was relevant to the field of industrial design and allowed the research study to triangulate the datasets contexts. Using a cause-and-effect predictive connection model, the evidence from Phase 3 - Conceptual framework development would be compared to the underlying actual notion.

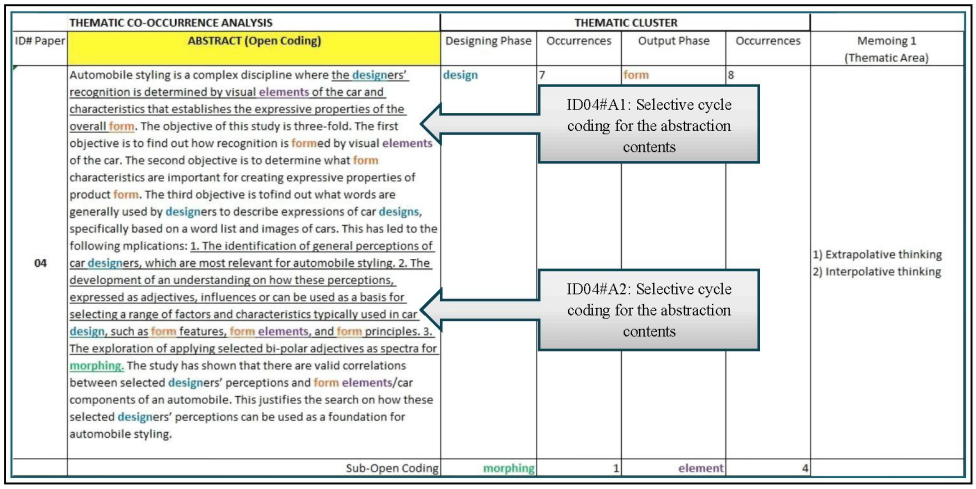


Plate 5.1 Identification of Selective Cycle Coding with ID04 Abstraction Contents

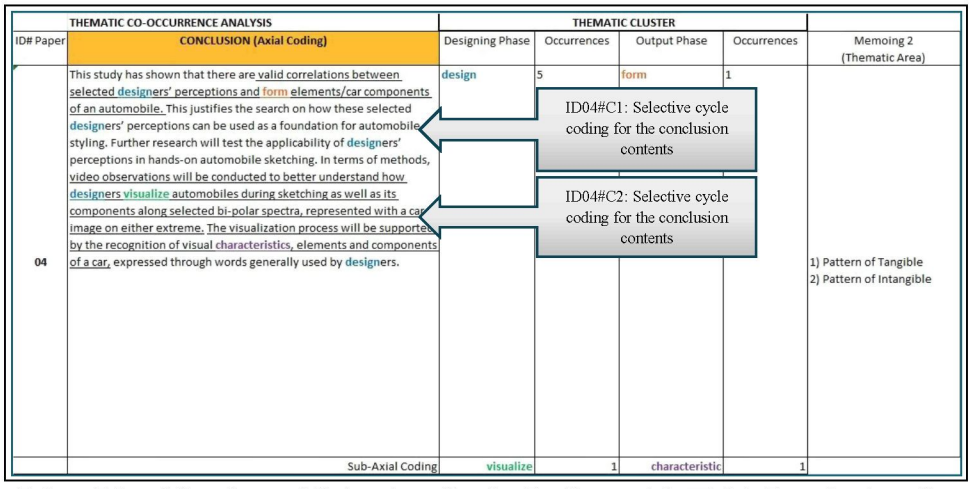


Plate 5.2 Identification of Selective Cycle Coding with ID04 Conclusion Contents

The research investigation proved an exact significant statement from the coding scheme analysis in Plates 5.1 and 5.2, indicating that the coding of abstraction/conclusion contents referred to the essence of the activity. The ID04 was

used to determine the results of the procedural phase of a thorough study of thematic co-occurrences. In the meantime, another ID45 result identified a continuous phenomenon with a period of years in the study's chronological order as Plates 5.3 and 5.4. The procedures and/or data analysis activities have put the fashioning of design knowledge to the test and exposed it to phenomena. As a result, the conceptual framework supported by the methodological assumption that the research study had discovered the article evidence has to be validated by an appropriate CLR analysis, and an effective form of literature review analysis needs to be selected.

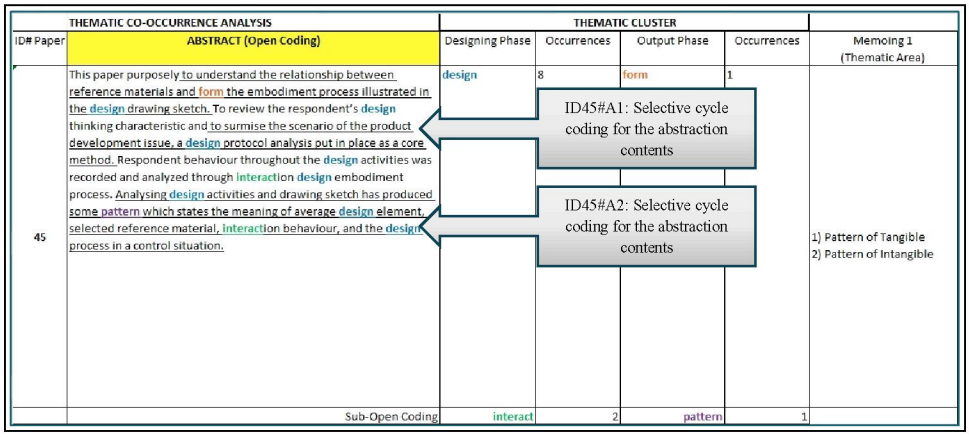


Plate 5.3 Identification of selective cycle coding with ID45 abstraction contents

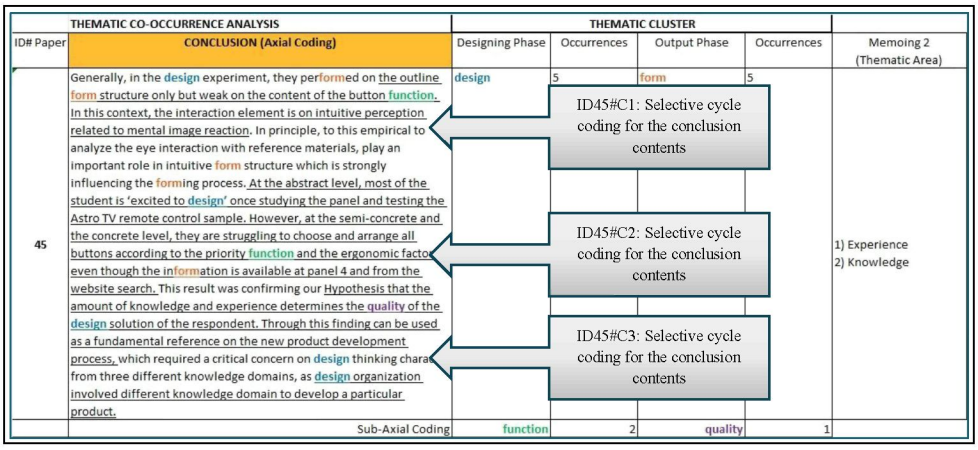


Plate 5.4 Identification of Selective Cycle Coding with ID45 Conclusion Contents

5.8.1 Pattern of Thematic Cluster: Tree Map and Sankey Diagrams

The research study specified the visualisation of the dataset in the particular field of the research topics' study under the literature review sources in the thematic cluster

approach (TC) pattern. When employing the TC approach, all data preparation must be conducted in a manner consistent with thematic analysis methods, while other techniques support the study design and the execution of the conceptual framework. Only the datasets from the selected cycle coding previously sourced by the "conclusion contents" were the subject of this investigation. Considerable evidence of analytical thinking has been observed when applying fundamental and/or basic research, as the funnel thinking notion embodied. In the DRM framework coded, it was necessary to identify the kind of pattern and/or conclude the last step of data analysis. Because of this, choosing the right tree map and Sankey diagrams is essential to understanding the data analysis and ensuring that the credibility and transferability of the datasets were consistently established. According to a previous study's justification for the research onion strategy alignment, which was presented in a table titled "The Methodological Context of Mixed Methods Strategy for Reliability and Validity," two areas of methodological strategies should be followed: (1) Grounded theory (verbal protocol analysis – VPA method) and (2) Theory building (product clinical adoption of survey method). Concurrently with an impact on the research study's reflection, the cause-and-effect link of the predictive relationship model was understood and acknowledged. In this case, the research investigation provided support for the two TC approach types that follow,

i) *Tree maps chart* - The frequency and co-occurrence of thematic clusters could be displayed using a tree maps chart. The significance of a theme may be emphasized by using larger rectangles to denote frequent co-occurrence with other themes
ii) *Sankey diagrams* - These graphic representations highlight the relationships and influences between various themes. This was crucial for multidisciplinary literature evaluations in particular, as topics frequently intersect and feed off one another.

Nevertheless, the datasets on the TC approach pattern were only partially considered for purposeful dataset analysis from the "Conclusion Contents." Since the application of the literature review structured was properly employed to triangulate the coding contents of co-occurrences contextually, the "Abstraction Contents" of datasets

analysis are not necessarily important. Thus, by employing tree maps and Sankey diagrams to map out the thematic landscape of the body of current literature, the research study was able to identify any missing or inadequately established clusters or links. This was necessary to support the importance of the literature review or suggest future lines of inquiry. When used in a pair, these resources improved the clarity and breadth of the literature review and gave the field a visual, organised representation, which helped to make the TC approach more concrete.

Subsequently, the research investigation needed to provide the percentage values for each coding separately in Table 5.66. Designing was known to be associated with a cause word. As this was going on, an effect is shown by the output phase, which used the value and quantity of co-occurrences from the Level 1 categorisation.

Table 5.66
The Percent of Coding Classified by TC Approach

	Designing phase			**Output phase**		
No.	Coding	Co-occurrences	Percent	Coding	Co-occurrences	Percent
1	Method	5	29.4%	Aesthetic	3	25.0%
2	Function	4	23.5%	Characteristic	3	25.0%
3	Structure	4	23.5%	Theme	2	16.67%
4	Visualize	2	11.8%	Emotion	2	16.67%
5	Attributes	2	11.8%	Quality	1	8.33%
6	-	-	-	Shape	1	8.33%
		17	100.0%		12	100.0%

First, nested rectangles representing themes or sub-themes were displayed in a tree map to show hierarchical data. The relevance or frequency of a certain theme in the literature could be inferred from the size and colour of each box. This made it easier for you to pinpoint recurring themes, developing sub-themes, and the order in which subjects fall inside larger categories. To observe the size within the theme of keywords appropriately, the research study must understand the pattern and portion of the hierarchical data of rectangles that the similarity method of the causes' keywords enabled.

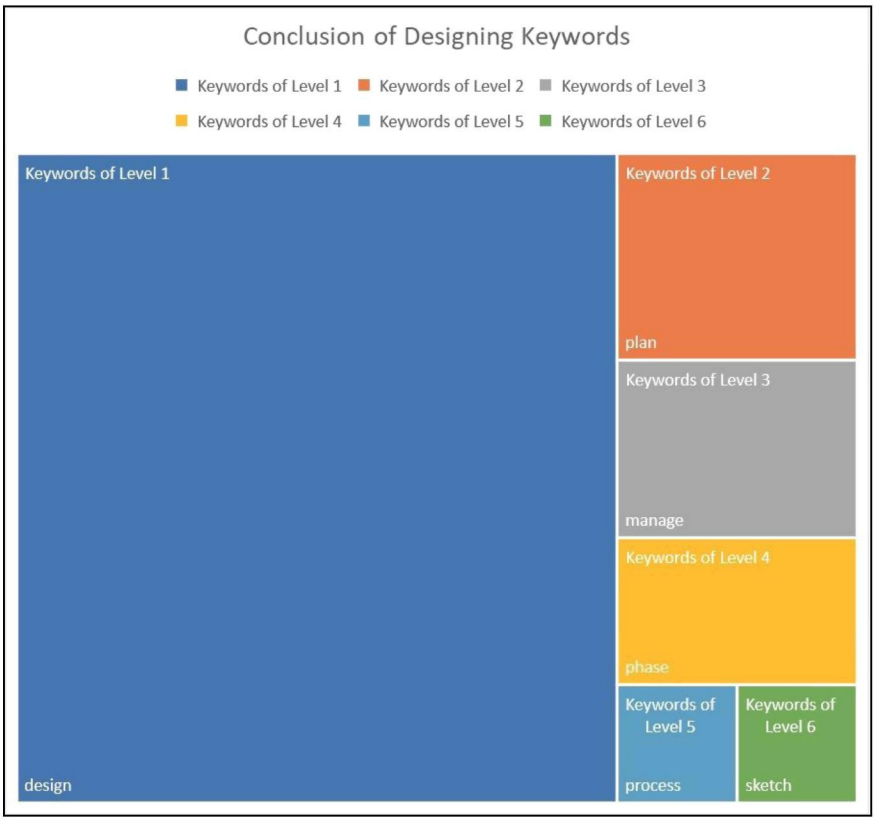


Figure 5.60 Tree Map Chart for The Causes' Keywords of Hierarchical Datasets

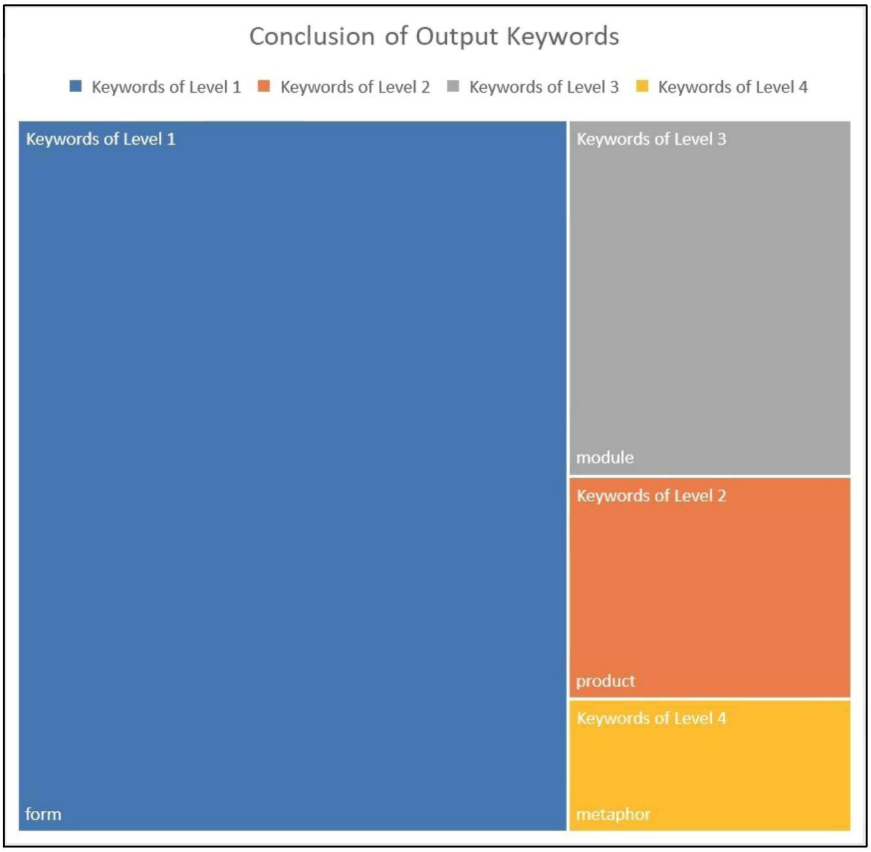


Figure 5.61 Tree Map Chart for The Effects' Keywords of Hierarchical Datasets

Significant result (cause-effect keywords) - The interpretation of treemaps displayed dominant rectangles. The only things justified and addressed are the similarities between the two tree maps. In Figure 5.60 and 5.61, the main conclusions of the keyword data analysis were discovered using the tree maps and were explained as,

a) The related section of the hierarchical data for rectangles was identified by Level 1 classification.
b) The dominant area of the research study was introduced in blue.
c) The scaled rectangle, appropriately sized for the highest levels of interaction

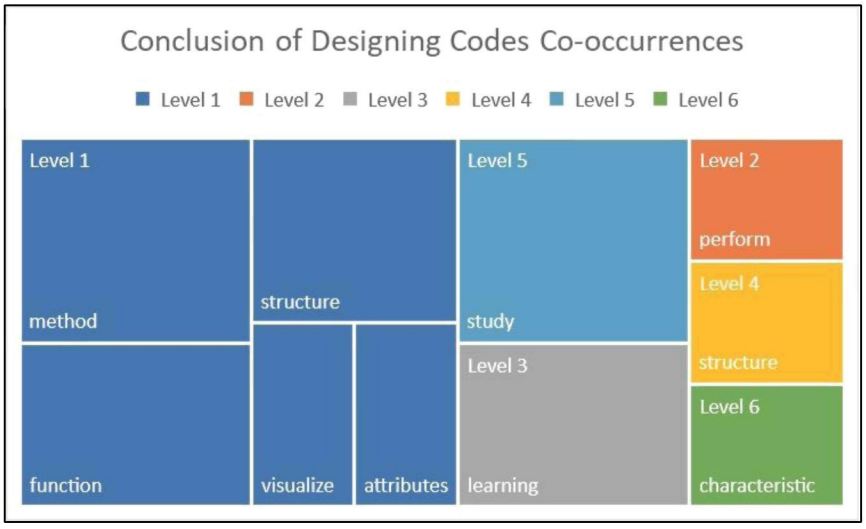


Figure 5.62 Tree Map Chart for The Causes' Coding of Hierarchical Datasets

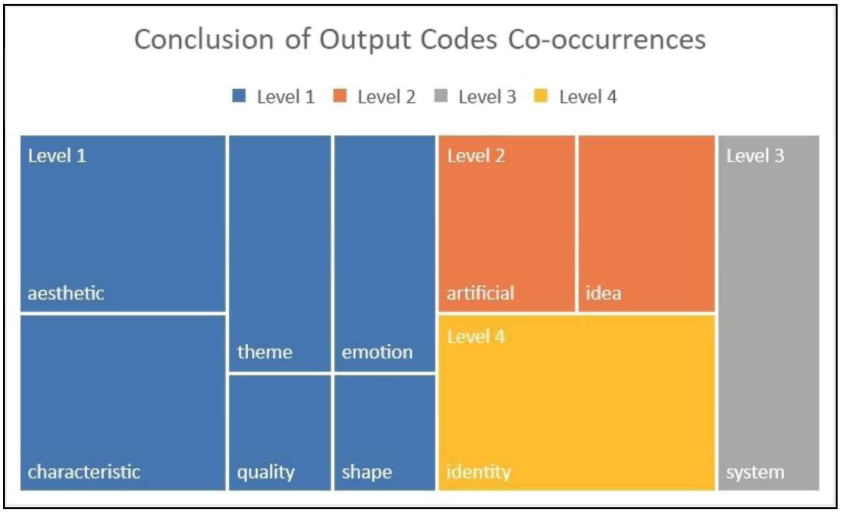


Figure 5.63 Tree Map Chart for The Effects' Coding of Hierarchical Datasets

Significant result (cause-effect coding) - The hierarchical datasets caused codings arranged the breakdown pattern in different ways. Using the tree maps, the primary findings of the coding data analysis were revealed in Figures 5.62 and 5.63, where they were explicated as follows:

a) Six coding rectangles for co-occurrences of designing codes and five coding rectangles for co-occurrences of output codes were used to extract the tiny rectangle boundaries of the hierarchical data for rectangles.
b) The two tree maps' dominating rectangle proportions were blue and sufficiently similar.
c) From Level 2 onwards, there were non-sequential numbering levels, which meant that the scaled rectangles for the second highest levels of interaction were improperly patterned.

Second, a Sankey chart is a type of flow diagram (nodes) that visualised the flow of resources or quantities from one set of categories to another. While it was commonly used in various fields, such as energy flow, material flow, or financial flows, it could also be adapted for thematic cluster analysis. Thematic cluster analysis was a method used to identify patterns or themes within a dataset. Itwas often applied in fields like text analysis, where documents or texts were grouped based on similar themes or topics. To create a Sankey chart for thematic cluster analysis were typically represented the flow of data from the initial dataset to the identified clusters or themes.

Initiate the analysis with the dataset obtained from analyzing sources using the TCA abstraction method. These datasets, derived from pertinent articles, were utilized to identify themes or clusters, as depicted in Figure 5.64. Once identified, summarizing documents or data points were assigned to their corresponding cluster. Determine the flow of documents from the original categories (e.g., authors' articles or data points) to the clusters or themes. This involved counting the number of documents assigned to each cluster (e.g., pre (designing phase) and post (output phase) activities/processes) that it was referred by "Abstraction Contents of Sankey Analysis" as Figure 5.65. Label each column and line in the Sankey chart to clarify which categories they represented. The study may also customise the appearance of the nodes' chart, such as colour-coding clusters or adjusting the thickness of the flow lines to represent the relative volume of

documents flowing between categories. The analysis research accordingly allocated a 100% value to each of the designing and output phases.

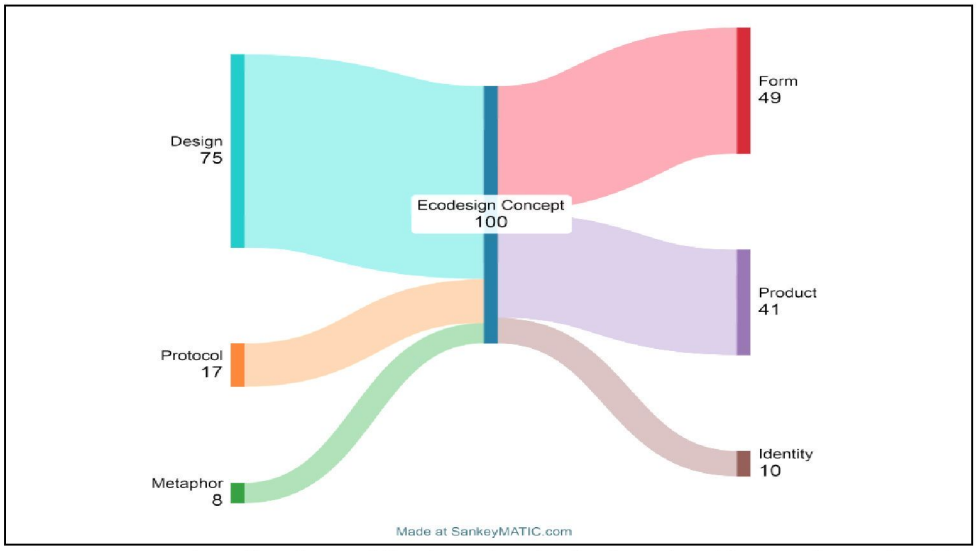


Figure 5.64 Visualisation of Sankey Analysis for The Abstraction of TCA

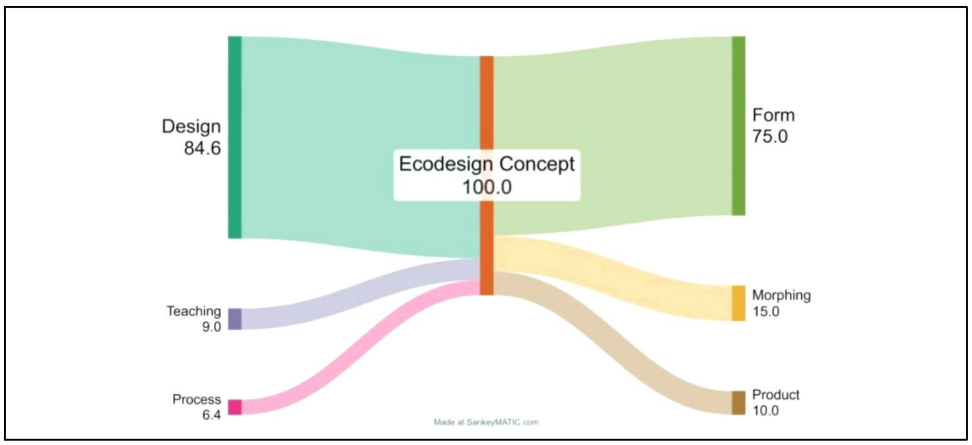


Figure 5.65 Abstraction Contents of Sankey Analysis

Therefore, the goal of the research study was to concentrate on the significance of the coding in the Sankey analysis nodes displayed. The Level 1 group has been classified and selected as the highest grouping classification for the specific coding co-occurrences. This was based on the selective cycle coding study and the previous tabulation, specifically titled "Summary for The Key Findings of Axial Coding for Thematic Clustering Context." Hence, to determine whether the true spectrum of line thickness could be seen with each colouring represented separately, the percentage of coding classified by cause-effect of co-occurrences was counted. The Sankey diagram

analysis's proof of concept demonstrated an appropriate framework for the reason explanation while comparing the frequency of coding performances. Next, the Sankey diagram of SankeyMATIC reported the percentage distribution of input co-occurrences, as shown in Figure 5.66. The input supply was indicated by the real node of rates % that emerged from the attribution of sources (causes' coding) and was routed into each effects individually. Nevertheless, the output co-occurrences, as shown in Figure 5.67, displayed an exact amount of 100%. The overall value of all nodes' flows appeared automatically in parallel. As to the SankeyMATIC website, the output was credibly reported.

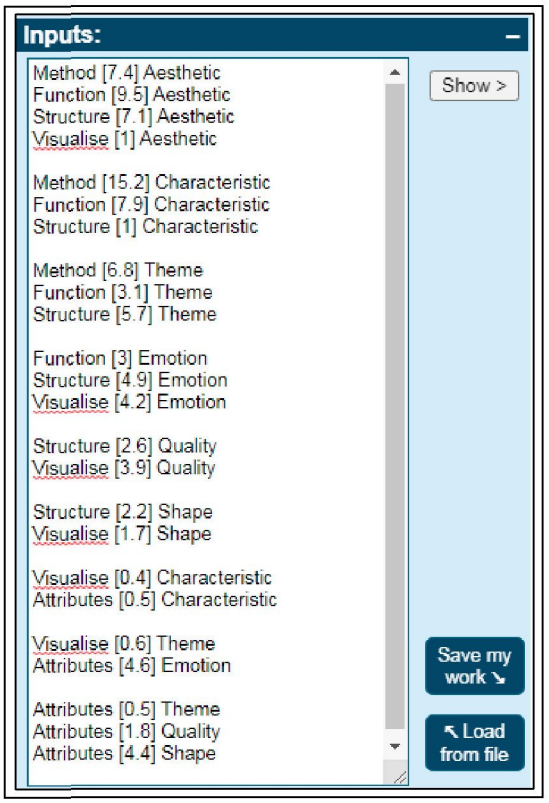


Figure 5.66 Percentages' Distribution of Input Co-Occurrences

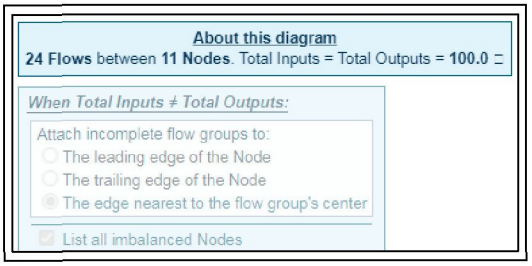


Figure 5.67 100 Percent Reported Completion of Output Co-Occurrences

This Sankey diagram, which showed the interaction between causes (left) and effects (right) in an observation of datasets study, demonstrated the strength of these engagements based on the line thickness. The larger nodes, such as Method, Function, and Structure, have a greater impact on a broader range of outcomes. The size of each node indicated its importance within the system. However following the grounded theory of the conceptual framework, the study decided on the robust causal relationships that were connected to causation reasoning.

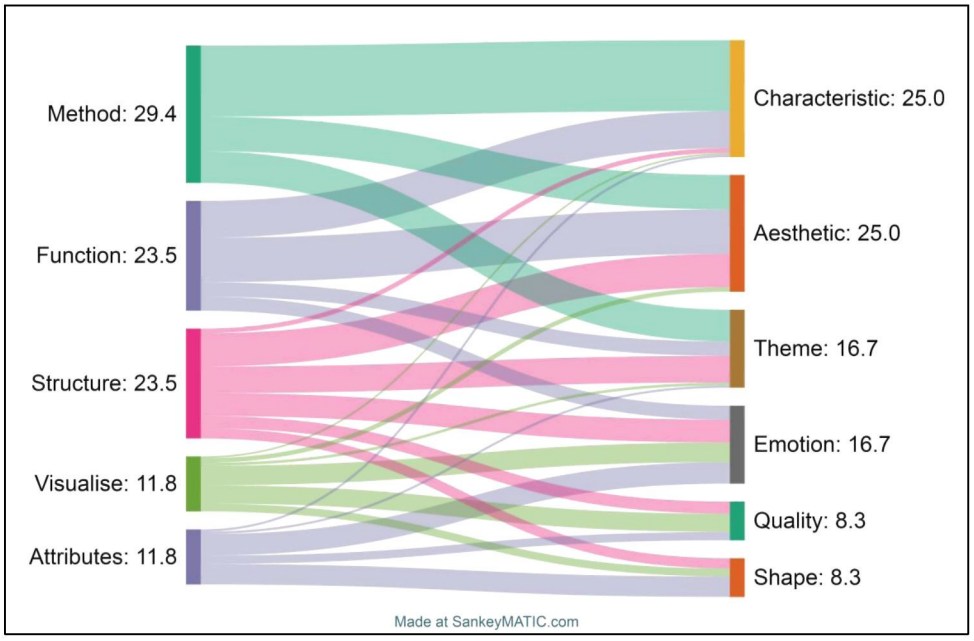


Figure 5.68 Causation of Sources' Sankey Analysis (Cause)

Significant result - Causation of sources' Sankey analysis acrossed 4 flows between 4 nodes was summarised by 22.6% and 17.4% of Method and Function caused (as Figure 5.68), respectively, as shown below:

a) The observation of a bipolar pair may refer to the "design method" versus "product identity characteristics."
b) Creating Methods (cause) had a stronger influence on outcomes like Characteristic (15.2%), compared to Theme (6.8%). This suggests that creating Methods has a greater impact on performance than Theme.
c) The 9.5% score for Function (cause) as the second highest may have a significant impact on outcomes such as Aesthetics, indicating that a product's design identity affected how people perceive it.

The study discovered integrating coding in the validity datasets transferability patterned during the lessoning of data analysis. Knowing how the causes (left-side nodes) and effects (right-side nodes) were connected through bipolar conceptual pairs was necessary to integrate the causal relationship with the bipolar analysis in the setting of a Sankey diagram. Two opposing or contrasting notions were often looked at in bipolar analysis to determine how they were related to or had an impact on particular aspects. To combine bipolar analysis and causal links in the following Sankey diagram,

i) Bipolar concepts were used to represent the causes.
ii) These bipolar causes' relative participation influenced the effects, which were the results.
iii) One end of the bipolar spectrum's influence on specific results (effects) was depicted by the flow lines.
iv) This facilitates the understanding of the visual balance and how complementary or competing aspects affected a given system or design output.

5.9 Summary

The research study consistently applied the feasibility study within the DRM framework, as confirmed by the data analysis summary. These activities were rooted in essential behavioural understanding to support foundational research within the conceptual framework roadmap. Observational methods such as think-aloud protocols in psychomotor data collection, combined with video recordings and design manuscript development were identified as appropriate strategies aligned with grounded theory and qualitative methodologies. The feasibility study's contextualisation, informed by the Program Logic Model (PLM), advanced practice-based evidence (PBE) through the lens of product clinical adoption (PCA). Furthermore, verbal protocol analysis (VPA) capsule method was strongly endorsed as a qualitative evaluation method for investigating design phenomena. This approach contributes to assessing the validity and reliability of design-based assumptions and beliefs.

According to the data analysis, the course on using inverted thinking went fairly well. Following the thematic coding, the research investigation discovered a correlation between message → product → appeal and hypothetical shape. The inversion thinking process of VPA's capsule triangulation was revealed by the impact of the theme

categorisation that was presented. When meta-data cognition was used to process the proper research scope, the nodes of Scenario 2, which was a problem-centred learning study, reversed the total of another type of meta-data cognition into Scenario 1, which is a student-cantered learning study. Concurrently, experiential learning research was conducted to apply the levels of domains like cognitive, affective, and psychomotor along the progression. The bridging knowledge has thus emerged from the interpretation of behaviour. The research question has continuously been validated and increased the number of research answers by meta-data cognition in a similar manner by the end scenarios. Accordingly, the primary contribution of the important findings was the participants' short-term memory regarding the think-aloud, which may have shown how the language and linguistics were created to depict a designerly method of behaving that emerged from the thick and/or thin description.

In analysing the results, the study identified a correlation within the hypothetical sequence: product form imagery → verbalisation (message) → design thinking (product) → product representation (attractiveness). This pattern aligned with both grounded theory and varying levels of descriptive analysis. While grounded theory emphasised iterative, data-driven theory development, it differed from thick description, which offers rich cultural interpretation, and thin description, which presents factual observations with minimal context. The findings suggest each approach contributes uniquely to understanding design cognition and representation. Meanwhile, thick description refers to a detailed account of a social phenomenon, including not only the actions or events themselves but also the context, meaning, and interpretation of those actions. It seeked to provide a deep understanding of the cultural and social significance of an event or behaviour. Shifting the tick description onto the thin description involved moving from a detailed, context-rich account (tick description) to a more abstract, general, or surface-level description (thin description). It began with identifying the core elements or actions described in the tick description. Focus on the key components that convey the basic meaning without the detailed context. Replace specific, context-heavy language with more general terms. Here the simple comparison has been found,

i) Tick Description: "Superior drawing coupled with two design elements. They were triangulated together, allowing them to produce a "fusion design" concept,

which meant that the form of the product design disclosed an ecological form of identity."

ii) Thin Description: "An ecological form of ecodesign identity was inspired by the fusion gesign concept."

The experiential lessoning of thin descriptions simplified the details, and focused on the core message or concept at each stage without the surrounding context or intricate details. By following these steps, the study can effectively shift a tick description to a thin description, making the content more general and less detailed.

In motivation, inverting the usual flow of a process can help identify weak points or flaws that might not be apparent when following the standard approach. For instance, by considering how a process could fail, the study can proactively address potential issues. When a process was inverted, it revealed new pathways or alternative steps that might be more efficient or effective. This adaptability is crucial in dynamic environments where conditions and variables frequently change. By considering the inverse outcomes, leaders and planners can develop more resilient strategies that account for a broader range of possibilities, both positive and negative. The unexpected insights gained from inverted thinking can inspire teams to push boundaries and think beyond the obvious, fostering a culture of continuous innovation. Thus, inverted thinking plays a critical role in enhancing the flow process by fostering creativity, improving problem-solving, ensuring adaptability, and promoting strategic insight. Deliberately reversing conventional approaches helps in identifying potential issues and uncovering innovative solutions that can lead to more efficient and effective outcomes.

CHAPTER 6
DISCUSSION

6.1 Introduction

In this research, the discussion stage seeks to integrate and analyse the results from the qualitative approaches, belief systems, and applied observation techniques that were previously discovered. The contribution of the DRM framework and bubbling model to comprehend the intangible ecological form of ecodesign identity will be critically examined in this step. As participants express their comprehension of ethical behaviours and environmental observations throughout the design process, expected results are predicted based on the way their thoughts are articulated. By connecting human behaviour and emotional reactions to design practice, cognitive processes will improve comprehension of ecodesign identity. The cognitive processes that are verbalised also offer rich, empirical evidence for comprehending ethereal features like ecodesign identity.

6.2 Discussion

The results of the validation of the qualitative prescriptive study (PS) stage will highlight how well qualitative prescriptive approaches can be applied to synthesize articulated data from the DRM framework's DS-1 staged before. Two main topics will be covered in particular: (1) preparing for ethical behaviour and (2) how designers incorporate ethical considerations into their design processes. Based on actual occurrences, an environmental observation was conducted to determine how participants see, understand, and integrate environmental elements into their design notions. The discussion will thus show that an adequate structure for comprehending and assessing design behaviors can be obtained by combining cognitive verbalisation (VPA method), prescriptive research, and dual media observation techniques. It is anticipated that the results will promote future developments in design thinking studies by making a substantial theoretical contribution to the study of ecodesign identity as well as the practical application of qualitative research methodology.

The initial goal is to determine how to differentiate intangible ecological forms by comprehending designers' emotional influence. The findings, which draw on data from the PS stage and are delivered into the descriptive study II (DS-2) stage, show that the designers' emotions have a significant impact on how they discern and create ecological shapes. Then, the observation and think-aloud techniques reveal how the idea of ecodesign identity is influenced by emotional reactions. Therefore, ethical behaviours are shaped by emotional factors, which aid designers in recognising the intangible characteristics of ecological forms.

As ecodesign information, the second goal is to develop a fusion model of ecodesign identity and ecological form knowledge. According to the findings of PS within DS-2 stage, the results include: (1) a structured design model that incorporates ecological knowledge into the development of product forms; (2) an understanding of how ecological form formulation can be used to improve future ecodesign identity; and (3) a platform that allows designers to convert ecological concepts into concrete product forms, offering useful guidelines for future designs.

The third objective aims to complete the DRM roadmap by applying the bubble model to the three stages that were addressed as identified in the DS-1 stage mentioned and which examined the crucial elements of ecodesign identity as well as potential design problems. The PS stage suggested techniques and resources, such as observational methods and rubric evaluations, to address these issues. Lastly, the DS-2 show how the bubble model improves the design process and produces quantifiable results by validating the suggested solutions.

6.2.1 Results of Prescriptive Study Stage

Patterns and meanings behind the identity fusion of ecodesign interpretations in ecodesign contexts are revealed by using grounded theory with VPA method to help discover designers' cognitive processes during the prescriptive study (PS) stage. It responds to the following research questions (RQs), 1, 2, and 3 following,

RQ1: What stimulate of drawing process for the concept of ecodesign identity in the design manuscript?

Answer: The drawing process is stimulated by the design mimicry process.

Explanation: The design mimicry process involves defining the product's form identity by positioning it within the framework of the evolution of form (EoF). This approach emphasizes a comparative analysis with competing designs that also employ mimicry, thereby enabling the precise articulation of the product's unique form identity and its alignment with ecodesign principles. Midst of processing, the analytical process of tackling dualistic or opposing aspects in problem-solving, which has its roots in system thinking knowledge, is known as "bipolar digitisation." When used in design thinking to create a product shape with an ecodesign identity, this idea stresses striking a balance between competing elements, including market demands and environmental sustainability, innovation and tradition, or practicality and aesthetics. Bipolar digitisation is a primary solution study in this regard that combines systemic analysis to bring these conflicting components together. By doing this, it helps the designer create a product form that adheres to ecodesign principles, guaranteeing that the design is not only effectively functional and aesthetically pleasing but also environmentally conscious. This method enables the creation of comprehensive, flexible solutions that are in line with both ecological.

RQ2: How do young designers inspire an ecological form of ecodesign identity by comparing design theme and pattern instinctively?

Answer: Young designers draw inspiration from the visual elements (VE) of subject matter that are morphologically aspired – zoomorphism approach.

Explanation: This morphology process involves a continuum of evidence in form integration, facilitated through design cognition. Specifically, it incorporates zoomorphism, where elements of the subject matter are creatively translated into product design. By leveraging natural patterns, shapes, and motifs, young designers instinctively align their creations with ecological principles, fostering an ecodesign identity that bridges the organic qualities of nature with functional design. This approach highlights the role of natural inspiration in driving innovative and sustainable design practices. Using zoomorphism enables young designers to create an ecological

type of ecodesign identity by naturally drawing inspiration from the natural world. Incorporating organic patterns, shapes, and forms into product design that are influenced by animals and natural ecosystems is known as zoomorphism. By using biomimetic concepts, this method promotes sustainability and strengthens the bond between nature and design. Therefore, young designers that embrace zoomorphism naturally integrate ecological values into their creative processes, so incorporating environmental concern into their designs. This approach contributes to a unified ecodesign identity that reflects harmony with the environment by highlighting not just the visual appeal of nature but also supporting sustainable and functional design principles.

RQ3: Why choose the design pattern of semantic representative for the ecodesign identity?

Answer: The design pattern of semantic representation is chosen because it relates to the versatile adoption of a continuum process in the "think-aloud" designerly methods. These methods encompass the design continuum, transitional continuum, hypothetical continuum, and cognition continuum in a comprehensive manner.

Explanation: Using the "think-aloud protocol", evidence from paired data sampling of design manuscripts demonstrated the role of continuum processes in shaping ecodesign identity. This included:

i) Panel B1 - Butterfly: Manuscripts (a) A6 and (b) C7.
ii) Panel B2 - Dragonfly: Manuscripts (a) A13 and (b) B6.

Both sets of design manuscripts focused on the same subject matter, employing a biomimicry process to drive product form identity. The integration of "Gestalt principles" into semantic design representation enabled the sketches or drawings to convey sustainability visually and aesthetically. This approach ensured that visual components, such as shape, structure, and material depiction, collaborated to deliver a cohesive message of environmental responsibility. The analysis utilized high-quality representation (HQR) to identify patterns of fusion in ecodesign identity, aligning with

Gestalt theory's principle that "the whole is greater than the sum of its parts." Through this framework, the semantic design pattern effectively captured the essence of ecodesign identity by harmonizing aesthetic coherence, biomimicry, and sustainability into a unified representation. By leading designers through several phases of cognitive, transitional, and speculative processes, the flexible adoption of a continuum process in the "think-aloud" designerly approaches is essential in forming the final product form of an ecodesign identity. Developing products that meet sustainability objectives requires a dynamic, adaptable, and iterative examination of design concepts, which this method facilitates. There are several interrelated stages in the continuous process following,

a) *Design Continuum* - This illustrates how ideas flow naturally, with designers always improving their thoughts by modifying the final product shape in response to new information.
b) *Transitional Continuum* - As designers progress from early concepts to more polished prototypes, they make sure that sustainability considerations are incorporated into each step of the process.
c) *Hypothetical Continuum* - Designers examine how diverse materials, shapes, and structures may promote sustainability while preserving functional and aesthetic coherence by speculating about alternative design possibilities and their environmental implications.
d) *Cognition Continuum* - The cognitive process makes designers think carefully about how their intuition assessments of ecological principles and sustainability and mental models affect their design choices.

As they navigate these continuum, designers express their ideas aloud using the think-aloud technique, revealing the implicit information that informs their choices. It is possible to have a more thorough grasp of how sustainability concepts can be smoothly integrated into the product form by using this reflective technique. Because of this process's adaptability, designers can modify their approaches, incorporate ecodesign and biomimicry, and make sure that every design choice advances the product's overall environmental liability. In the end, the development of ecodesign

identities that are both creative and environmentally sound is facilitated by this iterative and diverse approach.

6.2.2 Results of Descriptive Study II Stage

In the descriptive study II (DS 2) stage, by documenting future designers' fusion identity interpretations, preferences, and perceptions within ecodesign processes, the designing clinical survey (DCS) method facilitates theory construction. The following research questions (RQs) 4, 5, and 6 are addressed,

RQ4: What is drawing of the product semantics scaled in the concept of ecodesign identity?

Answer: The process is stimulated by the correlation between recycling methodology and the materials used, which drives a fusion design approach.

Explanation: The relationship between recycling methodology (Q9) and materials used (Q7) was analyzed, revealing a *positive moderate correlation* with a Spearman's rank correlation coefficient ($r_s = 0.510$). This correlation was statistically significant at the 0.01 level under a two-tailed test ($n = 45$, $p < 0.000$). This finding highlights the interdependence of these variables and their role in fostering a fusion design approach, where the integration of sustainable material choices and recycling strategies informs the creation of an ecodesign identity. An ecodesign identity is mostly shaped by the incorporation of recycling techniques and sustainable material selections, according to a related body of knowledge (similar source). Designers can produce goods that adhere to environmental sustainability principles by balancing the use of recyclable and environmentally friendly materials with creative recycling techniques. This strategy guarantees that the product lifecycle maximises resource efficiency while minimising environmental impact. Essentially, this integration promotes a design philosophy in which the development of the product shape is guided by the sustainability of the materials and their potential for reuse or recycling. In addition to increasing the product's ecological value, this synergy establishes it as a symbol of contemporary ecodesign, which combines sustainability, use, and aesthetics.

RQ5: Why classifying of the design theme for the fusion design in an ecological form of form identity?

Answer: Classifying the design theme is essential because the fusion of ecodesign identity emerges from the conjunction of triangulating metaphor visualization within the industrial design (ID) field and bipolar digitization, which reflects algorithmic digitization in the engineering design (ED) field. This process is synonymous with new product development, relying on tacit knowledge—ideas embedded in the designer's mind—to advance the morphing concept of product form.

Explanation: The relationship between *Ecodesign Identity (Q28) and Quality of Ecodesign Identity (Q18) was analyzed, revealing a positive moderate correlation with a Spearman's rank correlation coefficient ($r_s = 0.549$), significant at the 0.01 level ($n = 45$, $p < 0.000$). Next, a 54.496 chi-square statistical value, yielded the equation df= $(r - 1)(c - 1) = (5\text{-}1)(5\text{-}1) = (4)(4) = 16$. A two-tailed p-value of.000 for Sig was then obtained, indicating that "25 cells (100.0%) have expected count less than 5." Because of this, the p-value of.001 is less than the alpha value of .05. The research investigation utilised the gamma coefficient value, which produced a result of .494 with a significant level of .040. Following the "positive strong association" that both variable associations between "Q21. Product Form *Q18. Quality of Ecodesign Identity" had been tied in this strength of association, it then fell between ± 0.30 and ± 0.99. Therefore, the output of ordinal descriptivism described a "positive strong association" generated from the pair of ranking scales with 5 x 5 contingency tables (exceeding 2 x 2 contingency tables) were needed for the Chi-square Test of Independence. Within the conceptual design approach, both variables' correlations are grouped under the same themes so that they can be compared together. The study's validity was reinforced through descriptive analysis supported by inter-coder reliability assessments, employing statistical measures like Cohen's Kappa (k)and Krippendorff's Alpha (α) to ensure agreement beyond chance.

Percent agreement further quantified inter-coder reliability, demonstrating consistent coding across raters – 80% of percent agreement: strong, 64-81% of data reliabled. This process ensured that the classification and interpretation of design themes aligned with rigorous standards, enabling the seamless integration of complex

ecological and fusion design principles into the product development process. By structuring themes with validated reliability, designers can effectively translate conceptual ideas into tangible forms that embody an ecological form of identity in fusion design. Hence, a conceptual framework called "triangulating metaphor visualisation", which unites disparate design viewpoints to provide a unified ecological form identity, is integrated to achieve the fusion of ecodesign identity. Through the use of metaphorical visual elements, this method links computational and methodical engineering design (ED) methods with industrial design (ID) concepts, which emphasise creativity and form. The "triangulation" is a dynamic interaction of ecological values, technical viability, and intellectual ideation.

Designers combine practical design solutions with abstract inspirations by utilising triangulating metaphor visualisation, which guarantees that the final product shape complies with sustainability objectives. This fusion advances morphing concepts that adapt and convert traditional ideas into creative, environmentally conscious forms by utilising tacit knowledge, which is the intuitive understanding and creative insights of designers. In the end, this method makes it easier to create goods that are not only better in terms of appearance and functionality but also align with contemporary ecodesign identity and environmental sustainability principles.

RQ6: How to collate the semantic representative of ecodesign identity through the recycling methodology?

Answer: The semantic representation of ecodesign identity can be collated using the "Fusion Design Scheme", which is based on the impact of the bubble model resulting from measurable and / or success criteria of key findings.

Explanation: The reliability of the instrument was assessed using Cronbach's Alpha to evaluate the internal consistency of the items, with a sample size of (N = 45). The Cronbach's Alpha values ranged between 0.798 and 0.817, with the final value of 0.812, and the Cronbach's Alpha based on standardized items was 0.792. These values exceed the widely accepted threshold of 0.8, indicating "very good reliability" of the scale. This suggests that the instrument demonstrates strong internal consistency and is reliable for measuring the constructs under investigation. Further analysis of the key

variables revealed a “positive moderate correlation” between *Q33-Level 3 – Proficiency* and *Q16-Heuristic Procedural Step*, with a Spearman’s rank correlation coefficient ($r_s = 0.505$). This correlation was statistically significant at the 0.01 level under a two-tailed test ($n = 45$, $p < 0.000$). These results underline the robustness of the instrument and the relationship between the proficiency level and heuristic steps in the context of the ecodesign identity, supporting the use of the Fusion Design Scheme in examining the influence of recycling methodology on design outcomes. The Fusion Design Scheme, which incorporates the dynamic and interrelated parts of design, is an excellent way to compile the semantic representation of ecodesign identity. This plan is based on the impact of the bubble model, a conceptual framework that illustrates how different design elements interact and shape the ecological character of the final product. Different design components (such as materials used, ecodesign identity concept, design thinking, and system thinking) are represented by the bubble model as discrete "bubbles" that overlap and merge, indicating their connectivity throughout the design process as Figure 6.1.

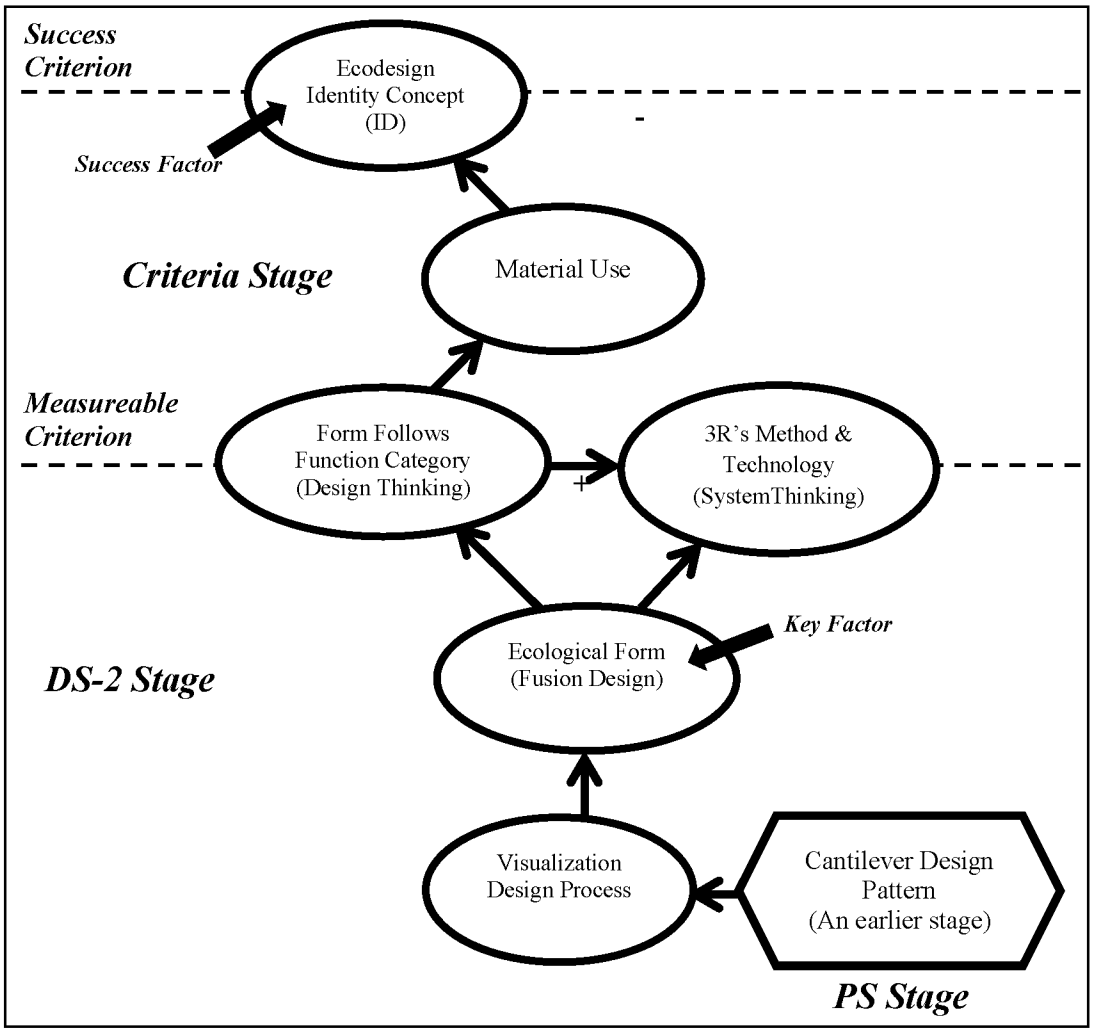


Figure 6.1 A Completion of Impacts' Bubble Model.

This paradigm, when used to ecodesign, enables designers to evaluate the ways in which several facets of sustainability such as recycling practices, material selection, and environmental impact - converge and influence the final product shape. Underpinned by the bubble concept, a beyond fusion design scheme facilitates the mapping of these connections and offers an organised method for comprehending how specific design choices support the larger objective of ecodesign identity. A consistent and sustainable product identity that is in line with ecological values is ensured by this method's incorporation of quantifiable success criteria and important results (key factor into success factor), which enable the systematic evaluation of design outputs and the improvement of ecodesign principles.

6.3 Intangible Ecological Form of Ecodesign Identity: Bubbling Model

The set of belief for an intangible ecological form of ecodesign identity throughout the bubbling model is significantly shown an impact on the research dissertation in the synthesizing of literature review. According to the DRM framework's goal principles - during the initial DS-1 stages of the search topic, the researcher discovered that the significant discoveries of articulated data might be extended into a more qualitative methodology known as fundamental and/or basic research study. Allowing to the design research methodology (DRM) framework, the results of the preceding interview protocol revealed a patterned design causation of thin description from the DS-1 stage, which was appropriately attributed to the PS stage. Meanwhile, the articulated dataset has evolved from a thin description pattern to allow for the matching of design criterion findings, which were successfully established by the research onion strategy (longitudinal and cross-sectional) for the measureable criterion in DS-2 stage entirely. By right, the weight of the study design for design criteria is concentrated and remains on the DS-1 approach, as described in the statistical tabulation analysis. At this moment, knowing the end-to-end research paradigm is necessary while also navigating the DRM framework accomplishment. However, the hypothesis statement was then generated and evaluated from the DS-2 stage, which encodes the previous interpretation of design criterion findings. Thus, the justification of explanatory study refers to the schools of thought where the design team essentially surrounding with the designing activities from PS stage such as involving products, people, teams, tools, organisations and their micro- and macro-economic context.

As a result, a null hypothesis statement was rejected, indicating the existence of a mysterious design thought based on the ecodesign identity that required further investigation. The design causes indicated the probing for the design activities reffering to verbalization of prescriptive procedures (the minds and human body interaction), will investigate the "specific" VPA process / phases / stage following the higher ranking and / or rating from the numbers of subjects frequently. The study used the VPA approach to investigate a real-world occurrence in the PS stage of DRM framework.

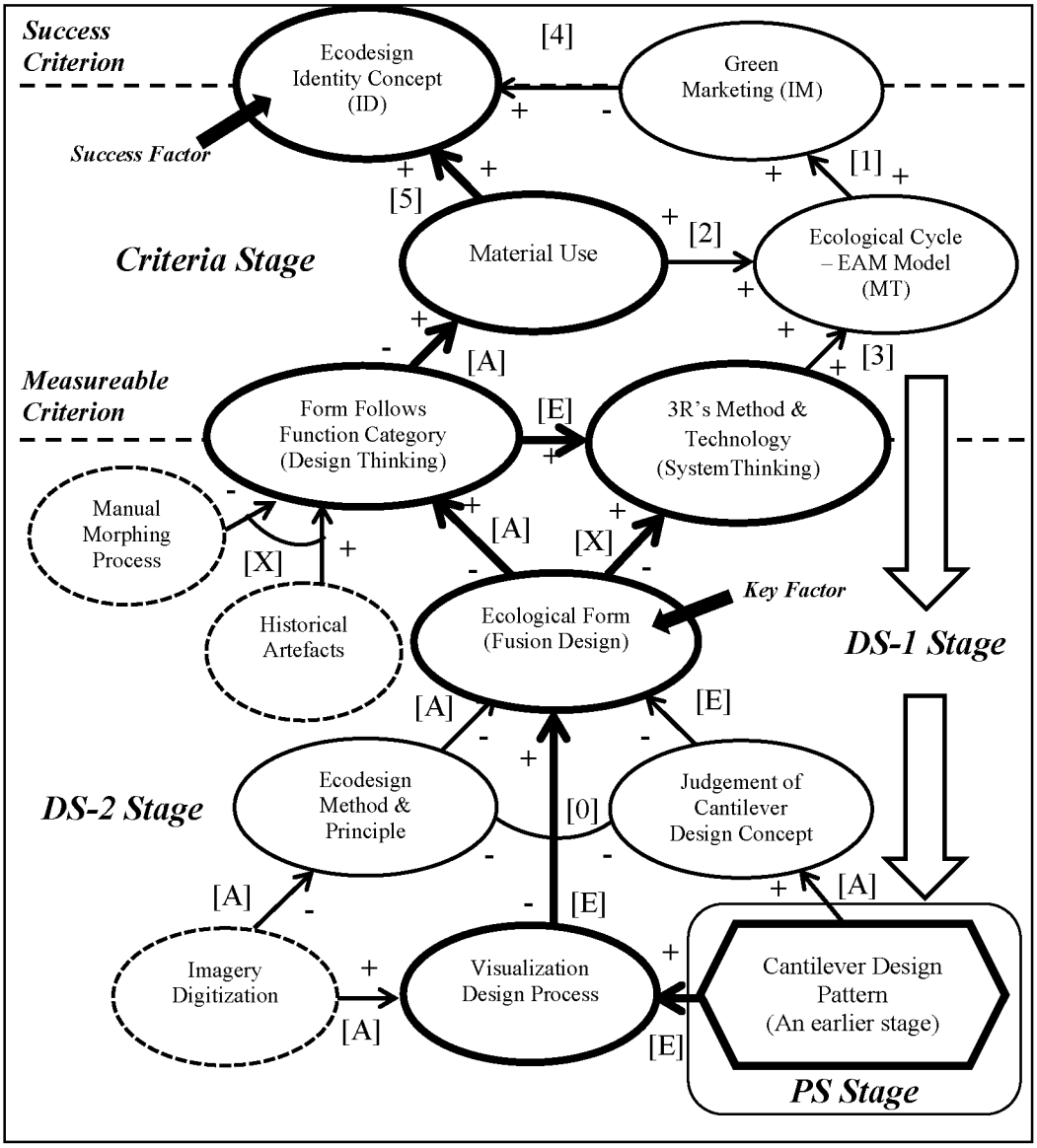


Figure 6.2 An Impact Model Focused on The Bubbling Modelling Study

Therefore, think aloud interpretation is required to define an accurate pattern of design experience, with the transcribing design process addressed in the design manuscript. Based on this phenomenon situation, a logical methodological approach has been used to assess the trustworthiness of a qualitative research study using articulated datasets. However, the nodes' interaction should be produced by the graphical representation indicated by the visualisation of the bubbling model supplied an impact model of the DRM framework as synthesizing literature review. This Impact Model emerged as proof of the systematic inductive reasoning that has occurred.

In Figure 6.2, an earlier bubbling model transformed to the Impact Model of DRM framework. This bubling model is initiavely revealed to begin from the Chapter

3 under the Reference Modelled - "the network of influencing factors" in Figure 3.22 previously. A lessoning of graphical representation recognised the progression of the bubble modelling gradually for the evaluation of criterions. The evaluation of the "success criteria" and "measurable success criteria" have had to address the criterions that desired value of the factor the research project sets out to understand and/or influence into the direction of research goal. From the observation of literature review, within the process, there had two points of factors such as (1) key factor representing an ecological form by the fusion design context and (2) success factor reffering to the ecodesign identity concept. For the purpose of bold highlighted, both ovals and hexagon element, and the arrows indicated the pathway of networking between the key factor and success factor which meant the causal linkage is engaged to make the assumptions explicit and ensure that the claims are realistic. This requirement of visualization is needed to the research study for anserwing the research questions within the research objectives together holistically. Hence, two factors criterion is systematically displayed an exact content of the research title study.

For the lessoning of nodes' indication by the experts Blessing and Chakrabarti (2009), the research study outlined to follow the several procedures related for the research topic purposely. Herewith, the tips summaried for the network of influencing factors,

Attributes have values:

a) *Values can be qualitative, such as 'high' and 'poor', or quantitative,*

b) *The existing or desired value of an attribute is attached to a link between factors by means of a '+', '−', or '0' sign.*

c) *Values should not be included in the description of the factor in the node. Thus 'poor problem definition' is not a correct formulation for a factor. The first reason is that including the value (poor) rather than the attribute (quality) introduces ambiguity: it is not clear whether poor refers to poorly written, poor contents, etc. The second reason is that including the value in the node does not allow multiple, differing statements to be represented using the same node.*

The links between factors show how the factors influence or are desired to influences each other, i.e., they represent explicit statements about the existing or desired situation.

d) *The combination of '+', '−' and '0' signs at the ends of a link describe how the value of the attribute of the factor at one end relates to the value of the attribute of the factor at the other end.*

e) *If the link is known or assumed to be a causal link, this is indicated with an arrow (→) from cause to effect.*

f) *If a link exists between three or more nodes, e.g., two factors together affect another factor, the links near the affected factor are connected and a single value is placed near the connection.*

g) *If certain factors are known to influence a factor in the network, but are themselves outside the scope of the research project, these factors are drawn differently.*

h) *Statements that are found in the literature cannot simply be reversed: if high costs lead to reduced sales, this does not imply that low costs lead to high sales. The latter would be an assumption. It is important to base the Reference Model on the original statements, even if this implies a non-continuous line of argumentation. The Reference Model represents the current understanding as-is. Assumptions can be added that differ from the original statements, as long as they are labelled as such. The Impact Model, in describing the desired situation, provides the freedom to change statements, but here too, these have to be marked as assumptions.*

i) *It is useful to place the nodes such that the main cause and effect chains are easily seen.*
Every link is labelled with the source(s) of the statement(s) it represents, using the following abbreviations:

j) [X]: the statement was published in the reference numbered X;

k) [A]: the statement is an assumption;

l) [E]: the statement is based on experience of the stakeholders;

m) [O]: the statement is based on own investigations;

n) [#]: the statement is based on source of literature review-mapping;

Next, the models' node explanation is a vital requirement that it can be built the proper sources to represent the design theory in the body of knowledge throughout the research topic

> *"A model is a likeness of something that exists in reality, but restricted to some particular aspects of this reality. Which aspects are represented depends on the purpose of the model, i.e., on its intended use. Models are used in science to provide conceptual organisation. They show the significant relationships between the concepts or attributes, and thus highlight the aspects that are the focus of the research. Models are not theories, but they can be used to represent a theory."*

6.3.1 Design Theory for New Product Development

The Design Theory for New Product Development (NPD) in ecodesign identity, structured within the DRM framework, systematically integrates sustainability principles throughout the design process. It emphasizes semantic and morphological thinking, iterative user-centered development, and the utilization of tacit knowledge to foster innovation. The theory promotes systems thinking by considering material choices, manufacturing impacts, and product life cycles. Through the fusion of technical performance and aesthetic value, this approach enhances ecodesign identity, supporting sustainable development goals while meeting both functional and emotional user needs in new product design.

Using design theory as a DRM framework for creating product design identity approaches three key advantages of design theory:

i) Design theory provides a systematic approach to understanding the principles, processes, and methodologies involved in design. By applying design theory, designers can analyze and deconstruct existing design conventions, styles, and trends to inform their decision-making process. This structured approach helps ensure that design choices are intentional, coherent, and aligned with the desired product design identity.

ii) Design theory helps clarify the purpose and objectives of the design process. By grounding design decisions in theoretical principles, designers can articulate the underlying rationale behind their choices and ensure that they are in line with the brand's identity, values, and goals. This clarity of purpose facilitates effective communication and collaboration among team members and stakeholders, leading to more focused and cohesive design outcomes.

iii) Design theory equips designers with a toolkit of problem-solving techniques and strategies. By understanding different design theories and approaches, designers can effectively address complex design challenges and balance competing priorities, such as functionality, aesthetics, usability, and sustainability. Design theory encourages experimentation, iteration, and innovation, enabling designers to explore new ideas and push the boundaries of conventional design norms.

Many design theories emphasize the importance of user-centered design principles, such as empathy, usability, and accessibility. By prioritizing the needs and preferences of end-users, designers can create products that are intuitive, engaging, and meaningful. Design theory provides frameworks for conducting user research, gathering feedback, and alliteratively refining design solutions to ensure that they meet the needs of diverse user groups. It helps ensure consistency and coherence across all aspects of the product design identity. By adhering to established design principles and theories, designers can create cohesive design systems that unify visual elements, messaging, and brand personality. Consistent design language and aesthetics contribute to brand recognition, trust, and loyalty among consumers. Design theory encourages designers to be adaptable and flexible in their approach to problem-solving. By understanding the underlying principles of design, designers can apply theoretical frameworks in diverse contexts and adapt their methodologies to suit evolving trends, technologies, and user preferences. This adaptability enables designers to stay relevant

and responsive to changing market dynamics while maintaining the integrity of the product design identity.

Therefore, leveraging design theory for the creation of product design identity offers the design theory advantages such as (1) a systematic approach, (2) clarity of purpose, and (3) problem-solving capabilities. By grounding design decisions in theoretical frameworks, designers can create compelling and impactful products that resonate with consumers and reinforce the brand's identity and values.

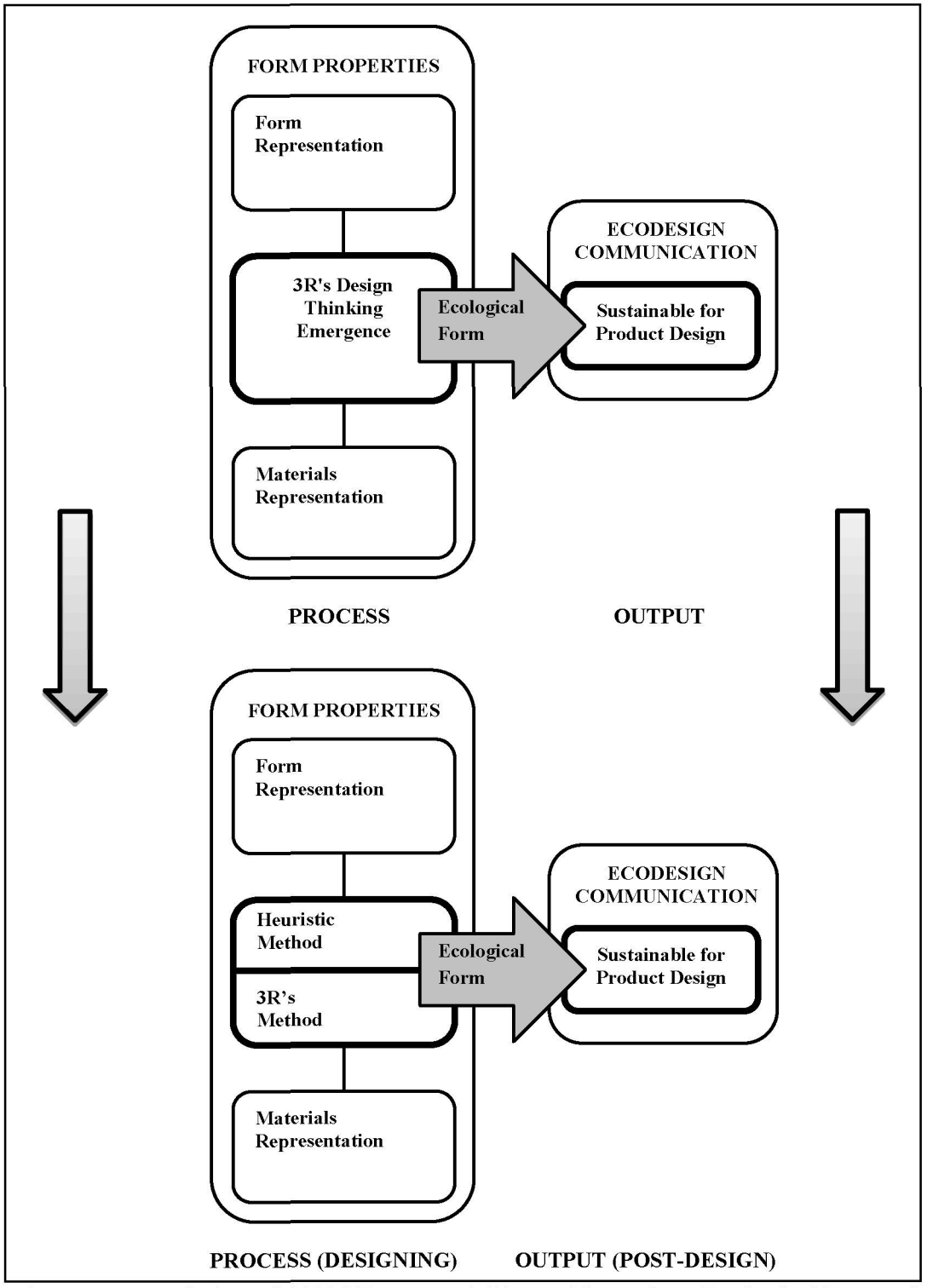


Figure 6.3 Evolution of DRM Framework Phases Through an Ecological Form of Bubble Model as Deliverables "Support" (Process: Designing) And "Evalution" (Output: Post-design)

In Figure 6.3, the development of the "body of knowledge" emphasizes the process of defining (1) form properties: via ecological form within ecodesign identity theory – that it integrating with (2) Sustainable for Product Design (SfPD) theme

namely aesthetics, morphological inspiration, semantic design thinking, and systematic methodologies to establish a coherent theoretical foundation for theme of ecodesign communication.

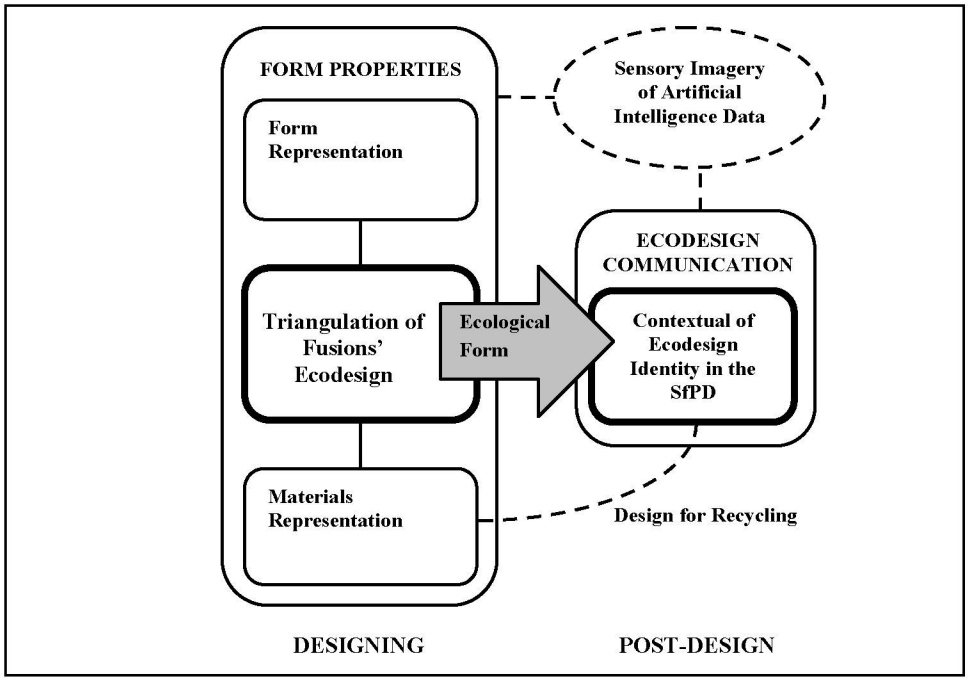


Figure 6.4 The Emergence of Triangulation of Fusions' Ecodesign (Process: Designing) and Contextual of Ecodesign Identity in The SfPD (Output: Post-design)

Figure 6.4, this theory acknowledges the interconnections between products, people, and the environment, advocating for designs that minimize negative environmental impacts throughout their lifespan while also promoting social equity and well-being. In the context of emergence of triangulation of fusions' ecodesign and contextual of ecodesign identity, the ecological form of ecodesign identity theory manifests through several process – output key principles of SfPD following:

a) *Process Stage* - Representation of material selection is a critical aspect of ecodesign identity. Designers prioritize the use of sustainable and renewable materials, such as recycled plastics, organic fabrics, and responsibly sourced wood, to minimize environmental impact. Additionally, they consider factors such as material toxicity, biodegradability, and recyclability to ensure that products are safe for both users and the environment. The ecological form of ecodesign identity theory advocates for designs that minimize waste generation

and facilitate recycling and reuse such as 3R's method. Designers explore strategies such as modular design, disassembly for repair and recycling, and the use of recycled materials to extend the product's lifespan and reduce its environmental footprint. Meanwhile, form representation in ecodesign identity serves as the physical embodiment of sustainable design principles, reflecting ecological responsibility in product aesthetics. The triangulation of fusions in ecodesign identity combines various sustainability practices, integrating them into a cohesive approach. The ecological form of ecodesign identity theory manifests through this fusion, transforming abstract principles into tangible product designs. Guided by the key principles of SfPD, this process ensures that the product not only meets environmental goals but also aligns with consumer expectations for eco-friendly, functional design, reinforcing the product's identity as sustainable and responsible.

b) *Output Stage* - Sensory imagery of artificial intelligence (AI) data in ecodesign communication plays a vital role in sustainable product design by combining sensory experiences with data-driven insights. AI helps analyze materials, environmental impact, and user preferences, guiding designers in making more sustainable choices. Sensory imagery, such as visual, tactile, and auditory cues, is used to communicate the ecological benefits of the product. By integrating AI data with sensory design elements, designers can create products that not only perform well but also engage consumers emotionally, making sustainability more relatable and impactful.

In addition to environmental considerations, ecodesign identity theory emphasizes social responsibility and equity. Designers prioritize the well-being of workers throughout the supply chain, ensuring fair labor practices, safe working conditions, and equitable compensation. They also consider the social impact of products on communities and strive to create inclusive designs that meet the diverse needs of users. By integrating these principles into the design process, the ecological form of ecodesign identity theory promotes the creation of products that are environmentally sustainable, socially responsible, and aligned with the values and identity of both the brand and its target audience. Heuristically, these products not only minimize environmental impact but also contribute to a more equitable and sustainable society.

6.3.2 Design Model for Product Form Iteration

The design model for product form iteration in ecodesign identity is an iterative approach that integrates sustainability into product design. It focuses on refining the product's form to meet aesthetic, functional, and ecological goals through continuous feedback and testing. Key elements include material selection, energy efficiency, and recyclability, with design thinking and sustainability criteria driving each iteration. This model ensures products evolve to align with ecodesign principles, contributing to sustainable development while meeting market and environmental needs. Using a design model for creating product design identity offers four levels distinction of designing advantages:

a) *First Level Distinction* - Design models offer a structured framework that guides designers through the entire product development process, from initial conception to final implementation. By following a predefined sequence of steps, these models ensure that all aspects of the design process are systematically addressed, resulting in more organized and efficient workflows. This structured approach helps clarify the roles and responsibilities of each team member, enabling effective communication and collaboration among designers, engineers, marketers, and other stakeholders. By delineating specific tasks and milestones, design models align all participants with the project's overarching goals.

b) *Second Level Distinction* - A key feature of design models is their incorporation of iterative feedback loops, allowing designers to refine their designs based on user feedback, testing results, and evolving requirements. These continuous evaluations ensure that the product design remains aligned with user needs, market trends, and brand objectives, ultimately optimizing the product's identity.

c) *Third Level Distinction* - Design models also play a crucial role in risk management by systematically identifying and addressing potential risks throughout the design process. By anticipating challenges early on, designers can mitigate the impact of these risks, reducing the likelihood of costly errors or design flaws. Additionally, design models promote effective resource allocation, ensuring that time, budget, and manpower are used efficiently. By

prioritizing tasks and managing dependencies, resources are allocated optimally, which contributes to the successful realization of the product's design identity.

d) *Fourth Level Distinction* - Design models help maintain consistency and quality control by establishing standards and best practices. This ensures that each design iteration aligns with predefined guidelines, maintaining quality across different product versions. Definitely, these models support knowledge management by documenting key insights and decisions, fostering continuous improvement for future projects.

Therefore, using a design model for creating product design identity offers level distinction of designing advantages such as (1) a structured process and clarity of workflow, (2) iterative improvement, (3) risk mitigation and efficient resource allocation, (4) quality control and knowledge management. By leveraging a design model, designers can streamline the design process, mitigate risks, optimize resource allocation, and ensure that the final product embodies the desired design identity effectively.

In the benchmark of product form frameworks' model, the fundamental (1) iterative model and (2) the product form model are both frameworks used in product design, but they approach the design process from different perspectives. For example, the Old Master Heskett Model (OMH) represents an iterative model, proposed by John Heskett, focuses on the aesthetic and functional aspects of design. It emphasizes the importance of balancing form and function to create products that are both visually appealing and practical. The model consists of three key components:

i) *Form* - Refers to the physical appearance and sensory characteristics of a product, including its shape, color, texture, and materials.

ii) *Function* - Relates to the practical utility and performance of a product, including its usability, ergonomics, and efficiency.

iii) *Meaning* - Encompasses the symbolic, emotional, and cultural significance of a product, reflecting its perceived value and resonance with users.

The OMH Model suggests that successful product design involves a harmonious integration of form, function, and meaning, resulting in products that are not only visually appealing and functional but also meaningful to users. In the other hand, the product form model, developed by Wolfgang Jonas, focuses specifically on the formal aspects of product design. It proposes a structured approach to analyzing and designing product forms based on four key dimensions:

i) *Semantic Dimension* - Considers the symbolic and cultural meanings associated with product forms, such as brand identity, cultural symbolism, and aesthetic preferences.
ii) *Pragmatic Dimension* - Relates to the functional requirements and technical constraints that influence product forms, including usability, ergonomics, and manufacturing considerations.
iii) *Syntactic Dimension* - Deals with the formal composition and organization of product forms, such as proportions, scale, symmetry, and rhythm.
iv) *Haptic Dimension* - Addresses the sensory qualities of product forms, such as tactile sensations, texture, and surface finishes.

Here, the product form model provides a comprehensive framework for analyzing and designing product forms, taking into account various factors that influence their appearance, functionality, and user experience. When considering how the OMH of iterative model relates to the product form model, we can see that they both share a focus on the formal aspects of product design, particularly in terms of form and meaning. While the OMH of iterative model incorporates function and meaning as integral components of design, the product form model provides a more detailed analysis of the formal dimensions of product forms. Thus, the studies have recognised to decode the meaning of these design models combination for product form iteration in ecodesign identity following;

"Form is to form a formgiving to form an ecological form of ecodesign"

Together, these models offer complementary perspectives that designers can use to create products that are not only aesthetically pleasing and functional but also culturally meaningful and technically feasible.

6.3.3 Design Scheme for Ecodesign Identity Creation

The Fusion Design Scheme (FDS) is an approach to product design creation in product form of ecodesign identity context that involves blending of two elements or two sources similarly from different styles, cultures, or disciplines to create innovative and unique designs. It emphasizes creativity, diversity, and the synthesis of disparate influences to produce products that stand out in the market.

FDS is a design practice solution that tackles current issues in identity expression, market differentiation, and sustainable design in addition to being a stylistic approach. Adopting fusion as a process gives designers the ability to go beyond traditional limits and create goods that are commercially unique, culturally relevant, and environmentally conscious. This method promotes creativity by utilising the advantages of various traditions and technology, which eventually results in more flexible, inclusive, and progressive design approaches. Here's an explanation of the FDS and how it applies to product design creation following,

a) FDS involves integrating diverse influences, such as cultural motifs, architectural styles, artistic movements, or technological advancements, into the design process. Designers draw inspiration from a wide range of sources, spanning different time periods, geographic regions, and artistic traditions, to create a rich tapestry of design elements.
b) FDS encourages creative synthesis, where disparate elements are combined in unexpected and imaginative ways. Designers experiment with mixing and matching different styles, materials, textures, colors, and forms to create products that are visually striking and conceptually intriguing. By transcending conventional boundaries and blending contrasting elements, fusion design challenges traditional notions of aesthetics and opens up new possibilities for design expression.
c) FDS fosters innovation and uniqueness by encouraging designers to think outside the box and push the boundaries of conventional design norms. By combining elements from different domains, designers can create products that defy categorization and offer fresh perspectives on familiar themes. This emphasis on innovation and uniqueness helps products stand out in the competitive marketplace and capture the attention of consumers looking for

something distinctive and original.

d) FDS celebrates diversity and eclecticism, it also requires sensitivity to cultural contexts and traditions. Designers must be mindful of the cultural significance of the elements they incorporate and strive to respect and honor the heritage and symbolism associated with them. By embracing cultural diversity with respect and authenticity, fusion design can create products that resonate with global audiences and foster cross-cultural appreciation and understanding.

e) FDS offers an opportunity for personal expression and identity, allowing designers to infuse their creations with their unique perspectives, experiences, and influences. Designers can use fusion design as a means of self-expression, exploring their own cultural heritage, interests, and creative vision through the design process. This personal touch adds depth and authenticity to the design and imbues it with a sense of character and identity.

In Figure 6.5, FDS for ecodesign identity refers to a structured, template-based framework that guides industrial design students or professionals in the creation of hybrid product forms through the strategic blending of diverse design influences, while embedding sustainable principles and cultural narratives. Like the business model canvas (BMC), FDS serves as a visual and analytical tool such as 3D of cognitive levels domain that supports (1) draw, (2) dissect, and (3) decide of ecodesign communication in the early cognitive activity levels of ecodesign development. The verbs activities take from the Circular Taxonomies introduced by an academic expert Simon Paul Atkinson (PhD) – suitable for design studio laboratory.

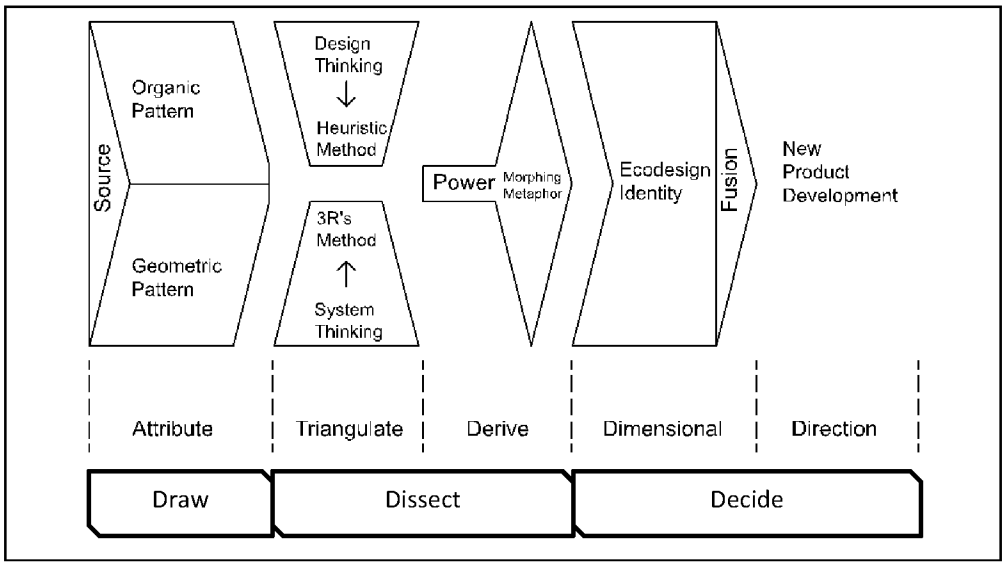


Figure 6.5 3D - Fusion Design Scheme (FDS) for Ecodesign Identity

Therefore, the integration of the FDS into design pedagogy necessitates a multidimensional teaching approach that emphasizes interdisciplinary synthesis, cultural literacy, and creative innovation. Rooted in the ecodesign identity context, FDS encourages students to explore and combine elements from diverse cultural, stylistic, or disciplinary origins. Pedagogically, this can be achieved through studio-based learning frameworks that incorporate cultural research, comparative analysis, and material experimentation. Teaching strategies such as thematic workshops, design critique sessions, reflective journaling, and sustainability-focused design briefs facilitate students' ability to critically engage with complex aesthetic and contextual variables. Furthermore, by promoting iterative prototyping and storytelling as core practices, educators can cultivate learners' capacity to construct hybrid forms that are both contextually grounded and market-relevant. Definitely, FDS-based pedagogy fosters the development of designers who are not only creatively agile but also culturally and environmentally conscious.

Overall, the use of a FDS for creating product design identity offers brands a powerful tool for innovation, differentiation, cultural relevance, versatility, storytelling, and global appeal, ultimately contributing to their success in the marketplace.

6.4 Implication of The Study

This study offers important implications for the future of industrial design education and practice. The inverted iceberg model encourages future designers to look

beyond surface-level creativity and instead engage with the fusion of disciplines that define contemporary ecodesign - merging technology, ecology, culture, and computation. In particular, it promotes a shift in mindset where designers must learn to navigate between visible design expressions and invisible systems knowledge. The identity of ecodesign fusions such as metaphor combined with data-driven logic, or natural form married to algorithmic structure becomes a central interpretive framework. Designers are called to become hybrid thinkers, capable of understanding how aesthetic, functional, and systemic elements interrelate across layers of knowledge.

For industrial designers, this means cultivating the ability to translate deep design logic into accessible and meaningful outcomes, while maintaining ecological responsibility. It also implies a growing need for trans-disciplinary fluency, where future designers work across engineering, material science, behavioral psychology, and environmental ethics.

The traditional iceberg model of culture, long employed in anthropology and communication theory, distinguishes between the visible aspects of culture - such as language, rituals, and art—and the deeper, often invisible elements - such as values, beliefs, and thought patterns. This framework has proven effective in understanding the layered nature of human systems. However, in the context of ecodesign, the model can be conceptually inverted to better reflect the knowledge hierarchy that drives sustainable design practices.

In Plate 6.1, the inverted ecodesign model, the visible aspects of design such as mimicry, zoomorphism, and behaviorally-driven aesthetics form the top layer. These elements communicate ecological themes and cultural narratives, serving as gateways for user engagement. Yet, their visibility does not equate to their depth; rather, they are informed by and dependent upon more foundational design knowledge. The middle layer focuses on functional semantics and material strategies, including recycling methodologies, material sourcing, and the communication of sustainability values. This layer mediates between surface aesthetics and deep systemic intent, demonstrating how ecological goals are operationalized through practical decisions. At the bottom layer, the deepest level of the inverted iceberg, lies the fusion of metaphorical reasoning with algorithmic and digital design systems. This includes the use of computational design tools, biomimicry algorithms, and parametric modelling - systems that drive innovation and long-term adaptability. Although hidden from the user, this layer forms the conceptual and strategic core of ecodesign thinking.

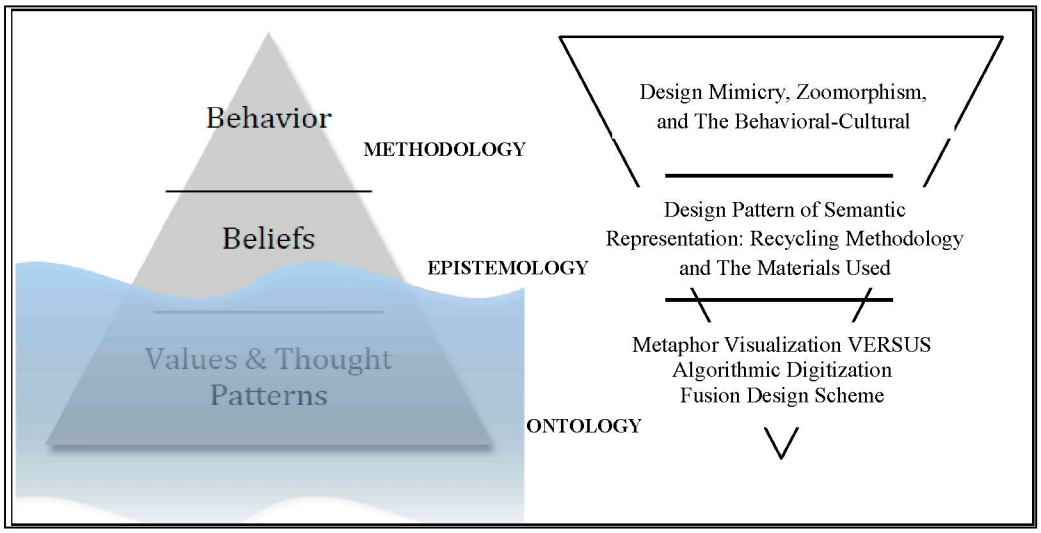


Plate 6.1 The Cultural Iceberg Model is Reinterpreted as an Inverted Iceberg Representing Ecodesign Knowledge.

Overall, the inverted iceberg model helps clarify the layers of ecodesign knowledge and changes the role of the designer. Instead of just creating forms, designers become key players in connecting different systems, combining innovation, sustainability, and cultural understanding to create meaningful design solutions.

6.4.1 Interpolative for an Explicit Knowledge

In the realm of product design identity, the process of interpolating explicit knowledge plays a pivotal role in integrating existing, codified information to generate innovative design solutions. Explicit knowledge, which includes documented data, design principles, case studies, and technical specifications, is easily transferable through written or verbal communication. However, to create meaningful and novel product identities, designers must engage in the process of analyzing, synthesizing, and combining this knowledge in new and creative ways. Interpolation in this context refers to the act of fusing disparate pieces of explicit knowledge to enhance understanding or generate insights that lead to innovative design solutions.

One critical aspect of interpolating explicit knowledge is its influence on the drawing process, particularly when design mimicry is involved. Design mimicry often draws upon the visual characteristics of existing forms, whether from nature, technology, or other design works. In this process, designers may refer to a wide variety of explicit knowledge sources, such as visual references or historical design principles,

and combine them to generate new design ideas. Interpolating explicit knowledge in this context allows designers to analyze existing design forms and use them as inspiration, transforming them into something that is new and relevant within the scope of the product's identity. In essence, the drawing process becomes a dynamic interaction between existing visual language and creative expression. Through the act of interpolation, designers do not simply reproduce past ideas but instead synthesize them, adapting and evolving them in the context of contemporary design needs and user expectations. The ability to mix and match elements of explicit knowledge, such as design styles or functional requirements, allows designers to forge new paths in visual and functional design, ultimately contributing to the creation of distinctive product identities.

Another significant approach in product design, especially for young designers, is the use of zoomorphism - the integration of animal forms and patterns into product aesthetics and structure. By examining the morphology of animals, designers can extract explicit knowledge about natural structures, textures, and functional forms that have evolved over time. The process of interpolating explicit knowledge in this context involves analyzing these forms, then combining and extrapolating information to create designs that are both innovative and functional.

However, by interpolating explicit knowledge in this way, young designers can expand the boundaries of their creativity, moving beyond traditional design methods and creating products that are not only visually compelling but also functionally efficient. This approach highlights the value of interdisciplinary thinking in design, where knowledge from diverse fields such as biology, engineering, and culture that it can be synthesized to generate innovative solutions.

Therefore, the process of interpolating explicit knowledge is a vital tool for product designers seeking to create innovative, functional, and meaningful product identities. By synthesizing and blending knowledge from various domains, such as design mimicry, zoomorphism, and technical expertise, designers are able to generate new insights and solutions that transcend traditional design boundaries. Through this process, the role of the designer evolves from a mere form-giver to a strategic integrator of diverse knowledge systems, capable of creating designs that are both aesthetically innovative and ecologically responsible.

6.4.2 Extrapolative for an Implicit Knowledge

In product and ecodesign processes, implicit knowledge refers to the kind of understanding that is intuitive, experiential, and often difficult to articulate. It is developed through practice, reflection-in-action, and tacit reasoning that the elements central to designerly ways of thinking. When this implicit knowledge is extrapolated, designers project their intuitive insights and experiential understanding into new, abstract, or speculative design contexts. In other words, extrapolation of implicit knowledge involves extending what is felt or sensed through internal cognition into concrete design strategies or systems, often without relying on overt explanation. Within the context of the design pattern of semantic representation, extrapolative thinking becomes vital. The think-aloud methods and the use of design continuums such as the design continuum, transitional continuum, hypothetical continuum, and cognition continuum - function as channels through which designers access and extend their tacit insights. These continuums serve as cognitive scaffolds that allow designers to externalize their internal thought processes, making space for the extrapolation of implicit patterns and unspoken ideas into coherent semantic forms.

The semantic representation pattern is not limited to fixed meanings; rather, it evolves through experiential engagement, where implicit knowledge helps shape nuanced, context-sensitive interpretations. Designers, especially in iterative or open-ended processes, often work within non-linear, associative thinking modes, where meanings emerge gradually. The extrapolation process thus allows for forward-thinking projections, informed by felt experiences and design intuition, even when the outcomes are not yet fully formed or defined.

Furthermore, the fusion between recycling methodology and material usage provides a material anchor for these abstract continuum. Designers intuitively perceive affordances, environmental consequences, and material behavior, and extrapolate these perceptions into strategies for sustainable design. The interaction between materials and methods is not just technical but cognitively and semantically rich. It enables the designer to infuse meaning, ethics, and values into material choices and processes. These decisions, while not always explicitly documented, stem from deeply embedded knowledge - refined through practice and extended into future design potential.

Therefore, from this perspective, extrapolative thinking of implicit knowledge allows designers to operate across uncertain, ambiguous, and evolving domains,

extending internalized understanding into tangible design propositions. It complements explicit knowledge use by filling in gaps where logic alone is insufficient. Definitely, it shapes how designers create meaning-rich, sustainable, and adaptable outcomes within a fusion-based design logic grounded in ecological consciousness and material sensitivity.

6.5 Summary

The evolving landscape of ecodesign necessitates a redefined understanding of how future designers interpret and construct fusion identities in product development. This process is underpinned by a sequence of interconnected design strategies, methods, and knowledge frameworks that collectively guide the formation of ecologically responsible and semantically rich product identities via data evidences of research questions tabulated as Table 6.1. Hence, six points elaborates the meaning of the research title contexted as well, within three phases accordingly.

a) *First phase* - Firstly, the drawing process, fundamental in early design ideation, is actively stimulated by design mimicry. Designers engage with visual references—particularly from nature—through observational and representational sketching. This practice initiates a reflective mode of thinking that encourages the transformation of mimicked forms into innovative product visuals. Secondly, young designers frequently draw inspiration from visual elements (VEs) that exhibit morphological characteristics aligned with the zoomorphism approach. This strategy enables them to infuse emotional resonance and familiarity into products by referencing organic forms, enriching the symbolic and communicative aspects of design.
b) *Second phase* - Thirdly, the design pattern of semantic representation is pivotal for articulating ecological meaning. Through "think-aloud" designerly methods, involving design, transitional, hypothetical, and cognitive continuums, designers externalize and refine implicit knowledge into structured design reasoning. This fosters the development of critical systems thinking, one of the core competencies in sustainability education. Fourth, recycling methodology and material selection actively stimulate a fusion design approach by embedding sustainability into the early stages of ideation. This aligns with the SDG goals,

particularly Goal 12: Responsible Consumption and Production, by encouraging designers to assess lifecycle impacts, material renewability, and reuse systems, forming a holistic and informed sustainability practice.

c) *Third phase* - Fifth, the act of classifying the design theme becomes crucial in identifying how fusion emerges from the convergence of metaphorical visualization in industrial design and algorithmic digitization in engineering design. This interdisciplinary synthesis empowers future designers to employ anticipatory competency—the ability to envision and evaluate future-oriented design solutions that are adaptive, ethical, and context-sensitive. Sixth, the semantic representation of ecodesign identity is visualized through a Fusion Design Scheme, structured by a bubble model that links key impact areas with measurable outcomes. These metrics may include environmental performance, social impact, and user behavior shifts, aligning with SDG Goal 9: Industry, Innovation and Infrastructure, and SDG Goal 13: Climate Action.

Hence, sustainability competencies embedded in fusion design thinking are required. The future designer's role thus expands beyond aesthetic production into strategic sustainability integration, underpinned by several core competencies:

i) *Design or systems thinking competency* - Understanding interdependencies between design, material, environment, and society.
ii) *Anticipatory competency* - Projecting and managing the impacts of future design decisions on sustainability.
iii) *Strategic competency* - Applying vision-driven and innovation-focused strategies to integrate sustainability goals in product identity.
iv) *Normative competency* - Reflecting on values, ethics, and socio-environmental priorities when designing.
v) *Collaboration competency* - Working across disciplines to integrate knowledge systems; ecological, technological, and cultural.
vi) *Critical Thinking competency* - Questioning design conventions and proposing transformative alternatives that align with long-term sustainable outcomes.

Together, these competencies reinforce a design education model aligned with the SDGs, preparing future designers to interpret fusion identities in ecodesign as a platform for systemic change. The designer evolves into a sustainability agent, capable of translating tacit knowledge, ecological ethics, and digital innovation into solutions that embody a resilient, regenerative, and inclusive future.

Table 6.1
Finding Evidences of Answering Research Questions Tabulated

Prescriptive Study (PS) Stage; Research Questions 1, 2 & 3					
Grounded theory (Verbal protocol analysis - VPA)		**Assessment Method**	**Reliability**		**Percentage of consistency (%)**
			Credibility	**Transferability**	
1. What	Design scheme	Think aloud method	Thematic analysis	Semantics design	0.75 (75%)
2. How	Artefact categorization	Heuristic method	Quality review of procedure	Tacit pattern of design manuscript	53% - Highest frequently (N=8/15)
3. Why	New product development		Design of product positioning	Design identity identification	44% - Highest frequently (N=6/15)
	Design manuscript	Analytic Rubric Evaluation	Criteria, scaling and value	Evolution of form	80% - Very good proficiency level
Descriptive Study II (DS-2) Stage; Research Questions 4, 5 & 6					
Theory building (Design survey method)		**Measurement Method**	**Validity**		**Value of accuracy (*P*)**
			Internal	**External**	
4. What	Pilot as clinical survey	Correlation of variables	Nominal, ordinal and scale ranking	Rehearsal of small sampling	N=45, CA=0.812
5. What	Fieldwork as clinical survey	Pearson correlation*	Items' variables Sig. at the 0.01 & 0.05 level (2-tailed).	Generalization	N=45, P=54.496, *df*16, <0.05= Sig. 0.000
		Correlation coefficient*	Value interpretation - Strong	Setting population	N=45, <0.05= Sig. 0.040
		X2 Independence Test	Association - Strong	Labelling and bipolar adjectives	N=45, P=54.496, Gamma: 0.494 - X2(5x5)=62.2%
6. How	Instrumentation of items	Reliability analysis and coefficient	Cronbach alpha and Intraclass Correlation coefficient (ICC)		N=45, CA=>0.798 < 0.817

*Note: Non-parametric test

CHAPTER 7
CONCLUSION AND RECOMMENDATIONS

7.1 Conclusion

The research study's conclusion focuses on the knowledge contribution in an ecologically significant way for fusions' ecodesign identity under the output of ecodesign communication resulted previously. The researcher takes the initiative to highlight and clarify the brief explanations of hypothetical form contents in Monö model communication that come after the preceding chapters' reference of "product form imagery → verbalization ways (message) → design thinking (product) → product representations (attractiveness)." An optional method to explain the concepts and phenomena of think aloud is to use yet another detailed explanation. Because of design belief direction, many industrial designers adopt the widespread practice of reflecting on design-based experience. However, the research findings suggest that fusions' ecodesign identity provide knowledge to the studied issue in ecodesign communication. The outcomes should be roughly the same or similarly inlined along designing methods that it reflects the surrounding roles into the related design studies – under the model of experience. On an individual basis, the industrial designer addresses the metacognition of design thinking by means of a design belief (based on designing actions) that utilizes the orientation of word-of-mouth to design reputation.

In reality, the majority of pattern descriptions available for the area of industrial design are focused on the design processes involved in new product development (NPD). However, industrial designers' notion of think aloud designerly approaches is founded on physical functionality and objects' physic as the entire entity of product form identity, due to fusions' ecodesign concept and ideation of creative design thinking. Since this decade has seen the trending and/or fashioning of design concepts, the application of the well-known human-centered design (HCD) design process is growing in popularity. Further, the information of pattern descriptions, specifically the (1) thick description and the (2) thin description, must therefore be understood by awareness and response. Industrial designers use think aloud as a means of communicating their designs, and the importance of pattern in analogously framing these statements is in essence what represents this idea. To put it simply, let's break it down such Table 7.1

and change the thick descriptions to thin descriptions for each point in the hypothetical form study presented.

Table 7.1
Communication Study in The Comparison of Hypothetical Form Function Patterns

No.	Thick Description	Thin Description
1.	Product Form Imagery → Verbalization Ways (Message)	
	Short-term memories of a biomimicry design setting are evoked by the product's tactile visual features, which also resemble Gestalt Theory. In keeping with the inverted thinking for design attributes, this product form conveys an underlying message of cutting-edge technology and sustainable product development.	The product of biomimicry prefers ecodesign technology
2.	Verbalization Ways (Message) → Design Thinking (Product)	
	The product's form exhibits patterns that prompt the R&D team to strategize how to incorporate the most recent technology developments into the product's design. The design thinking methodology places a strong emphasis on human-centered design techniques, guaranteeing that the final product will not only have beautiful design but also offer state-of-the-art functionality and user experience.	The sign of patterns a focus on fusion ecodesign.
3.	Design Thinking (Product) → Product Representations (Attractiveness)	
	A product that smoothly integrates system thinking and is visually attractive is the outcome of the design thinking process. By taking into account the materials, components, and durability of the product - 3Rs' Methods improve its fusions' ecodesign identity and turn it into a highly appealing and functional product.	Design thinking elevates product form.
4.	Product Representations (Attractiveness)	
	While it comes to interpolative and extrapolative strategies and appealing to consumers' sense of design aesthetic and fashioning, the finished product must have excellent surfaces, graceful curves, and deliberate detailing. Its ability to demonstrate refinement and high design quality through beyond appearance is what makes the product representation captivating.	The product admires aesthetic identity.

Table 7.2
Waterfall Process for Fusions' Ecodesign Identity Revealed from Thin Descriptions Communication

Think-aloud	Message	Product	Attractiveness
Product Form Imagery → Verbalization Ways			
	The product of biomimicry preffers ecodesign technology		
	Verbalization Ways (Message) → Design Thinking (Product)		
		The sign of patterns a focus on fusion ecodesign.	
		Design Thinking (Product) → Product Representations (Attractiveness)	
			Design thinking elevates product form.
			Product Representations (Attractiveness)
			The product admires aesthetic identity.

In Table 7.2, thin descriptions simplify the specifics (Italic Bold), focusing on the primary message or concept at each stage rather than the surrounding background or elaborate details. Thick description pertains to a comprehensive depiction of a social phenomena, encompassing not just the acts or occurrences per se but also their context, significance, and interpretation. This concept is derived from the rigorous analysis of basic qualitative research. The aim is to offer a comprehensive comprehension of the cultural and social importance of an action or occurrence. In the meantime, a thin description provides the essential details without further context or interpretation. Because of the knowledge domain and the contextual relationship to the body of knowledge, the presentation of waterfall ecodesign information is suitably focused on the pillar structure of sustainable product design along ecodesign communication within the DRM frameworks.

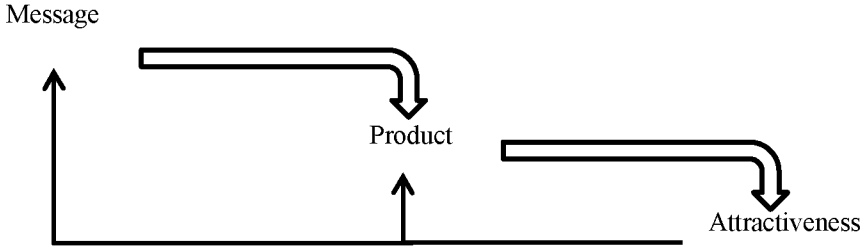
Table 7.3
The Development of Waterfall Model for Fusions' Ecodesign Identity

Word-of-Mouth To Design Reputation
(Message) The product of biomimicry preffers ecodesign technology
→ **(Product)** The sign of patterns a focus on fusion ecodesign.
→ **(Attractiveness)** Design thinking elevates product form.
The product admires aesthetic identity

Normally, a number of factors may lead to the modification of the conventional Waterfall process into a more straightforward three-stage approach. The (1) requirements, (2) design, (3) implementation, (4) verification, and (5) maintenance stages are the standard ones in the classic Waterfall model. These phases are linear and sequential in nature. However, faster iteration and change response are possible with a three-stage Waterfall approach that has been simplified. In Table 7.3, each step in a classic waterfall model is contingent upon the success of the preceding one, which might cause rigidity and delays in the event that modifications are required. Organizations are better able to adjust to new knowledge and modifications in project requirements when there are fewer steps involved. Simplifying the reasoning process might help it be easier to comprehend and follow, particularly for fewer young industrial designer or simpler projects. It lessens the overhead of handling several stages and paperwork, which in the conventional Waterfall approach can frequently become laborious.

Table 7.4
Structured Integration: Applying The Waterfall Model to Fusion Ecodesign Identity

Stage 1	Stage 2	Stage 3
Planning and Requirements	Design and Implementation	Testing and Deployment



Even while a condensed three-stage Waterfall model can have these advantages, it's crucial to remember that not all projects—particularly those that are extremely complicated or demand strict regulatory compliance—may be appropriate for it as Table 7.4. In these situations, the prescriptive qualitative study may still require more thorough phases and checks due to the think aloud metacognition that is communicated through design-based experience.

a) *Stage 1: Planning and Requirements* - This initial phase focuses on gathering and documenting all relevant user and stakeholder needs while formulating a strategic overview for development. It is guided by the conceptual influence of "product form imagery", which helps shape early design intentions.
b) *Stage 2: Design and Implementation* - In this stage, the design solution is formulated and refined, incorporating principles of ecodesign. The process is shaped through "verbalization ways" (techniques), enabling clearer articulation of design intent and sustainable objectives.
c) *Stage 3: Testing and Deployment* - The final phase involves testing the ecodesign solution, resolving any issues identified, and preparing the product for release. This stage draws on "design thinking" methodologies and "product representation" tools (visual) to validate and communicate the final product effectively.

Once more, the research study discovered that the research topic, "Elucidation of Future Designers Interpret the Identity of Fusion in Ecodesign," discusses how to understand designerly ways of thinking aloud throughout the prescription of designing activities among the design group and / or organizations. This allows for verbal communication through the orientation of word-of-mouth to design reputation via design society. Regarding the awareness of using the pattern description such as thick/thin description has occurred and especially mentioned, depending on the individual who has significantly given the knowledge domain, niche, and specialized abilities into the fewer group that it is very significant to them. As a consequence, responses to the prescribed activities are mirrored in everyday language and the voices of design development approaching ecodesign communication.

However, the effectiveness of thick/ thin description understanding impacts the essential of Triple Helix model as suggested by researchers' conclusion that academics agenda purposeful for Malaysian ministry of higher education (MOHE) itself. In Figure 7.1, the Triple Helix model, which involves the interaction between (1) university, (2) industry, and (3) government, plays a significant role in driving innovation, economic development, and knowledge transfer in many countries, including Malaysia. By promoting collaboration between universities, industry, and government, the model helps align academic research with industrial needs, enhances human capital development, supports national development goals, and fosters regional economic growth into the 17th sustainable development goals (SDGs). The Malaysian government actively supports this model through policies, funding, and infrastructure, recognizing its importance in building a knowledge-based economy and achieving sustainable development.

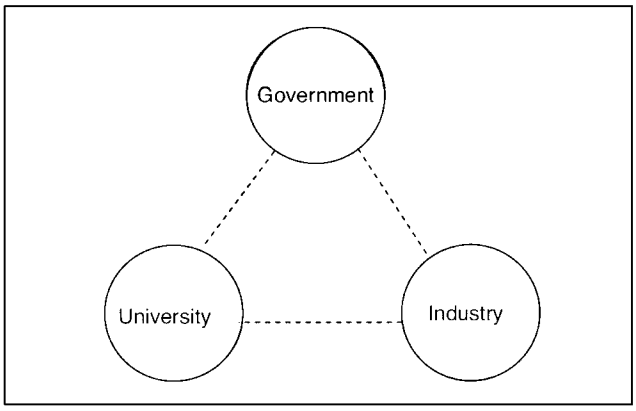


Figure 7.1 The Laissez- faire Model in The Triple Helix I

Source: Etzkowitz and Leydesdorffr (2000) and Etzkowitz (2008)

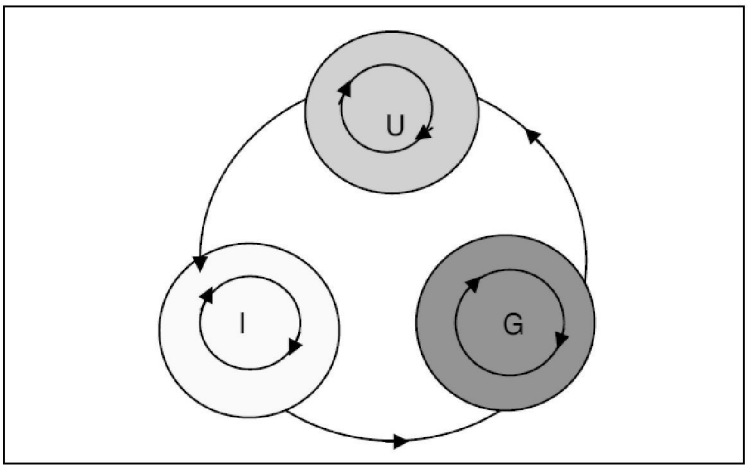


Figure 7.2 Circulation of individuals in The Triple Helix

Source: Etzkowitz and Leydesdorffr (2000) and Etzkowitz (2008)

In Figure 7.2, the diagram depicts the Triple Helix model, which reflects the interactions and circulation of individuals amongst three important entities: university (U), industry (I), and government (G). In this model, various organisations collaborate to promote innovation, knowledge production, and economic development. The diagram's arrows connecting the University, Industry, and Government represent the dynamic flow of knowledge, resources, and persons between these three entities. These relationships are critical for building a strong innovation environment.

Consequently, the following three categories highlight the three elements of the Triple Helix model: (1) design education, which aims to improve teaching and learning techniques in universities; (2) design practitioners, who establish a reputation for their R&D departments in the manufacturing of products and/or industry; and (3) the industrial design field, which supports the standards and design ecosystem in line with the ministry policies agenda of the Malaysian government. Moreover, educational institutions are increasingly adopting the Quadruple Helix model to bridge gaps between education and industry. A prime example is The Ship Campus, located within the Batu Kawan Industrial Park (BKIP) in Penang, Malaysia. This innovative campus embodies a synergistic collaboration among (1) academia, (2) industry, (3) government, and (4) civil society.

The Ship Campus serves as the national headquarters for Peninsula College Malaysia, offering a diverse range of programs in logistics management, business, accountancy, tourism, and computer studies. Its unique Campus-in-Industry model situates the educational institution directly within an industrial park, facilitating

seamless integration between theoretical learning and practical application. Students benefit from close collaboration and part-time employment opportunities with industry partners, gaining invaluable real-world experience while pursuing their studies. The campus boasts state-of-the-art facilities designed to accommodate students, tenants, and the broader BKIP community. These amenities support a wide array of activities, including Technical and Vocational Education and Training (TVET) upskilling, events, and leisure pursuits. Such infrastructure fosters an environment conducive to innovation and continuous learning. Furthermore, The Ship Campus actively engages with government initiatives and community leaders to align its educational offerings with national development goals. Scholarship programs and partnerships with local polytechnics underscore its commitment to social responsibility and community upliftment.

Complementing this approach, Universiti Malaysia Pahang (UMP) has implemented the Teaching Factory concept, where students are taught by experienced faculty in environments that closely resemble actual industries. This setup prepares students for real-world challenges by integrating practical skills with academic learning. The initiative aligns with the university's commitment to producing industry-ready graduates equipped with both theoretical knowledge and hands-on experience.

Similarly, Universiti Teknikal Malaysia Melaka (UTeM) has introduced the "Teaching Factory 2.0" approach. This model emphasizes long-term, project-based learning, allowing students to engage in product development projects over multiple semesters. The process involves stages from design briefs to pre-production prototypes, fostering collaboration between students, educators, and industry partners. This approach not only enhances students' technical competencies but also cultivates essential soft skills such as teamwork and problem-solving.

Additionally, Universiti Tun Hussein Onn Malaysia (UTHM) at its Pagoh Campus has adopted the Teaching Factory model to enhance the quality of teaching and learning in industry-based courses. By providing students with hands-on experience in real-world industrial environments, UTHM Pagoh collaborates with various industry partners to offer practical training. This ensures that students are well-equipped with the necessary skills and knowledge to meet industry demands, aligning with the university's mission to produce competent and employable graduates.

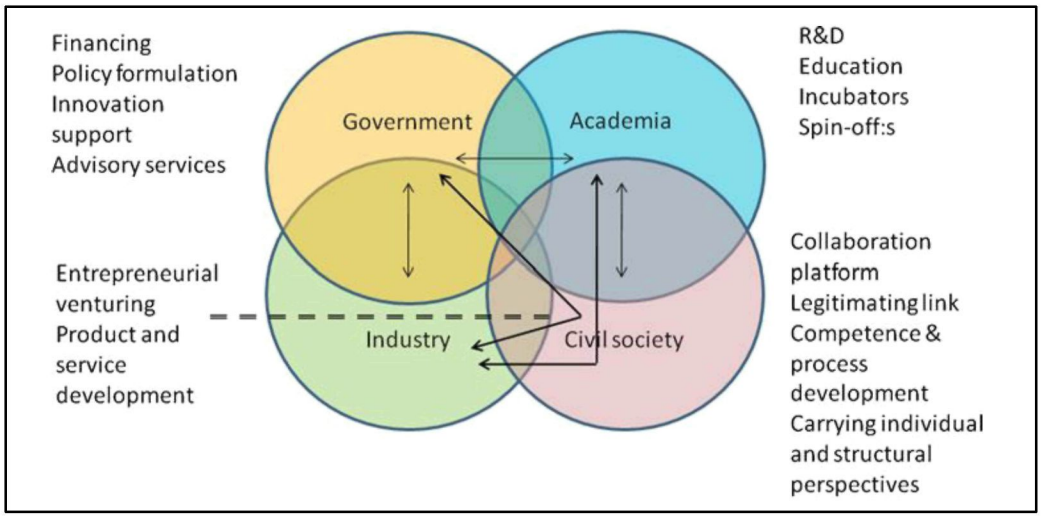


Figure 7.3 The Quadruple Helix Model

Source: Lindberg, Lindgren and Packendorff (2012)

In Figure 7.3, by integrating the Quadruple Helix model, institutions like The Ship Campus, UMP, UTeM, and UTHM Pagoh Campus exemplify how educational institutions can serve as catalysts for innovation, economic growth, and societal well-being. Their holistic approaches ensure that graduates are not only academically proficient but also equipped with the practical skills and experiences necessary to thrive in a dynamic global economy. Therefore, in alignment with the sustainability competencies outlined in Quadruple Helix studies, the strategic implementation of the Fusion Design Scheme - characterized by the integration of diverse cultural and technological dimensions; serves as a central mechanism for advancing innovative approaches to design thinking. This approach is further structured through the Waterfall Model for Fusion's Ecodesign Identity, providing a sequential framework - encompassing stages from requirements analysis to maintenance, that ensures sustainability is embedded throughout the design process. Together, these methodologies enhance the synergy between academia, industry, government, and civil society, aligning educational outcomes with the demands of a globally interconnected and environmentally conscious market.

7.1.1 Design Education

Problem -based learning (PBL) studies emphasize the understanding of novice or young industrial designer (students) by giving students real-world problems to solve

and requiring them to research, work together, and come up with a solution. The need to address the problem based on the product design pragmatically, which gives the knowledge being learned context and relevance, drives the learning process. In order to solve problems, learners must take into account a variety of viewpoints since they frequently interact with stakeholders that are affected by the issue. Those impacted by the issue must have their needs met by the solution and its methodology.

PBL uses an iterative approach to determine what they already know, what they still need to learn, and how to use the new information to solve the problem. This frequently entails cycles of study, ideation, idea testing, and method improvement. PBL promotes cooperation among students, many of whom come from different academic backgrounds or specializations, in order to add a variety of viewpoints to the problem-solving process.

Table 7.5
The Refinement of Design Pedagogy: The Significant Biomimicry Design Concept

No.	Biomimicry Studies* and Methods	Teaching and Learning (T&L)	
		Design Thinking	System Thinking
1.	Understanding biology, ecology, and engineering.	√	√
2.	Addressing global environmental challenges and promotes responsible design practices.	√	√
3.	To meet these market demands and lead the way in sustainable innovation for the positioning for future trends	-	√
4.	Integrating ecodesign and biomimicry into design education reveals ethical design practise and thinking.	√	-
5.	To draw inspiration from natural processes and organisms.	√	-
6.	Social responsibility impact awareness can lead to the development of products.	√	√
7.	Creating unique product concepts develop a unique identity	√	-
8.	Holistic approach to problem solving.	-	√
9.	Encouraging experimentation to use the biomimicry and ecodesign principles.	√	√
10.	LCAs facilitate recycling and end-of-life management.	-	√

*Note: The Requirements of Knowledge-based View for Fusions' Ecodesign Identity

This is similar to real-world circumstances where cooperation is crucial. As an outcome, reflection is an essential component of PBL, when students evaluate their own learning, the viability of their ideas, and the things they could have done better. This metacognitive feature improves one's capacity for learning and solving problems.

However, design pedagogy integrates PBL approach, studio projects, prototyping, critiques, and user research to develop students' contextual, pragmatic, and empathetic reasoning; promoting reflective practice, interdisciplinary thinking, and collaboration essential for addressing real-world challenges in industrial design education.

Therefore, some of the ways that the teaching and learning program (T&L) and learning module have been refined to address the particular fusions' ecodesign identity have been detailed by the study. Design pedagogy can use ecodesign concepts, including biomimicry, to assist students internalise the value of sustainability. This is achieved by using an understanding of ecodesign principles. Students acquire the skills to design goods that are sustainable, economical, and have little effect on the environment by using the life cycle of nature as a model. In practice, however, the development of ecodesign principles into teaching and learning methods - especially when biomimicry is employed that it can greatly influence how novice or young industrial designers define themselves and their potential. Students can develop a more creative, sustainable, and forward-thinking mindset through design programs by incorporating these ideas into the curriculum. The following summarises the significance of this refinement for the biomimicry design concept refers to Table 7.5.

For the advancement of upcoming industrial designers, it is also crucial to improve design pedagogy to include ecodesign and biomimicry concepts. It gives them the identities, perspectives, and abilities necessary to meet consumer demands for sustainable products and tackle today's environmental issues. Such an approach not only prepares students for successful professions but also advances the larger objective of sustainable development by encouraging creativity, improving problem-solving skills, and supporting ethical design practices. In the end, goods that are not only creative and useful but also ecologically and socially conscious are produced as a result of this connection with nature-inspired, sustainable design.

It is essential to identify and match learning outcomes in the context of knowledge-based view (KBV) for experience or design pedagogy to make sure that students gain practical skills, critical thinking, and creative problem-solving talents in addition to theoretical knowledge. The categories of learning that results generally fall into are referred to as learning outcome domains (LOD). The three most prevalent domains are (1) cognitive, (2) psychomotor, (3) affective and (4) knowledge. These domains are very important in design education because they address the complexity of design practice ecspecially addressing the specific verbs of T&L activities. The

following are some significant findings from the LODs study about ecodesign knowledge and experience pedagogy are according to the Circular Taxonomies introduced by an academic expert Simon Paul Atkinson (PhD) – suitable for design studio laboratory,

i) *Cognitive domain (Intellectual Skills)* - In order to comprehend ecodesign principles, sustainable and environmental theories, and life cycle methods, it is imperative that one engages in critical thinking, analysis, and synthesis within this domain. By developing a strong theoretical foundation, students' practical work is informed by their cognitive outcomes – C2/ C3/ C4; Apply/ Analyse/Evaluate.
ii) *Psychomotor domain (Practical, Technical and Transferable Skills)* - Being a practical field, ecodesign demands the acquisition of concrete abilities like modelling, prototyping, drawing, and algorithmically employing design software. The domain's outcomes guarantee that students can utilise KBV for fusions' ecodesign identity in real-world situations to produce both visually beautiful and functional solutions – P2/ P3/ P4; Manipulate/ Perfect/ Articulate.
iii) *Affective domain (Professional and Personal Skills)* - The formation of attitudes, values, and ethics falls within this category. Developing a mindset that prioritises sustainability, ethical responsibility, empathy for consumers, and openness to feedback is crucial for industrial design field. The LODs in this area help students grow both personally and professionally, training them to become novice or young industrial designers who are socially responsible – A2/ A3/ A4; Respond/ Value/ Organise.
iv) *Knowledge Domain (Subject and Discipline Knowledge)* - This domain encompasses foundational and advanced understanding of industrial design theories, sustainability frameworks, materials science, and design thinking versus systems thinking. Mastery in this area ensures students grasp core subject matter and are able to integrate interdisciplinary knowledge effectively when addressing complex ecodesign challenges in both academic and professional contexts – K2/ K3/ K4; Contextualise/ Conceptualize/ Process.

When considering the T&L activities or techniques situation in its entirety, as well as the influence of novice or young industrial designers in a design studio laboratory, PBL offers a strong framework that is very compatible with the needs and characteristics of the ecodesign industry. PBL activities offers substantial benefits that give beginning or young industrial designers the algorithmically and mindset-driven tools they need to succeed in their careers by helping them (1) develop practical skills, (2) improving problem-solving abilities, (3) fostering collaboration, (4) encouraging creativity, and (5) preparing them for real-world challenges. As a result, the application of design scheme fusions' design (referring to the findings and research answered) is clearly appropriate, and it is suitable for the beginner or novice industrial designers to approach the ecodesign process formatting in producing the fusion ecodesign identity of SfPD creation.

Also, the waterfall model for fusions' ecodesign identity is a step-by-step approach to project management and product development. It is commonly employed in software engineering (system thinking), but it may also be used to other industries, such as product design and development, such as establishing a fusion ecodesign brand identity. This approach contains distinct, well-defined stages that must be accomplished before going on to the next one. Its emphasis on detailed requirements gathering, methodical testing, and documenting makes it appropriate for projects requiring clear milestones and predictability. While the waterfall model may not be as adaptable as more iterative techniques (e.g., Agile), its linear character gives considerable benefits in situations where clear, predefined processes and outputs are essential for project success. This makes it an excellent alternative for creating ecodesign identity products that meet high quality, functionality, and environmental standards.

Last but not least, students intent on graduating must possess the ability to present real-world projects. PBL's desiging portfolio gives aspiring designers the chance to work on actual projects that they may showcase in their portfolios. Employers find them more appealing when candidates complete projects that showcase their creativity, problem-solving talents, and practical capabilities. The PBL's emphasis on problem-solving enables students to develop a portfolio that demonstrates their versatility and adaptability across various design challenges contexts. This portfolio is intended to address and recognise a proficiency and/or graduate competency in talent management organisation. Simultaneously, the requirement for exposure to a diverse range of projects refers to this concept itself.

7.1.2 Design Practitioners

Understanding user demands and real-world challenges is the first step in the design process in the human-centered design (HCD) research. Industrial designers prioritize the needs of the user throughout the entire process by empathizing with them, defining the problem, ideating, prototyping, and testing solutions. HCD is naturally user-centered for the user/stakeholder-centered approach, necessitating a deep understanding of users' needs, behaviors, and pain areas on the part of designers.

In order to make sure the solution is practical and easy to use, the design process is iterative and involves continuous user feedback. After that, HCD uses iterative cycles of testing, prototyping, and design refinement in response to user input. Because of the method' flexibility, designers are able to review and update their understanding of the issue and its resolution whenever new information becomes available. In order to build a product that is not just functional but also desired and viable, HCD also places a strong emphasis on cooperation, frequently needing input from several disciplines (e.g., design, engineering, marketing). Collaboration and transdisciplinary learning are clearly connected with HCD. Iterative design leads to continual improvement in both the design and the process by encouraging designers to evaluate the design process, collect feedback, and analyze what worked and what didn't. Meanwhile, PBL and HCD Learning have a similar approach to product design that is based on solving real-world problems, utilizing user/stakeholder-centered methodologies, iterative processes, collaboration, and reflection. Both approaches seek to produce solutions that are useful, user-centered, and pertinent to the given environment, which makes them effective instruments for both practice and instruction in product design.

On the reflection of the HCD process, the research and development department (R&D) of a manufacturing organisation is essential to the process of creating fusion ecodesign products. This involves integrating ecological sustainability concepts with innovative design methodologies, frequently making use of interdisciplinary or cross-disciplinary processes and cutting-edge technologies.

For technologists as industrial designers employed in this domain, it is imperative to emphasise certain key actions. The aims of producing useful, visually pleasing, and ecologically responsible products are in line with these activities of key actions. The research study was classified based on how R&D activities responded to the KBV for the fusions' ecodesign identity. A total of eighteen classifications have

been made in order to correlate and characterise each design practitioner. Below is a thorough explanation of these crucial actions as Table 7.6.

Table 7.6
Classifying of R&D Activities Reactions to KBV for Fusions' Ecodesign Identity

No.	Classification of R&D Activities	Description	KBV for Fusions' Ecodesign Identity		
			Cog.	Psy.	Aff.
1.	Design, Research and Product Innovation	New product development (NPD) and sustainable for product development (SfPD)	√	√	√
2.		Softwares, design technology and rapid protoyping	√	√	√
3.		marketing, branding and advertising	√	-	√
4.	Networking, Digitals and Internet of Things (IoT)	Design visualization, communication and project management	√	√	√
5.		Operational data, devices and smart manufacturing	√	-	√
6.	Manufacturing Technology and Precision Tooling	Lean and green manufacturing, design for disassembly (DfD) and design for manufacturing (DfM)	√	√	-
7.		Lifecycle assessment (LCA) of materials and carbon foot print.	√	√	√
8.	Quality Assurannce System, Standards, Methodology and Approach	ISO families, quality management systems and TQM system	√	√	√
9.		Continuous improvement cycles	√	√	√
10.	Safety and Standards Regulations	Ergonomics, performance and environmental testing	-	√	√
11.		Product standards certification	-	√	√
12.		Regulatory compliance and standards adherence	√	√	-
13.	R&D Expenditures	Intellectual property (IP) management	√	-	√
14.		Product license, product research and collaboration	√	-	√
15.	Professional Training and Skills Competency	Professional, technologist and skills competency courses	√	-	√
16.	Leadership Recognition and	International design competition, design awards and exhibitions.	√	-	√

	Contribution				
17.	Socials and	Corporate social responsibility programs	-	√	√
18.	Communities	Social media, applications, connectivity	√	-	√

Legends: Cognitive domain = Cog.; Psychomotor domain = Psy.; and Affective domain = Aff.

Nonetheless, in the preceding scenario, the manufacturing R&D department's primary initiatives must be highlighted in accordance with the professional practices of technologists. Indeed, an R&D department's target areas and operations can differ based on the manufacturing model the company uses, such as (1) original equipment manufacturer (OEM), (2) original design manufacturer (ODM), and/or (3) original brand manufacturer (OBM). In the process of developing new ecodesign products, each of these models has certain duties and responsibilities that impact the objectives, procedures, and priorities of the R&D department. Therefore, using their own manufacturing model, the decision-making process for implementing the process of developing fusion ecodesign products is clearly different.

Generally, creativity, sustainability, and efficiency are at the core of the R&D department's main efforts in the production of fusion ecodesign goods. Ecodesign product development, process optimisation, environmental standard compliance, and sustainable material research are all included in this list of activities for technologists. Technologists may help create sustainable products that nevertheless have a high level of usability and aesthetic appeal by concentrating on these areas. The company maintains its competitive edge and leads the way in sustainable product design thanks to other factors including efficient IP management, cross-disciplinary cooperation, and continual improvement.

7.1.3 Industrial Design

In the field of industrial design, the study concludes two waves of knowledge contribution namely (1) knowledge-based view of fusions'ecodesign identity in design scheme works or practise for the professional industrial design society, (2) protection of intellectual property rights and contribution of enhancing National, (3) knowledge transfer contribution between academic instituitions - problem-based learning and industry organisations - human-centered design (HCD) learning, and (4) Enhancing the

Malaysian government and ministries through a national grant scheme and policy agenda.

First, a firm's knowledge-based view (KBV) prioritises knowledge as the most strategically significant resource for attaining a competitive advantage. The KBV is important for the professional industrial design society for a variety of reasons when it comes to fusion ecodesign identity in design plan work or practice. Industrial designers may build creative and sustainable solutions that fulfil modern environmental and market demands by successfully using their knowledge base. The knowledge-based perspective is critical for the successful creation and application of fusion ecodesign identity in industrial design activities. Professional industrial designers may encourage innovation, promote sustainable practices, foster cooperation, and boost market competitiveness by efficiently exploiting knowledge. It promotes strategic alignment with regulatory requirements and market trends, improves organisational learning, and fosters ethical and responsible design practices. Embracing the KBV enables designers to create things that are not only functional and visually beautiful, but also environmentally friendly, leading to a more sustainable future for the industrial design sector.

Second, The Industrial Designs Act 1996 (Act 552), which is governed by the Intellectual Property Corporation of Malaysia (MyIPO), may provide protection for products with ecodesign identities. The Act offers a framework for legally registering and safeguarding product designs, especially those that emphasise ecodesign or sustainable elements. A legal framework is available to safeguard the distinctive visual elements and aesthetics of ecodesign identity items. The safeguarding of creative efforts by designers and firms that prioritise sustainability is ensured by the protection against unauthorised use and imitation. While trademarks and patents are examples of additional intellectual property rights that can be used to fully protect the creative characteristics of ecodesign products, the Act primarily covers visual design elements. Taken together, these safeguards promote investment in environmentally friendly innovation in Malaysia and aid in the expansion of sustainable product development.

Third, in the wave of of knowledge transfer contribution, that there is potential for concurrent knowledge transfer divided by two area entities: (1) academic institutions using PBL and (2) industrial organizations using HCD learning. The development of tools to transfer knowledge between these two entities can greatly accelerate the production of creative, useful, and user-centred solutions. Each learning style has

distinct capabilities that can complement one another. A Memorandum of Intent (LOI), Memorandum of Understanding (MOU), or Memorandum of Agreement (MOA) are three documents that can be intentionally and strategically used to support knowledge exchange and collaboration in order to bridge the gap between academic institutions using PBL and industrial organisations using HCD learning. Important bridge tools that can improve concurrent knowledge transfer include the following: (1) cooperative projects; (2) joint workshops; (3) shared digital platforms; (4) internship programs; (5) co-developed courses of study; (6) research collaborations; (7) advisory boards; (8) design competitions; and (9) mentorship programs. These are agreements based on mutual understanding between two parties. By putting these tools to use, educational institutions and business organisations may foster a collaborative atmosphere where theory and practice support and enrich one another, resulting in more creative, user-focused, and environmentally friendly design solutions. Common practice in academic institutions is to focus on how well students comprehend concrete knowledge domains from design education teaching and learning approaches that may be applied to industrial organisations. For instance, this can be seen in how newly graduated industrial designers navigate a new workplace and strive for positions with challenging responsibilities in the field of product manufacturing. For young industrial designers to be truly competent, both hard and soft skills are crucial. PBL and HCD are essentially design and instructional methodologies that center on real-world problem solving. Although PBL in education and HCD in design come from distinct backgrounds, their approaches to product creation have a lot in common.

Fourth, The Science, Technology, and Innovation (STI) Policy: National Science, Technology, and Innovation Policy 2021–2030 under Ministry of Science, Technology, and Innovation (MOSTI) is referred to in other government service efforts since it is associated with product innovation. In order to facilitate the creation of a fusion ecodesign identity in sustainable product design, MOSTI offers a thorough framework. The policy fosters innovation by promoting green technologies, improving research and development, allowing information transfer, supporting economic growth, and cultivating a sustainable culture. These initiatives not only support international sustainability objectives but also establish Malaysia as a pioneer in environmentally friendly design and innovation, promoting economic expansion alongside environmental preservation. As an alternative, the Malaysian Law: Technologists & Technicians Act 2015 (Act768) The National Science, Technology, and Innovation

Policy, among other policies, outlines Malaysia's national aspirations for sustainability, which are in keeping with the recognition granted by MBOT to industrial designers. Environmental impact reduction and sustainable development are national goals that industrial designers may actively support. In addition to supporting innovation, ensuring quality and ethical standards, and aligning with national sustainability goals, it also increases their professional credibility. Ecodesign product is becoming an increasingly important aspect of Malaysia's technology and environmental landscape because to the recognition and support system that helps to progress the Therefore, by developing ecodesign goods that are both marketable and beneficial to the environment, qualified professionals may support economic growth. Malaysia's standing in the international green market can be improved by the products' capacity to appeal to an expanding group of customers who acknowledge sustainability.

7.2 Recommendations

Further research into the successful interpretation of fusion ecodesign identity within the context of a globalized society is crucial for advancing sustainable product design. The fusion design scheme functions as a strategic approach that integrates diverse cultural aesthetics and sustainable practices, enabling designers to create products that resonate across various cultural contexts. This scheme facilitates the blending of traditional design elements with modern sustainability principles, ensuring that products are both culturally relevant and environmentally responsible.

Research should focus on understanding how different cultural values and consumer preferences affect the acceptance of fusion ecodesign products. This understanding can help future designers tailor products to meet the diverse needs and expectations of global markets while maintaining sustainability. Investigating methods for adapting fusion ecodesign identity to various cultural contexts without compromising its core principles is essential. This could include the use of culturally significant materials, design motifs, or production techniques that resonate with specific cultural groups.

To systematically implement fusion ecodesign identity, the Waterfall Model can be applied as a structured development framework. This model involves sequential phases such as requirements analysis, system design, implementation, integration and testing, deployment, and maintenance - ensuring thorough planning and documentation

at each stage. By following this linear approach, designers can methodically incorporate cultural insights and sustainability goals into the product development process, allowing for clear milestones and reducing the risk of overlooking critical factors. The Waterfall Model's emphasis on detailed documentation and phase completion before progression ensures that the fusion of cultural elements and ecological considerations is deliberate and cohesive throughout the design lifecycle.

In alignment with the structured design lifecycle of the Waterfall Model, knowledge eco-innovation emerges as a pivotal mechanism to navigate the complexities of globalized societies. This model's sequential phases—ranging from requirements analysis to maintenance - provide a disciplined framework that can be instrumental in addressing global environmental challenges. Globalist societies have increasingly prioritized environmental health over traditional concerns such as security and safety, especially prevalent in more statist systems. This shift underscores a collective recognition of the intertwined nature of environmental well-being, economic stability, and societal health. Such a focus propels innovation in green technologies, renewable energy, and sustainable products. The Waterfall Model's emphasis on thorough documentation and phase-wise progression ensures that eco-innovative solutions are systematically developed and implemented. This structured approach facilitates international collaboration, as seen in globalist societies that support environmental agreements and standards, emphasizing transparency and shared responsibility. Moreover, the model aids in the effective transfer of knowledge and eco-innovation through cross-border collaborations, international research partnerships, and global supply chains. By adhering to a disciplined development process, the private sector, including multinational corporations, can invest in sustainable practices and technologies that resonate with environmentally conscious consumers worldwide.

In essence, the Waterfall Model's design lifecycle not only supports the structured development of sustainable products but also aligns with the globalist agenda of fostering environmental health, economic growth, and societal well-being through knowledge eco-innovation. Thus, certain concerns pertaining to the relationship between Malaysian design community / academic research society and fusions' ecodesign identity have been discovered through study studies. Putting a strong emphasis on knowledge transfer explanations will result in both explicit and tacit knowledge, according to the results of the current study. The suitability of fusions' ecodesign tool for sustainable product development as a tool for design practitioners in

Malaysian design community / academic research society can be explored and prioritised for future research. The research study offers the following optional proposal research in this case,

a) *Explicit knowledge for the identity of fusion in ecodesign* - Fusion ecodesign principles can be more easily adopted by Malaysian design practitioners (industry players) such as PEREKA Malaysia society with the support of clear information resources. For example, designers can find it easier to incorporate eco-friendly techniques into their workflows if they have access to comprehensive guides and guidelines on sustainable design. This knowledge can be efficiently disseminated through seminars, training programs, and educational materials to ensure that practitioners are up to date on the most recent sustainable design approaches using fusion ecodesign.
b) *Tacit knowledge for the identity of fusion in ecodesignn* - To foster innovation in fusion ecodesign, the Malaysian design community or academic research society believes that exchanging implicit knowledge is essential. The transmission of tacit knowledge can be aided via teaching factory using cooperative projects, workshop, teaching of thought (ToT), mentoring programs, and community involvement initiatives. Younger or fewer experienced industrial designers can learn about the subtleties of making ecodesign products that satisfy local identity requirements as well as international sustainability criteria by collaborating closely with more seasoned designers and taking part in real-world projects.

Lastly but not least, in light of the divergent structures and strategic roles within various manufacturing models such OEM, ODM, and OBM. It is critical that future designers comprehend how fusion in ecodesign is contextually implemented across different industrial environments. These organizational models differ in terms of design ownership, R&D scope, and brand influence, which directly affects the integration of sustainable principles, innovation practices, and ecological value. Each model can be strategically aligned with specific Sustainable Development Goals (SDGs):

i) *OEM* - Typically focused on contract manufacturing, OEMs operate with

externally provided specifications. In this context, SDG 12: Responsible Consumption and Production becomes central. Future designers working within OEMs must develop competencies in eco-efficiency, material substitution, and lifecycle assessment, ensuring that sustainability is upheld despite limited control over product ideation. Design interventions here must focus on optimization and compliance, enhancing sustainability within predefined systems.

ii) *ODM* - ODMs are responsible for both design and manufacturing, offering greater flexibility. This model supports SDG 9: Industry, Innovation and Infrastructure, as it encourages co-development and innovation within the product lifecycle. Future designers in ODM settings must act as sustainability negotiators, balancing client expectations with ecological design standards, while integrating semantic and material fusion that reinforces brand identity and environmental responsibility.

iii) *OBM* - OBMs control the full value chain, from R&D to branding and marketing. This model strongly supports SDG 13: Climate Action and SDG 11: Sustainable Cities and Communities, as OBMs have the capacity to lead systemic transformation. Here, designers can fully embed fusion ecodesign strategies into brand narratives, product functions, and market positioning, thus shaping resilient and adaptive product identities that reflect both cultural insight and environmental stewardship.

To prepare future designers for these contexts, design education and R&D collaboration models must evolve. Curricula should be restructured to emphasize interdisciplinary thinking, including systems design, sustainability science, innovation management, and cultural semiotics. Furthermore, design studios and industrial training programs must simulate real-world manufacturing environments, encouraging students to adapt ecodesign strategies based on their position within the production chain.

Overall, the pathway toward meaningful fusion in ecodesign is dependent upon a designer's ability to interpret, negotiate, and lead within the manufacturing model they operate in. Designers must evolve into strategic integrators, capable of aligning design form and function with technological innovation, sustainable development goals, and industrial feasibility. Through this alignment, designers will not only enhance product

identity but will also actively contribute to the ecological transformation of the design industry, supporting the SDGs through intentional, context-aware design practice.

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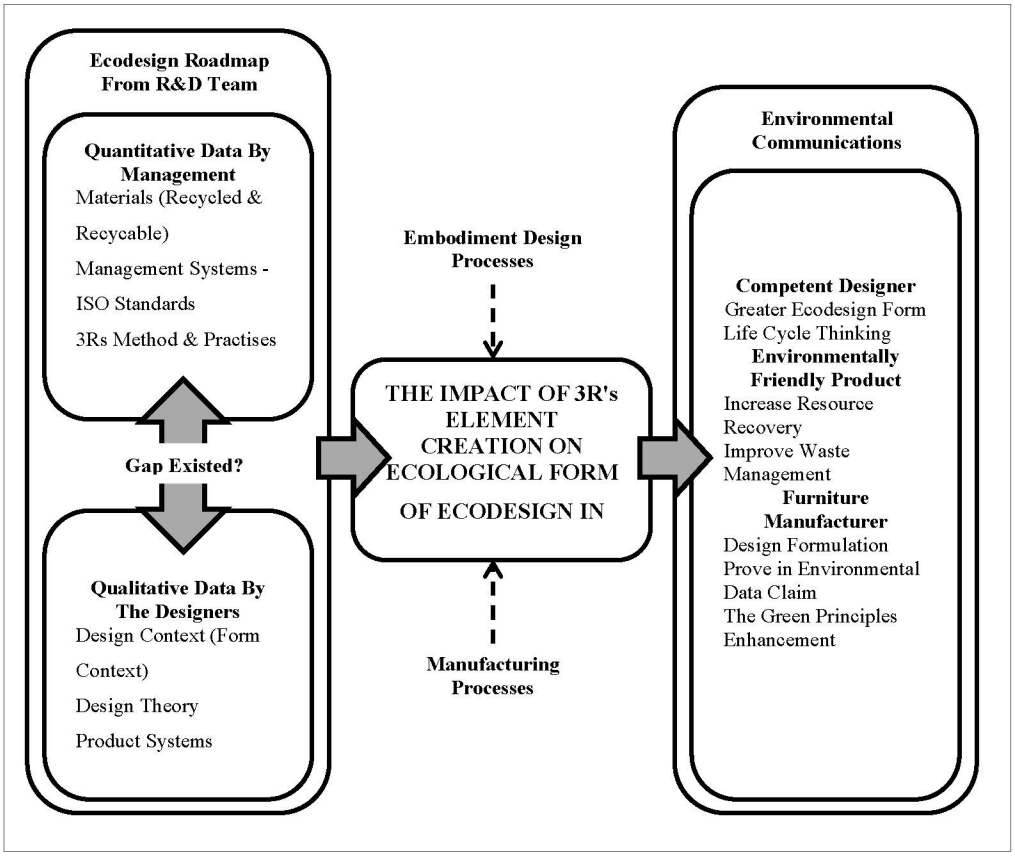
Yilmaz, S., Daly, S. R., Seifert, C. M., & Gonzalez, R. (2011). Evidence-based design heuristics for idea generation. *Design Studies, 32*(3), 221–249. https://doi.org/10.1016/j.destud.2011.01.001

APPENDICES

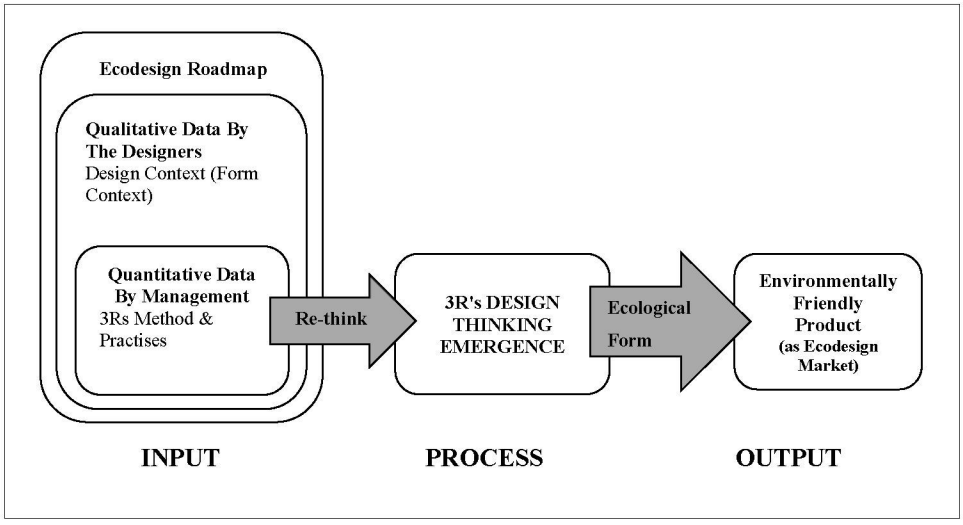
APPENDIX 1

The Establishment of Theoritical Framework: DS-1 Stage Conception

a) An early investigation of MA study

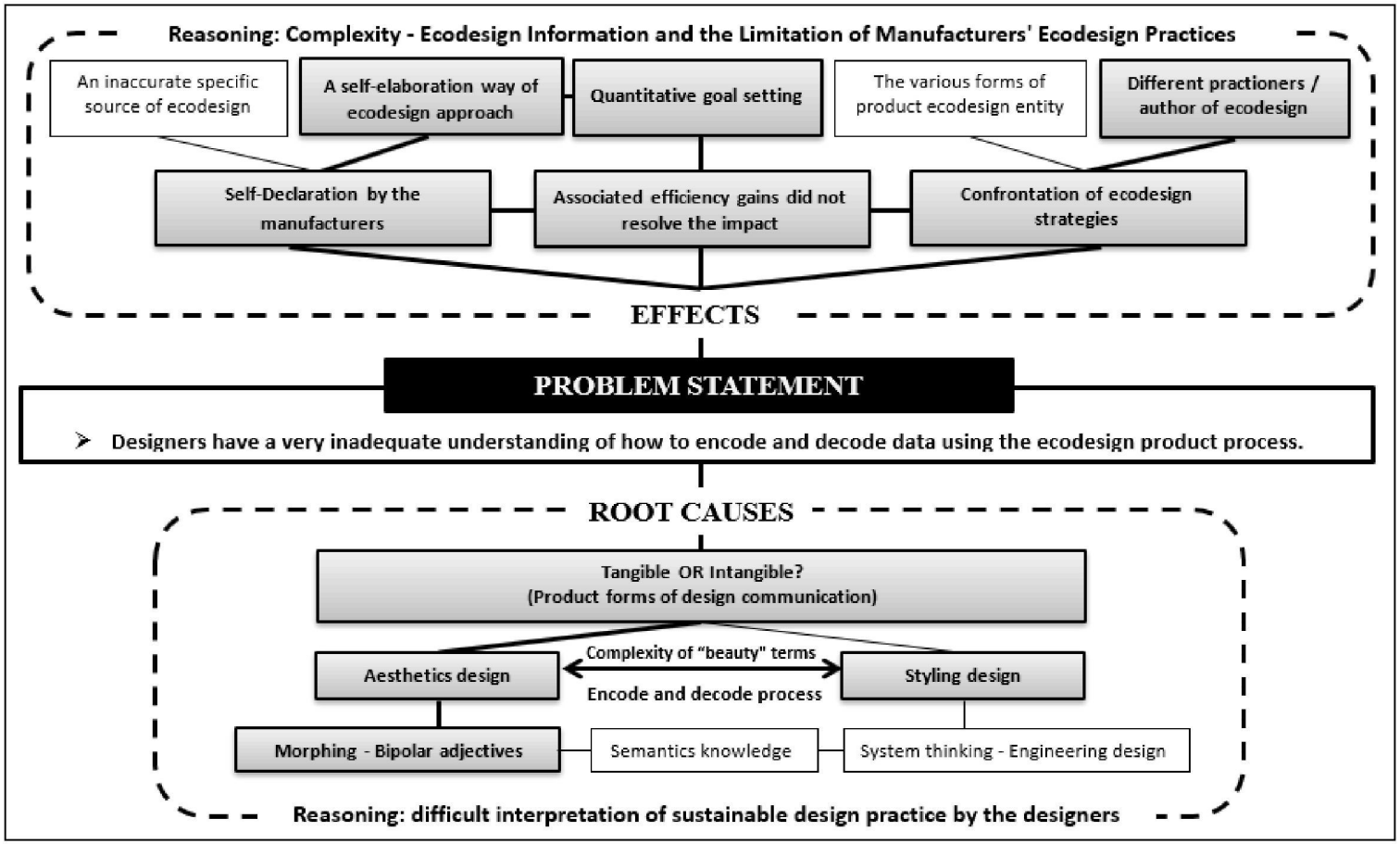


b) After research study (as a whole design activity)



APPENDIX 2

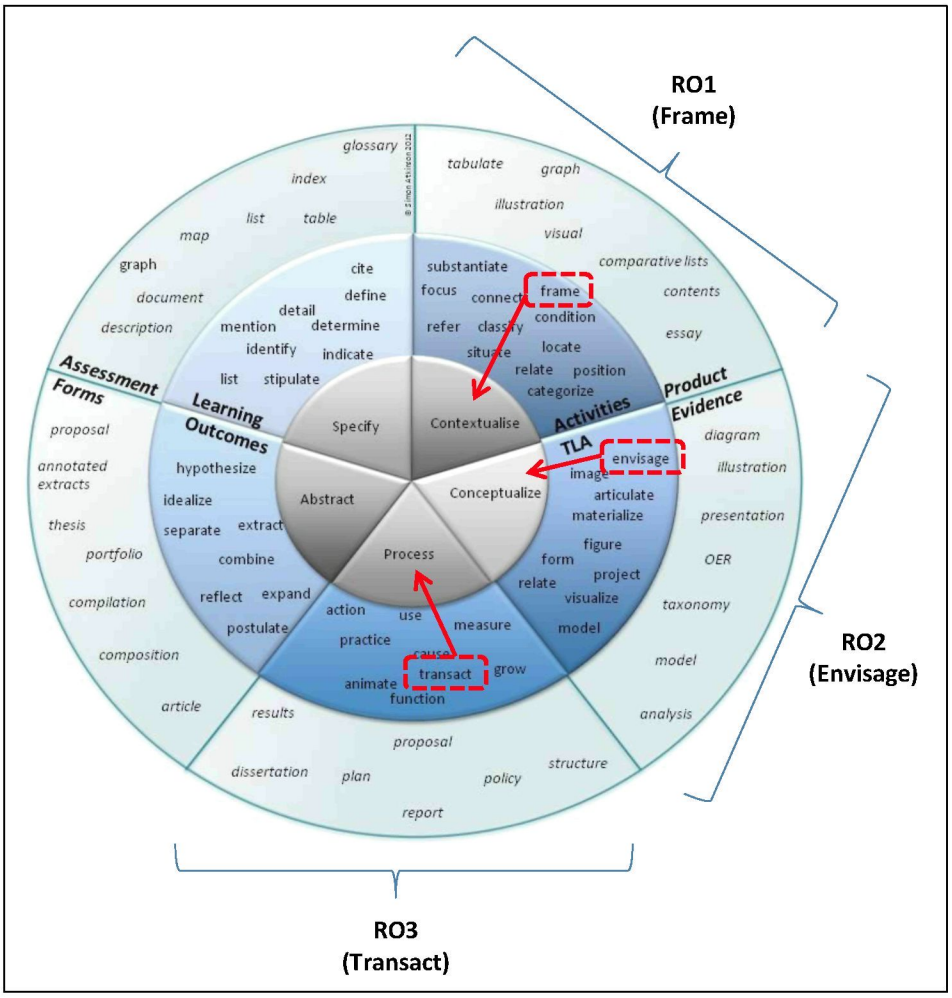
The Problem Tree Analysis And Structure For Ecodesgn Identity In The SPD Development



APPENDIX 3

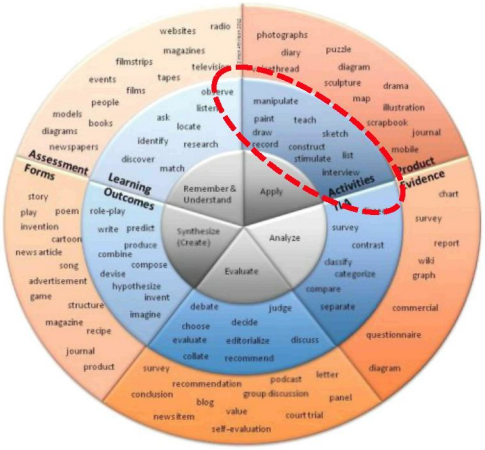
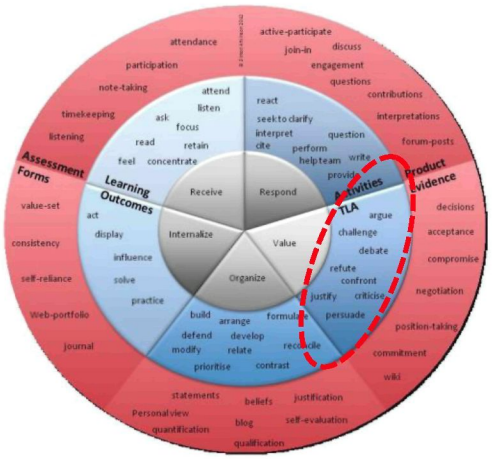
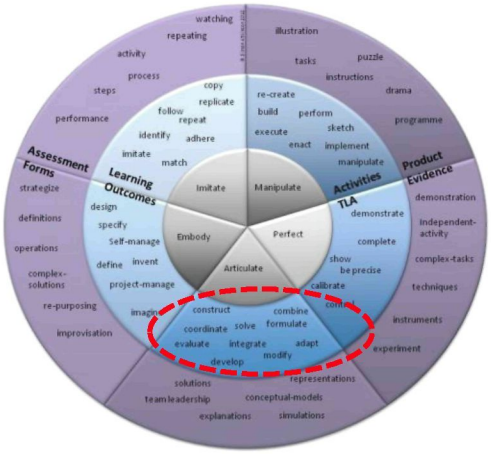
Knowledge Domain Hierarchy for the Research Objectives Mapping

Subject (Knowledge) Domain targeted to the Prot-Verb of Taxonomy Circle (Atkinson, 2013)



APPENDIX 4

Mapping Knowledge Domain Hierarchy for the Research Questions

<table>
<tr><td> 
</td><td colspan="2">Cognitive Domain</td></tr>
<tr><td>Teaching and Learning (T&L)</td><td>RQ1 Verbs:
• Stimuli
• Construct</td></tr>
<tr><td colspan="2">RO1: To frame the ecodesign identity method of distinguishing intangible ecological form through the human emotion of the designer in the SPD concept.</td></tr>
<tr><td> 
</td><td colspan="2">Affective Domain</td></tr>
<tr><td>Teaching and Learning (T&L)</td><td>RQ2 Verbs:
• Compare
• Classify</td></tr>
<tr><td colspan="2">RO2: To envisage the design scheme work model of fusions' ecodesign identity in ecological form knowledge as ecodesign information, in order to elucidate "an ecological form formulation" into the future NPD system that could be enhanced the development of ecodesign identity using the product form understanding.</td></tr>
<tr><td> 
</td><td colspan="2">Psychomotor Domain</td></tr>
<tr><td>Teaching and Learning (T&L)</td><td>RQ3 Verbs:
• Choose
• Collate</td></tr>
<tr><td colspan="2">RO3: To transact the visualization of bubble modeling that it delivering the DRM roadmap completion according three stages in DRM framework provisionally; descriptive study I (DS-1), prescriptive study (PS) stage and descriptive study II (DS-2) stage.</td></tr>
</table>

APPENDIX 5

Matrix of Knowledge Domain Hierarchy for Low-High Order Thinking

Domains, proto-verbs and descriptors

Level of Domain Hierarchy (Order Thinking)	**Cognitive Domain** (Anderson & Krathwohl, 2001)	**Affective Domain** (Krathwohl et al., 1999)	**Psychomotor Domain** (Dave, 1967)	**Subject (Knowledge) Domain** - adapted from (Anderson & Krathwohl, 2001)
Level 1 (Low Order Thinking)	**Remember & Understand** - ability to recognize information and comprehend it and to recall and restate said information.	**Receive** - ability to learn from others.	**Imitate** - ability to copy, replicate the actions of others following observations.	**Specify** - ability to locate, identity and recognize factual knowledge, dates, terminology, artefacts (audio and visual) required of a given discipline domain.
Level 2 (Low Order Thinking)	**Apply** - ability to apply factual information and presented theories, models and structures to real world contexts and problems.	**Respond** - ability to participate responsibly, respectfully and actively as appropriate to the context.	**Manipulate** - ability to repeat or reproduce actions to prescribed standard from memory or instructions.	**Contextualize** - ability to place specific knowledge within appropriate discipline relationships, classifications, taxonomies and categorizations.
Level 3 (High Order Thinking)	**Analyze** - ability to construct complex relationships from single factual elements, reconstruct relationships and assess needs.	**Value** - ability to associate personal and collective values with contextual experience and express value judgments.	**Perfect** - ability to perform actions with expertise and without interventions and the ability to demonstrate and explain actions to others.	**Conceptualize** - ability to articulate relationships between knowledge contexts and to work with models, visualizations, theories and structures that relate between contexts or within contexts.
Level 4 (High Order Thinking)	**Evaluate** - ability to make complex judgments about the nature of context, information and processes to establish new conclusions not represented in the original information.	**Organize** - ability to structure, prioritize and reconcile personal and others' value systems.	**Articulate** - ability to adapt existing psychomotor skills in a non-standard way, in different contexts, using alternative tools and instruments to satisfy need.	**Process** - ability to utilize subject or discipline language and actions to specify, contextualise and conceptualize existing and new knowledge.

Level 5 (High Order Thinking)	**Synthesize** - ability to create new representations of knowledge structures, combining complex assemblages of information in original contexts.	**Internalize** - ability to articulate one's own values and belief systems and operate consistently within them.	**Embody**- ability to perform actions in an automatic, intuitive or unconscious way appropriate to the context.	**Abstract** - ability to recognise and process abstract, unseen or unspecified knowledge, and articulate knowledge origination, including metacognition.

Source: Atkinson (2013)

APPENDIX 6

Letter of Ethics Approval by Research Ethics Committee (RCE) EPU UiTM

Ethical permission letter is on Page 1 of 4,

www.uitm.edu.my

UNIVERSITI TEKNOLOGI MARA

Pejabat
Timbalan Naib Canselor
(Penyelidikan dan Inovasi)

Reference : 600-TNCPI(5/1/6)
Our reference : REC/10/2020 (MR/326)
Date : 21st October 2020

Assoc. Prof Dr Shahriman Zainal Abidin
Faculty of Arts & Design
Universiti Teknologi MARA
40450 Shah Alam
SELANGOR

Dear Assoc. Prof Dr Shahriman,

ETHICS APPROVAL BY UiTM RESEARCH ETHICS COMMITTEE

Title: Ecodesign Identity: Malaysian Young Designers Interpret Semantics of Intangible Ecological Form

Trial Site: See Attachment

Thank you for submitting your research ethics application. We would like to inform that the UiTM Research Ethics Committee had deliberated your proposal.

It is our pleasure to inform you that the Research Ethics Committee has agreed to grant an ethics approval for the said study. The approval code for the study is REC/10/2020 (MR/326), and validity period is from 21st October 2020 until 31st August 2021.

Please submit a progress report of the study to the REC Secretariat 12 months from the date of this approval letter, and annually until the study has been completed. Amendments to the study documents are to be submitted to the REC for approval. A final report must also be submitted to the REC at the end of the said study.

The UiTM Research Ethics Committee operates in accordance to the ICH Good Clinical Practice Guidelines, Malaysia Good Clinical Practice Guidelines and the Declaration of Helsinki.

If you require further information, please contact REC Secretariat at 03-55448069/03-55442794 or email at recsecretariat@uitm.edu.my.

Thank you.

Yours truly,

ASSOCIATE PROFESSOR DR ROHANA HASSAN
Chair
UiTM Research Ethics Committee

Universiti Teknologi MARA
Aras 3, Bangunan Wawasan
40450 Shah Alam, Selangor, MALAYSIA
Tel: (+603) 5544 2004/2255
Faks: (+603) 5544 2070

ISO 9001:2015 No. Sijil: 10120156

UiTM di hatiku

Ethical permission letter is on Page 2 of 4,

c.c.: Dean
Faculty of Arts & Design
Universiti Teknologi MARA
40450 Shah Alam
SELANGOR

Mohd Hasni bin Chumiran
Faculty of Arts & Design
Universiti Teknologi MARA
40450 Shah Alam
SELANGOR

Ethical permission letter is on Page 3 of 4,

No. Area of Degree / Diploma Name of Institution & Website

1. Universiti Kuala Lumpur KampusCawangan Malaysia Italy DesignInstitute (UniKL MIDI)
(Previously known as : Universiti Kuala Lumpur - Institute of Product Design and Manufacturing (UniKL IPROM)
midi.unikl.edu.my/

2. Universiti Teknologi MARA (UiTM) (Shah Alam)
www.uitm.edu.my

3. Universiti Teknologi Malaysia (UTM)
www.utm.my

4. Universiti Putra Malaysia (UPM)
www.upm.edu.my

5 Universiti Sultan Zainal Abidin (UniSZA) (Gong Badak Campus)
www.unisza.edu.my

6. DRB-HICOM University of Automotive Malaysia (Previously known as : International College of Automotive)
www.dhu.edu.my

7. Limkokwing University of Creative Technology (Previously known as : Limkokwing University College
of Creative Technology)
www.limkokwing.edu.my

8. Universiti Sultan Zainal Abidin (UniSZA) (Gong Badak Campus)
www.unisza.edu.my

9. Industrial Design Widad College (Previously known as : Shahputra College Campus Pekan)
www.widad.edu.my

10. Industrial Design Malaysian Institute of Art
www.mia.edu.my

11. Industrial Design Southern University College (Previously known as : Southern College)
www.southern.edu.my

12. Product Design Engineering German Malaysian Institute (GMI)
www.gmi.edu.my

13. Product Design Engineering Universiti Teknikal Malaysia Melaka (UTeM) (Previously known as : Kolej Universiti Teknikal Kebangsaan Malaysia (KUTKM))
www.utem.edu.my

14. Universiti Sains Malaysia (USM) (Minden)
www.usm.my

15. Product Design Engineering Universiti Malaysia Perlis (UniMAP) (Previously known as : Kolej Universiti Kejuruteraan Utara Malaysia (KUKUM))
www.unimap.edu.my

16. Product Design First City University College (Previously known as : KBU International College)
www.firstcity.edu.my

17. Product Design Linton University College (Previously known as : Kolej Linton)

Ethical permission letter is on Page 4 of 4,

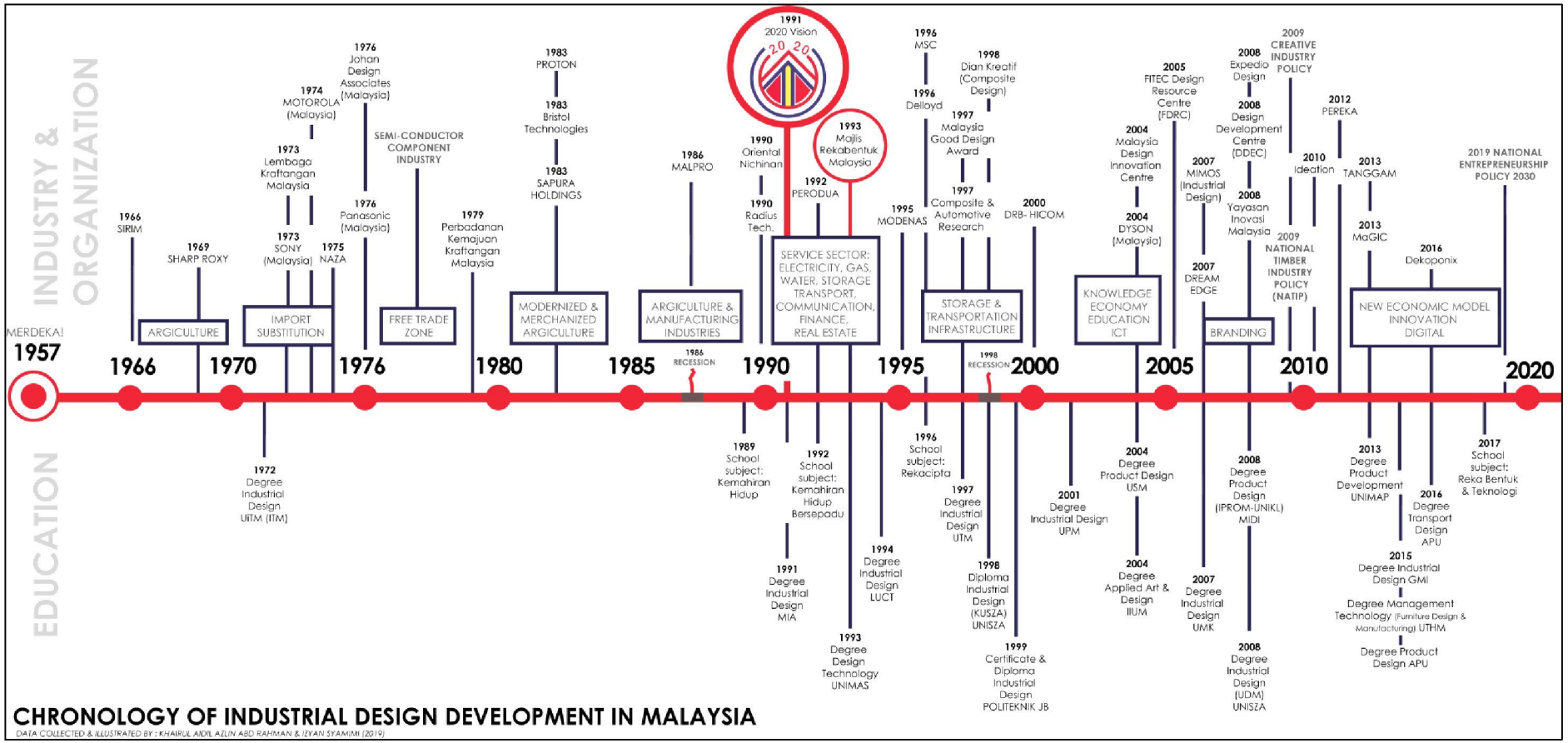
www.linton.edu.my
18. Product Design Kuala Lumpur Metropolitan University College (KLMUC) (Previously known as : Kolej Universiti Antarabangsa Cosmopoint)
www.klmuc.edu.my

19. UNITI College

Source: Malaysian Qualifications Register (MQR) - The Malaysian Qualifications Agency (2020)

APPENDIX 7

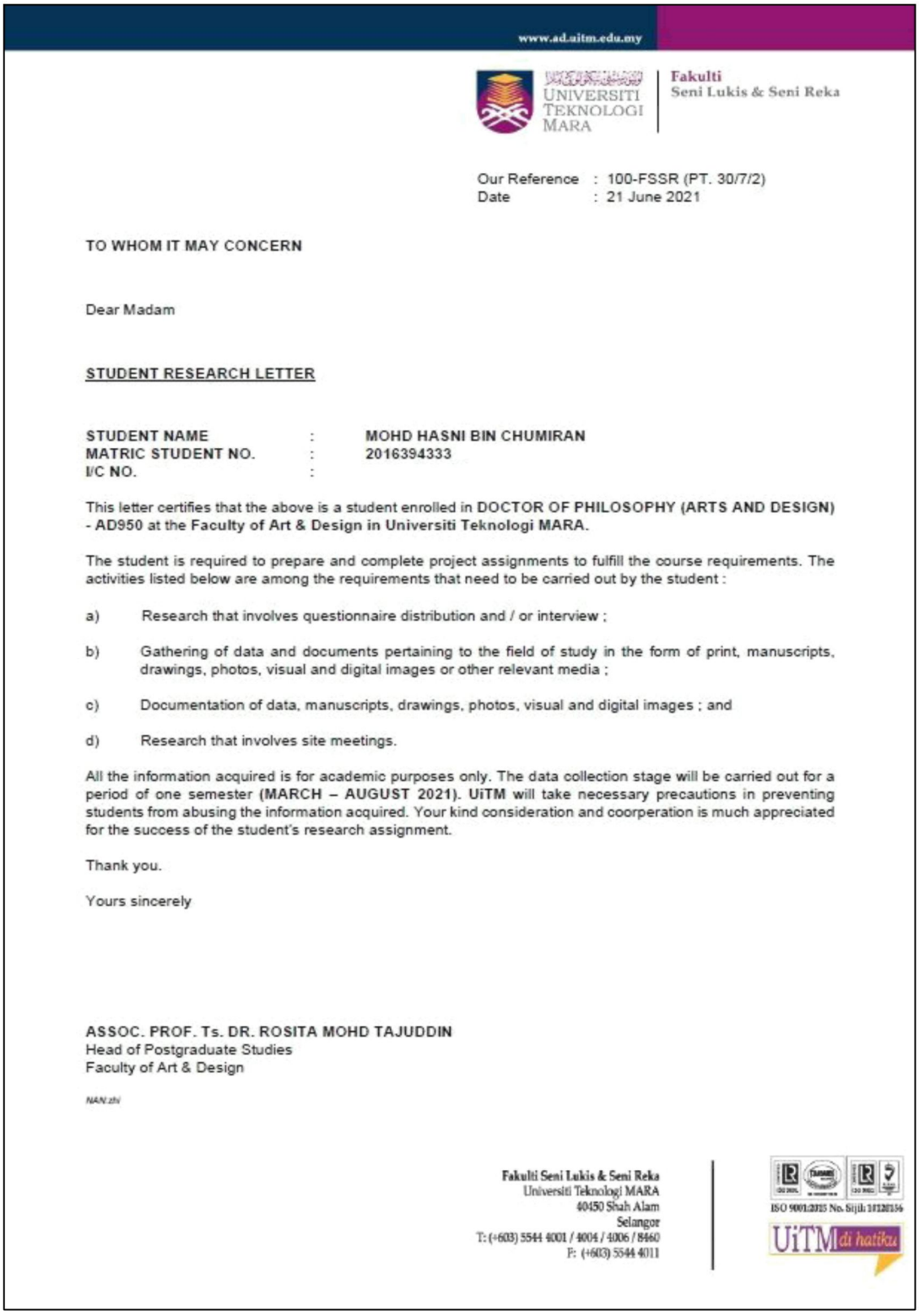
Chronology of Industrial Design Development In Malaysia



APPENDIX 8

An Evidence of Student Research Leter for Gathering the Data Collection

The Permission Letter of Postgraduate Studies is on Page 1 of 1,



www.ad.uitm.edu.my

UNIVERSITI TEKNOLOGI MARA | Fakulti Seni Lukis & Seni Reka

Our Reference : 100-FSSR (PT. 30/7/2)
Date : 21 June 2021

TO WHOM IT MAY CONCERN

Dear Madam

STUDENT RESEARCH LETTER

STUDENT NAME : **MOHD HASNI BIN CHUMIRAN**
MATRIC STUDENT NO. : **2016394333**
I/C NO. :

This letter certifies that the above is a student enrolled in **DOCTOR OF PHILOSOPHY (ARTS AND DESIGN) - AD950** at the **Faculty of Art & Design in Universiti Teknologi MARA.**

The student is required to prepare and complete project assignments to fulfill the course requirements. The activities listed below are among the requirements that need to be carried out by the student :

a) Research that involves questionnaire distribution and / or interview ;

b) Gathering of data and documents pertaining to the field of study in the form of print, manuscripts, drawings, photos, visual and digital images or other relevant media ;

c) Documentation of data, manuscripts, drawings, photos, visual and digital images ; and

d) Research that involves site meetings.

All the information acquired is for academic purposes only. The data collection stage will be carried out for a period of one semester **(MARCH – AUGUST 2021). UiTM** will take necessary precautions in preventing students from abusing the information acquired. Your kind consideration and coorperation is much appreciated for the success of the student's research assignment.

Thank you.

Yours sincerely

ASSOC. PROF. Ts. DR. ROSITA MOHD TAJUDDIN
Head of Postgraduate Studies
Faculty of Art & Design

NAN:zhi

Fakulti Seni Lukis & Seni Reka
Universiti Teknologi MARA
40450 Shah Alam
Selangor
T: (+603) 5544 4001 / 4004 / 4006 / 8460
F: (+603) 5544 4011

ISO 9001:2015 No. Sijil: MY 18120156

UiTM di hatiku

APPENDIX 9

An Evidence of Permission Letter to Malaysian Institution for Data Collection

The participant's two-page consent letter is on Page 1 of 2,

Department of Industrial Design,
Faculty of Arts & Design,
Universiti Teknologi MARA (UiTM),
40200 Shah Alam,
Selangor Darul Ehsan.

21th June 2021

Head of Department,
Department of Industrial Design,
Faculty of Design and Architecture,
Universiti Putra Malaysia,
43400 Serdang,
Selangor Darul Ehsan.

Dear Assoc. Prof. Dr. Hassan Alli,

Request A Clinical Survey Permission Through Virtual Platform.

My name is **Mohd Hasni Bin Chumiran**, with a UiTM identification number 2016394333. I am a PhD student at the Faculty of Arts & Design, Universiti Teknologi MARA (UiTM) Shah Alam. I want to request a clinical survey (CS) permission from your role and responsibility to allow me to conduct the research observation session such (1) verbal protocol analysis (VPA) method and (2) surveys in program Bachelor of Design (Industrial Design) with Honors.

I am writing to you in regard that my dissertation of thesis entitled "Ecodesign Identity: Malaysian Young Designers Interpret Semantics of Intangible Ecological Form" under the supervision of Professor Dr Shahriman Zainal Abidin. Currently, I am working on completing my dissertation of thesis and expected to be completed by December 2021.

I hope that in light of the above-mentioned events, you will allow 15 students of the participants from year two (2) semester, that there will be performed with the virtual platform by CS activity scheduled on **25th June 2021 at 3:00 pm until 5:00 pm** along with the Movement Control Order 3.0 Version (MCO 3.0). Also, I provide the token to the participant with the amount of RM40.00 each per individual for the kind of appreciation. All information provided is only for research purposes and strictly treated as academic and ethical; hence, the data would not be revealed under any circumstances.

Enclosed is the list of attachments for the kind of references following,

i) The listing and detail of participant student.
ii) Supporting Letter from Postgraduate Coordinator (Faculty of Arts & Design)

I shall be highly grateful for your support, and cooperation is much appreciated. I look forward to hearing from you soon.

Thank you.
Best Regards

APPROVED

22 JUNE 2021

.....
MOHD HASNI BIN CHUMIRAN
(H/p: 013-2855448)
hasniide@yahoo.com

PROF. MADYA Ts. [redacted] HASSAN [redacted] ALLI
Ketua Jabatan
Jabatan Reka Bentuk Perindustrian
Fakulti Rekabentuk dan Senibina
Universiti Putra Malaysia
43400 Serdang, Selangor
Tel: +603-9769 4096

The participant's two-page consent letter is on Page 2 of 2,

APPENDIX 1

The Particular of Year 2 Semester Participants.

No.	Name of Participant	Student ID #	Bank with A/C Number
1.	Nurul Jannah Binti Yahya	201983	
2.	Muhd Akmal Hakim Bin Mohd Noorhisham	204264	
3.	Nursyazawafaa binti Mohamed Safine	201981	
4.	Siti Nur Syafira binti Saedin	203368	
5.	Muhd Nazri Bin Muhd Nasir	202303	
6.	Mushrif ah Khairini Binti Muskhazli	200616	
7.	Aminatul Adilah Binti Amir Ihsan	201860	
8.	Nurul Nuha Binti Mohd Nizam	200321	
9.	Intan Liyana Binti Bujang	204650	
10.	Muhammad Fakhrullah Bin Mohammad Hizal	201861	
11.	Mohammad Faris Haikal Bin Shahrin	201982	
12.	Muhammad Hafizuddin Bin Mohd Asri	200598	
13.	Fatin Fathah bt. Mohd Faizal	204259	
14.	Muhamad Fahmi Bin Harun	200668	
15.	**Ariff Danial Bin Ismail**	203370	

APPENDIX 10

An Evidence of Consent Letter for Product Clinical Adoption Session

The participant's three-page consent letter is on Page 1 of 3,

Jabatan Rekabentuk Perindustrian
Fakulti Seni Lukis dan Seni Reka
Universiti Teknologi MARA
40450 SHAH ALAM

Borang Maklumat Subjek

Tajuk penyelidikan
IDENTITI REKABENTUK EKOLOGI: PEREKA MUDA MALAYSIA MENTAFSIR SEMANTIK BENTUK EKOLOGI TIDAK KETARA.

Pengenalan penyelidikan

Kaedah analisis prosedur lisan atau *'verbal protocol analysis'* (VPA) memperkenalkan pereka muda untuk menganalisis sesuatu buah fikiran dengan lebih mendalam dengan menggunakan alat lukisan bagi mencipta sebuah manuskrip rekabentuk. Ianya bertujuan mencari rupa identiti / produk yang sukar difahami. Prosedur VPA akan menggunakan rakaman video bagi merakam sifat rekabentuk atau berkaitan tingkah laku peserta dalam suatu masa serta kesesuaian situasi tempat penyelidikkan. Dalam kajian ini, seluruh peringkat analisis preskriptif atau *'prescriptive study'* (PS) mesti diselesaikan dalam tempoh 20 minit, dan kerja-kerja pemerhatian hasil lukisan amat diperlukan. Oleh itu, saya akan menyarankan para peserta untuk mengikuti taklimat rekabentuk agar mereka dapat berfikir secara bebas melalui pemikiran rekabentuk (pandangan) sebagai pemikir kritis dalam asas rekabentuk produk. Maka, ia dapat mencetus buah fikiran yang baik melalui model intelektual pembuatan bagi erti kata /maksud sebenar bagi sesuatu unsur dalam teka teki dan penyelesaian masalah tersebut.

Tujuan penyelidikan

Kaedah kajian VPA ini secara impirikalnya mentakrifkan bentuk PS dalam pengumpulan data bahawa segala teka-teki dalam bentuk satu kriteria berdasarkan fenomena pemerhatian rekabentuk. Ia terjadi melalui aktiviti pengalaman rekabentuk yang mana ujian saringan dan siasatan sesuatu konsep rekabentuk dilakukan secara khusus untuk mengenal pasti kriteria rupa bentuk produk. Di sini, hasilnya akan ditranskripsikan dan ia bertujuan untuk mengkategorikan jenis aktiviti rekabentuk iaitu intipati rekabentuk dan / atau tingkah laku secara sistematik.

Prosedur penyelidikan

Enam langkah persediaan eksperimen prosedur VPA yang mengaplikasikan kaedah PS secara sistematik: (1) maklumat demografi, (2) penerangan tema reka bentuk dan maklumat VPA, (3) interaksi pengimejan: papan mood (bantuan visual) dan bahan bacaan, (4) mod laman dalam dan luar dan persediaan susunatur kamera, (5) menarik media dan instrumen, dan (6) masa anggaran yang dicadangkan. Oleh itu, dua konsumsi input diperlukan dalam selepas pemerhatian, iaitu (1) manuskrip rekabentuk dan (2) videotaping: HD 1080p, 1920 × 1080 resolusi format. Untuk pelajaran output, analisis strategi VPA akan menggunakan bentuk transkripsi skim manual yang dikenali sebagai VPA *Design Scheme* (VPADS). Pakar kajian kes kualitatif menekankan bahawa amalan manual akan membentuk realiti penyelidikan (sumber primari) berasaskan secara semulajadi.

The participant's three-page consent letter is on Page 2 of 3,

Penyertaan dalam penyelidikan

Penyertaan anda di dalam penyelidikan ini adalah secara sukarela mewakili pelajar dalam program ijazah sarjana muda/ TVET. Anda berhak menolak tawaran penyertaan ini atau menarik diri daripada penyelidikan ini pada bila-bila masa tanpa sebarang penalti.

Manfaat penyelidikan

Maklumat yang didapati dari kajian ini akan memanfaatkan penyelidik kajian ini, Kerajaan Malaysia, ahli akademik, doktor falsafah, badan agensi kerajaan (berkaitan rekabentuk), profesional dan individu dalam kemajuan ilmu dan amalan rekabentuk klinikal pada masa depan.

Peserta akan dibentangkan dengan corak lukisan kesedaran mengenai kajian reka bentuk, iaitu proses reka bentuk, ciri-ciri reka bentuk dan keupayaan untuk menganalisis dan mentafsir evolusi reka bentuk dalam kajian metafora untuk reka bentuk perindustrian. Juga, untuk setiap subjek yang terlibat, token akan diberi pampasan kerana menghargai peserta subjek.

Risiko penyelidikan

Dalam penyelidikan, output lukisan mencerminkan pemikiran para peserta dengan buah fikiran yang mendalam untuk menghasilkan manuskrip reka bentuk; kesan dan potensinya adalah amat rendah, dan juga punca atau penyebab kepada kesakitan dan perasaan malu boleh berlaku secara subjektif. Kesan pada keadaan fizikal subjek amatlah rendah dan berkemungkinan berlakunya kemurungan terhadap subjek untuk berfikir kerana demonstrasi lukisan itu mendedahkan diri subjek kepada sindrom carpal tunnel dalam masa 20 minit, dan sakit belakang berkemungkinan akan berlaku dalam kaedah VPA. Walau bagaimanapun, untuk permasalahan fizikal pula, saya wajib memberi peringatan keatas diri subjek supaya menggalakkan mereka untuk bergerak secara bebas dalam keselasaan ergonomik dengan cara tersendiri dan agak fleksibel.

Kerahsiaan

Maklumat anda akan dirahsiakan oleh penyelidik dan tidak akan didedahkan melainkan jika ia dikehendaki oleh undang-undang.

Dengan menandatangani borang persetujuan ini, anda membenarkan penelitian rekod, penganalisaan dan penggunaan data hasil daripada penyelidikan ini.

Sekiranya anda mempunyai sebarang pertanyaan mengenai penyelidikan ini atau hak-hak anda, sila hubungi Mohd Hasni Chumiran di talian +6013-2855448.

The participant's three-page consent letter is on Page 3 of 3,

Borang Izin[1]

Untuk menyertai penyelidikan ini, anda atau penjaga sah perlu menandatangani Borang Izin ini.

Saya dengan ini mengesahkan bahawa saya telah memenuhi syarat umur dan berupaya bertindak bagi pihak saya sendiri/ sebagai[2] penjaga yang sah dalam perkara-perkara berikut:

1. Saya memahami ciri-ciri dan skop kajian ini.
2. Saya telah membaca dan memahami semua syarat penyertaan kajian ini: Dalam tesis PhD dan artikel jurnal, representasi visual (iaitu lukisan, pentafsiran, rekabentuk, rekod rakaman video, fotograf yang tidak mendedahkan identiti saya mungkin digunakan.
3. Saya berpuas hati dengan qualiti lukisan. Ia menjawab kemusykilan kajian ini.
4. Saya secara sukarela bersetuju menyertai kajian ini dan untuk mengikuti prosedur kajian kaedah protokol verbal (VPA) dan untuk menyediakan semua maklumat yang diperlukan kepada penyiasat seperti yang diminta (demonstrasi lukisan akan mendedahkan subjek kepada sindrom carpal tunnel dalam masa 20 minit, dan sakit belakang mungkin berlaku dalam kaedah VPA.
5. Saya boleh menarik diri daripada kajian ini pada bila-bila masa tanpa memberi sebab.
6. Saya telah pun menerima satu salinan Borang Maklumat dan Borang Izin.
7. Kecuali kecederaan yang disebabkan kelalaian dan kecuaian oleh penyelidik, saya dengan ini melepaskan dan menggugurkan UiTM dan semua penyelidik dari semua laibiliti berhubung dengan, wujud dari atau berkaitan dengan penyertaan saya dan bersetuju untuk menjadikan mereka tidak bertanggunggan terhadap apa-apa kerugian atau kecederaan yang mungkin akan saya tanggung disebabkan penyertaan saya.

Fatin Faisel
Nama Subjek/ Wakil Sah yang berkuatkuasa

Tandatangan

27 Jun 2021
No. Kad Pengenalan

Tarikh

Prof. Madya Dr. Hassan Bin Hj Alli
Nama Saksi[3]

Tandatangan

27 Jun 2021
Tarikh

Mohd Hasni Bin Chumiran
Nama Penyelidik/Pengambil Izin

Tandatangan

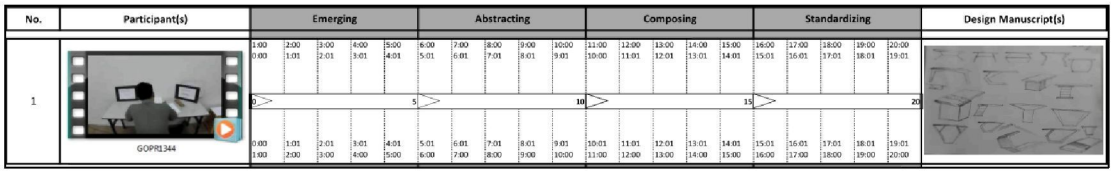
27 Jun 2021
Tarikh

[1] Salinan asal disimpan oleh Penyelidik Utama dan satu salinan diserahkan kepada subjek.
[2] Potong mana yang tidak berkenaan.
[3] Saksi dimestikan bagi izin secara lisan.

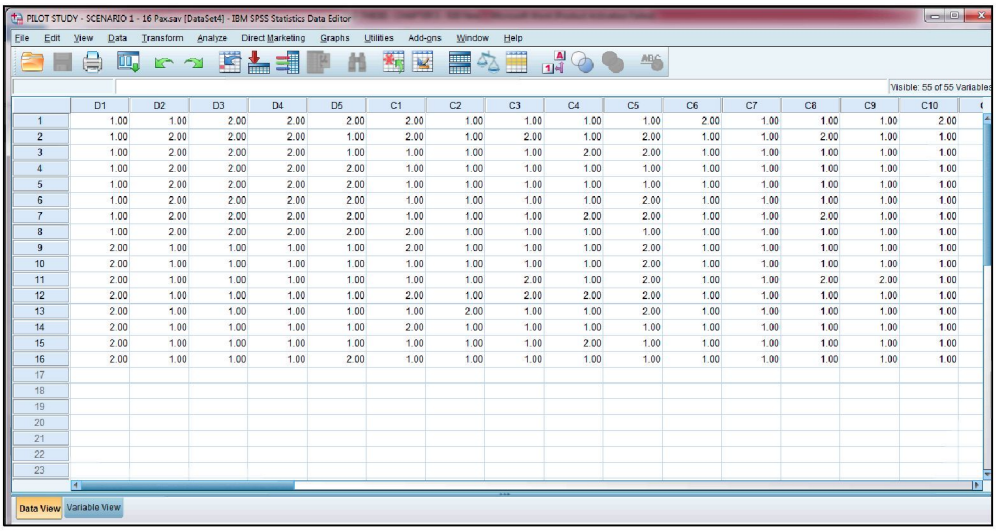
APPENDIX 11

Example of the Codes/ Variables in Preparing and Managing Data

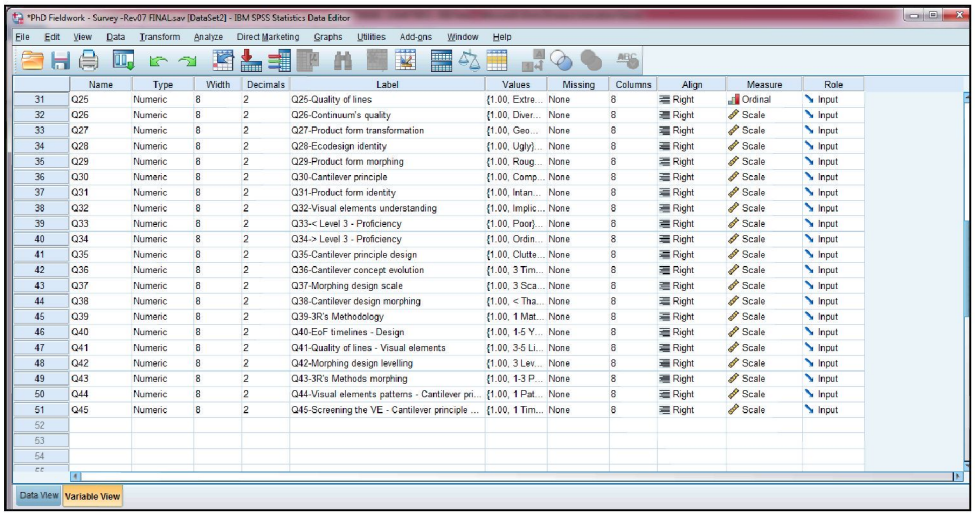
i) An Example of VPA segmentation of design scheme in the mental process



ii) Data entry for Scenario 1 for 16 people of students – Pilot survey



iii) Data entry for Scenario 2 for 45 people of students – Fieldwork



APPENDIX 12

SPSS Output For Demographics of Pilot Survey - Scenario 1

i) Testing Method of SPSS: Analyze > Reports > Case Summaries

Case Processing Summary[a]

	Cases					
	Included		Excluded		Total	
	N	Percent	N	Percent	N	Percent
Group	16	100.0%	0	0.0%	16	100.0%
Gender	16	100.0%	0	0.0%	16	100.0%
Age	16	100.0%	0	0.0%	16	100.0%
Qualification	16	100.0%	0	0.0%	16	100.0%
Final Year Semester	16	100.0%	0	0.0%	16	100.0%

a. Limited to first 100 cases.

Case Summaries[a]

	Case Number	Group	Gender	Age	Qualification	Final Year Semester
1	1	Group A	Male	21 - 25 years old	Degree	Semester 06
2	2	Group A	Female	21 - 25 years old	Degree	Semester 05
3	3	Group A	Female	21 - 25 years old	Degree	Semester 05
4	4	Group A	Female	21 - 25 years old	Degree	Semester 06
5	5	Group A	Female	21 - 25 years old	Degree	Semester 06
6	6	Group A	Female	21 - 25 years old	Degree	Semester 06
7	7	Group A	Female	21 - 25 years old	Degree	Semester 06
8	8	Group A	Female	21 - 25 years old	Degree	Semester 06
9	9	Group B	Male	18 - 20 years old	Diploma	Semester 05
10	10	Group B	Male	18 - 20 years old	Diploma	Semester 05

11		11	Group B	Male	18 - 20 years old	Diploma	Semester 05
12		12	Group B	Male	18 - 20 years old	Diploma	Semester 05
13		13	Group B	Male	18 - 20 years old	Diploma	Semester 05
14		14	Group B	Male	18 - 20 years old	Diploma	Semester 05
15		15	Group B	Male	18 - 20 years old	Diploma	Semester 05
16		16	Group B	Male	18 - 20 years old	Diploma	Semester 06
Total	N		16	16	16	16	16
	Minimum		Group A	Male	18 - 20 years old	Diploma	Semester 05
	Maximum		Group B	Female	21 - 25 years old	Degree	Semester 06
	Std. Error of Mean		.12910	.12809	.12910	.12910	.12809
	Mean		1.5000	1.4375	1.5000	1.5000	1.4375
	Median		1.5000	1.0000	1.5000	1.5000	1.0000

a. Limited to first 100 cases.

ii) Testing Method of SPSS: Analyze > Descriptive Statistics > Frequencies

Statistics

		Group	Gender	Age	Qualification	Final Year Semester
N	Valid	16	16	16	16	16
	Missing	0	0	0	0	0
Std. Deviation		.51640	.51235	.51640	.51640	.51235
Minimum		1.00	1.00	1.00	1.00	1.00
Maximum		2.00	2.00	2.00	2.00	2.00

Group

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Group B	8	50.0	50.0	50.0
	Group A	8	50.0	50.0	100.0
	Total	16	100.0	100.0	

Gender

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Female	7	43.8	43.8	43.8
	Male	9	56.3	56.3	100.0
	Total	16	100.0	100.0	

Age

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	21 - 25 years old	8	50.0	50.0	50.0
	18 - 20 years old	8	50.0	50.0	100.0
	Total	16	100.0	100.0	

Qualification

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Degree	8	50.0	50.0	50.0
	Diploma	8	50.0	50.0	100.0
	Total	16	100.0	100.0	

Final Year Semester

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Semester 06	7	43.8	43.8	43.8
	Semester 05	9	56.3	56.3	100.0
	Total	16	100.0	100.0	

APPENDIX 13

SPSS Output For Demographics of Fieldwork Survey - Scenario 2

i) Testing Method of SPSS: Analyze > Reports > Case Summaries

Case Processing Summary[a]

	Cases					
	Included		Excluded		Total	
	N	Percent	N	Percent	N	Percent
Gender * University	45	100.0%	0	0.0%	45	100.0%
Age * University	45	100.0%	0	0.0%	45	100.0%
Qualification * University	45	100.0%	0	0.0%	45	100.0%
Semester * University	45	100.0%	0	0.0%	45	100.0%
Specialisation * University	45	100.0%	0	0.0%	45	100.0%

a. Limited to first 100 cases.

Case Summaries[a]

		Gender	Age	Qualification	Sem.	Specialisation
University UiTM	1	Male	26-30 Years old	Degree	Deg. Sem 06	Product design
	2	Male	21-25 Years old	Degree	Deg. Sem 06	Furniture design
	3	Male	21-25 Years old	Degree	Deg. Sem 06	Furniture design
	4	Male	21-25 Years old	Degree	Deg. Sem 06	Transport design
	5	Male	21-25 Years old	Degree	Deg. Sem 06	Transport design
	6	Male	21-25 Years old	Degree	Deg. Sem 06	Product design
	7	Male	21-25 Years old	Degree	Deg. Sem 06	Transport design
	8	Female	21-25 Years old	Degree	Deg. Sem 06	Product design
	9	Male	21-25 Years old	Degree	Deg. Sem 06	Furniture design
	10	Male	21-25 Years old	Degree	Deg. Sem 06	Furniture design

	11		Male	21-25 Years old	Degree	Deg. Sem 06	Transport design
	12		Male	21-25 Years old	Degree	Deg. Sem 06	Furniture design
	13		Male	21-25 Years old	Degree	Deg. Sem 06	Transport design
	14		Male	21-25 Years old	Degree	Deg. Sem 06	Transport design
	15		Male	21-25 Years old	Degree	Deg. Sem 06	Product design
	Total	N	15	15	15	15	15
		Mean	1.0667	2.0667	2.0000	8.0000	2.1333
		Median	1.0000	2.0000	2.0000	8.0000	2.0000
		Std. Deviation	.25820	.25820	.00000	.00000	.83381
UPM	1		Female	21-25 Years old	Degree	Deg. Sem 04	Product design
	2		Male	21-25 Years old	Degree	Deg. Sem 04	Furniture design
	3		Female	21-25 Years old	Degree	Deg. Sem 04	Product design
	4		Female	21-25 Years old	Degree	Deg. Sem 04	Furniture design
	5		Male	21-25 Years old	Degree	Deg. Sem 04	Product design
	6		Female	21-25 Years old	Degree	Deg. Sem 04	Product design
	7		Female	21-25 Years old	Degree	Deg. Sem 04	Product design
	8		Female	21-25 Years old	Degree	Deg. Sem 04	Product design
	9		Female	21-25 Years old	Degree	Deg. Sem 04	Product design
	10		Male	21-25 Years old	Degree	Deg. Sem 04	Product design
	11		Male	21-25 Years old	Degree	Deg. Sem 04	Product design
	12		Male	21-25 Years old	Degree	Deg. Sem 04	Product design

	13		Female	21-25 Years old	Degree	Deg. Sem 04	Furniture design
	14		Male	21-25 Years old	Degree	Deg. Sem 04	Product design
	15		Male	21-25 Years old	Degree	Deg. Sem 04	Product design
	Total	N	15	15	15	15	15
		Mean	1.5333	2.0000	2.0000	6.0000	1.2000
		Median	2.0000	2.0000	2.0000	6.0000	1.0000
		Std. Deviation	.51640	.00000	.00000	.00000	.41404
UTM Razak	1		Male	21-25 Years old	Degree	Deg. Sem 03	Product design
	2		Female	18-20 Years old	Degree	Deg. Sem 03	Product design
	3		Female	21-25 Years old	Degree	Deg. Sem 03	Furniture design
	4		Female	21-25 Years old	Degree	Deg. Sem 03	Product design
	5		Male	21-25 Years old	Degree	Deg. Sem 03	Product design
	6		Female	21-25 Years old	Degree	Deg. Sem 03	Transport design
	7		Female	21-25 Years old	Degree	Deg. Sem 03	Product design
	8		Female	21-25 Years old	Degree	Deg. Sem 03	Product design
	9		Female	18-20 Years old	Degree	Deg. Sem 03	Product design
	10		Male	18-20 Years old	Degree	Deg. Sem 03	Product design
	11		Female	21-25 Years old	Degree	Deg. Sem 03	Product design
	12		Male	21-25 Years old	Degree	Deg. Sem 03	Product design
	13		Male	18-20 Years old	Degree	Deg. Sem 03	Product design
	14		Female	21-25 Years old	Degree	Deg. Sem 03	Furniture design

		15		Male	21-25 Years old	Degree	Deg. Sem 03	Product design
		Total	N	15	15	15	15	15
			Mean	1.6000	1.7333	2.0000	5.0000	1.2667
			Median	2.0000	2.0000	2.0000	5.0000	1.0000
			Std. Deviation	.50709	.45774	.00000	.00000	.59362
	Total	N		45	45	45	45	45
		Mean		1.4000	1.9333	2.0000	6.3333	1.5333
		Median		1.0000	2.0000	2.0000	6.0000	1.0000
		Std. Deviation		.49543	.33029	.00000	1.26131	.75679

a. Limited to first 100 cases.

ii) Testing Method of SPSS: Analyze > Descriptive Statistics > Frequencies

Statistics

		University	Gender	Age	Qualification	Semester	Specialisation
N	Valid	45	45	45	45	45	45
	Missing	0	0	0	0	0	0
Minimum		1.00	1.00	1.00	2.00	5.00	1.00
Maximum		3.00	2.00	3.00	2.00	8.00	3.00

University

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	UiTM	15	33.3	33.3	33.3
	UPM	15	33.3	33.3	66.7
	UTM Razak	15	33.3	33.3	100.0
	Total	45	100.0	100.0	

Gender

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Male	27	60.0	60.0	60.0
	Female	18	40.0	40.0	100.0
	Total	45	100.0	100.0	

Age

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	18-20 Years old	4	8.9	8.9	8.9
	21-25 Years old	40	88.9	88.9	97.8
	26-30 Years old	1	2.2	2.2	100.0
	Total	45	100.0	100.0	

Qualification

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Degree	45	100.0	100.0	100.0

Semester

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Deg. Sem 03	15	33.3	33.3	33.3
	Deg. Sem 04	15	33.3	33.3	66.7
	Deg. Sem 06	15	33.3	33.3	100.0
	Total	45	100.0	100.0	

Specialisation

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Product design	28	62.2	62.2	62.2
	Furniture design	10	22.2	22.2	84.4
	Transport design	7	15.6	15.6	100.0
	Total	45	100.0	100.0	

APPENDIX 14

SPSS Output For Scales Instumentation of Pilot Survey - Scenario 1

i) Testing Method of SPSS: Analyze > Scale > Reliability Analysis (Internal Reliability Analysis for 16 students)

```
RELIABILITY
  /VARIABLES=C1 C2 C3 C4 C5 C6 C7 C8 C9 C10 C11 C12 C13 C14 C15 C16
C17 C18 C19 C20 C21 C22 C23 C24
    C25 C26 C27 C28 C29 C30 C31 C32 C33 C34 C35 C36 C37 C38 C39 C40
C41 C42 C43 C44 C45 C46 C47 C48 C49
    C50
  /SCALE('16 students') ALL
  /MODEL=ALPHA
  /STATISTICS=DESCRIPTIVE SCALE
  /SUMMARY=TOTAL MEANS.
```

Case Processing Summary

		N	%
Cases	Valid	16	100.0
	Excluded[a]	0	.0
	Total	16	100.0

a. Listwise deletion based on all variables in the procedure.

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.565	.527	49

Item Statistics

	Mean	Std. Deviation	N
C1. Fundamental of Formgiving	1.3750	.50000	16
C1. Evolution of Product Form	1.0625	.25000	16
C1. Design Shifting	1.1875	.40311	16
C1. Visual Elements	1.2500	.44721	16
C1. Transitional Form	1.5625	.51235	16
C2. Geometric to Organic Shape	1.0625	.25000	16
C2. Cantilever Principle Design	1.1875	.40311	16
C2. Role of Design Evolution	1.0625	.25000	16
C2. Design Era Movement	1.0625	.25000	16
C3. Heuristic Procedural Step	3.8750	.71880	16
C3. Lining Structure	3.8125	.65511	16
C3. Design Continuum	3.8750	.80623	16

C3. Timeline of Form Evolution	4.0625	.44253	16
C3. An Intangible Ecological Form	3.8125	1.22304	16
C4. Quality Review Levels	4.3125	.70415	16
C4. Design Belief	3.9375	.77190	16
C4. Level (3) of The Quality Review	3.8125	1.10868	16
C4. An Exceeding Than Level (3) of The Quality Review	3.9375	.99791	16
C4. Quality of Lines	4.0000	.73030	16
C5. Continuum's Quality	4.5000	1.21106	16
C5. Product Form Transformation	5.3125	1.49304	16
C5. Ecodesign Identity Development	6.0625	.92871	16
C5. Product Form Morphing	4.7500	1.12546	16
C5. Cantilever Principle Design Emergence	5.6250	1.40831	16
C6. Product Form Identity	4.7500	1.94936	16
C6. Belief of Visual Elements	4.5000	1.31656	16
C6. The Best 3 Levels	5.7500	1.06458	16
C6. More Than 3 Levels	4.1250	.88506	16
C6. Cantilever Principle Design Concept	4.7500	1.39044	16
C7. Cantilever Principle Design Imagination	2.5000	1.03280	16
C7. Morphing Design Scales	2.8750	.80623	16
C7. Duration of Cantilever Principle Design Morphing	2.7500	1.12546	16
C7. Materials Consumption	2.6250	.50000	16
C7. Design Phenomenon	2.3125	.87321	16
C8. Visual Elements Lining	1.6875	.79320	16
C8. Quality of Morphing Design Levelling	2.3125	.87321	16
C8. Quality of Visual Elements	2.2500	1.12546	16
C8. Pattern of Visual Elements	3.2500	1.06458	16
C8. Visual Element of Cantilever Principle Design	2.6250	.88506	16
C9. Software For Evaluation of Heuristic Method	3.3125	1.44770	16
C9. Software For The Heuristic Method Evidences	2.7500	1.57056	16
C9. Manual Mode of Heuristic Method	2.6875	1.66208	16
C9. Evaluation of Manual Quality	2.4375	1.71148	16
C9. Evaluation of Media Quality	3.5625	1.78769	16
C9. 3D Modelling For The Visual Elements	3.8750	1.40831	16
C9. 3D Modelling Proficiency	3.9375	1.48183	16
C9. Category of Clinical Survey For Visual Elements	1.4375	.89209	16
C9. Cantilever Principle Design Mapping	3.0000	1.71270	16

C9. Triangulation of Formgiving Design	2.4375	.89209	16

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Cronbach's Alpha if Item Deleted
C1. Fundamental of Formgiving	153.6250	129.183	-.279	.578
C1. Evolution of Product Form	153.9375	126.329	-.022	.566
C1. Design Shifting	153.8125	128.962	-.312	.576
C1. Visual Elements	153.7500	125.000	.107	.563
C1. Transitional Form	153.4375	124.929	.094	.563
C2. Geometric to Organic Shape	153.9375	127.129	-.164	.569
C2. Cantilever Principle Design	153.8125	127.629	-.167	.572
C2. Role of Design Evolution	153.9375	129.129	-.515	.576
C2. Design Era Movement	153.9375	127.129	-.164	.569
C3. Heuristic Procedural Step	151.1250	121.850	.246	.553
C3. Lining Structure	151.1875	115.896	.705	.529
C3. Design Continuum	151.1250	119.050	.373	.544
C3. Timeline of Form Evolution	150.9375	123.929	.217	.559
C3. An Intangible Ecological Form	151.1875	119.229	.207	.551
C4. Quality Review Levels	150.6875	121.696	.262	.553
C4. Design Belief	151.0625	122.196	.204	.555
C4. Level (3) of The Quality Review	151.1875	125.762	-.029	.574
C4. An Exceeding Than Level (3) of The Quality Review	151.0625	116.729	.396	.537
C4. Quality of Lines	151.0000	123.467	.140	.560
C5. Continuum's Quality	150.5000	116.000	.337	.538
C5. Product Form Transformation	149.6875	134.362	-.298	.610
C5. Ecodesign Identity Development	148.9375	117.529	.391	.539
C5. Product Form Morphing	150.2500	111.533	.566	.517
C5. Cantilever Principle Design Emergence	149.3750	126.650	-.075	.583
C6. Product Form Identity	150.2500	147.533	-.529	.658
C6. Belief of Visual Elements	150.5000	131.333	-.225	.597
C6. The Best 3 Levels	149.2500	116.467	.377	.537
C6. More Than 3 Levels	150.8750	123.717	.090	.563
C6. Cantilever Principle Design Concept	150.2500	122.200	.069	.567
C7. Cantilever Principle Design Imagination	152.5000	114.933	.464	.530

C7. Morphing Design Scales	152.1250	119.983	.319	.547
C7. Duration of Cantilever Principle Design Morphing	152.2500	122.867	.086	.563
C7. Materials Consumption	152.3750	126.383	-.033	.568
C7. Design Phenomenon	152.6875	118.096	.390	.541
C8. Visual Elements Lining	153.3125	126.762	-.063	.572
C8. Quality of Morphing Design Levelling	152.6875	116.762	.463	.535
C8. Quality of Visual Elements	152.7500	123.133	.075	.564
C8. Pattern of Visual Elements	151.7500	133.800	-.352	.600
C8. Visual Element of Cantilever Principle Design	152.3750	124.383	.056	.565
C9. Software For Evaluation of Heuristic Method	151.6875	123.029	.036	.571
C9. Software For The Heuristic Method Evidences	152.2500	121.667	.062	.569
C9. Manual Mode of Heuristic Method	152.3125	126.762	-.087	.590
C9. Evaluation of Manual Quality	152.5625	109.329	.391	.522
C9. Evaluation of Media Quality	151.4375	112.262	.285	.538
C9. 3D Modelling For The Visual Elements	151.1250	105.450	.651	.495
C9. 3D Modelling Proficiency	151.0625	116.596	.234	.547
C9. Category of Clinical Survey For Visual Elements	153.5625	126.129	-.033	.572
C9. Cantilever Principle Design Mapping	152.0000	100.533	.664	.479
C9. Triangulation of Formgiving Design	152.5625	119.462	.308	.546

APPENDIX 15

SPSS Output For Scales Instumentation of Fieldwork Survey - Scenario 2

i) Testing Method of SPSS: Analyze > Scale > Reliability Analysis (Internal Reliability Analysis for 45 students)

```
RELIABILITY
  /VARIABLES=Q1 Q2 Q3 Q4 Q5 Q6 Q7 Q8 Q9 Q10 Q11 Q12 Q13 Q14 Q15 Q16
Q17 Q18 Q19 Q20 Q21 Q22 Q23 Q24 Q25 Q26 Q27 Q28 Q29 Q30 Q31 Q32 Q33
Q34 Q35 Q36 Q37 Q38 Q39 Q40 Q41 Q42 Q43 Q44 Q45
  /SCALE('FINAL Inter item correlation - 00') ALL
  /MODEL=ALPHA
  /STATISTICS=DESCRIPTIVE
  /ICC=MODEL(MIXED) TYPE(CONSISTENCY) CIN=95 TESTVAL=0.
```

Case Processing Summary

		N	%
Cases	Valid	45	100.0
	Excluded[a]	0	.0
	Total	45	100.0

a. Listwise deletion based on all variables in the procedure.

Reliability Statistics

Cronbach's Alpha	N of Items
.812	45

Item Statistics

	Mean	Std. Deviation	N
Q1-Formgiving fundamentals	1.4889	.50553	45
Q2-Evolution of product form	1.0000	.00000	45
Q3-Geometric to organic	1.0444	.20841	45
Q4-Visual elements	1.0444	.20841	45
Q5-Product design timeline	1.0444	.20841	45
Q6-Cantilever judge	3.6000	.80904	45
Q7-Material used	3.3556	.98062	45
Q8-Ecological form	3.8667	.91949	45
Q9-Recycling methodology	3.6000	1.11600	45
Q10-Ecodesign product	3.8444	.92823	45
Q11-Ecodesign evolution	3.8000	.91949	45
Q12-Design era movement	3.9778	.81153	45
Q13-Manufacturing process	4.0444	.82450	45
Q14-Material supply chain	3.7778	.79455	45

Q15-Environmental design	3.4667	1.17937	45
Q16-Heuristic procedural step	4.0667	.61791	45
Q17-Design beliefs	4.0667	.65366	45
Q18-Quality of ecodesign identity	4.0000	.82572	45
Q19-Timeline of form evolution	4.1333	.81464	45
Q20-Visual elements interpretation	3.9333	.68755	45
Q21-Product form	4.0889	.79264	45
Q22-Evolution of form	4.1778	.64979	45
Q23-Best level < 3 - quality review	3.9778	.89160	45
Q24-Exceeding level > 3 - quality review	4.1333	.81464	45
Q25-Quality of lines	4.1778	.74739	45
Q26-Continuum's quality	4.7111	1.35885	45
Q27-Product form transformation	4.7556	1.69432	45
Q28-Ecodesign identity	5.4444	1.32383	45
Q29-Product form	5.4222	1.37327	45
Q30-Cantilever principle	5.5111	1.51691	45
Q31-Product form identity	5.0667	1.40454	45
Q32-Visual elements understanding	5.0000	1.43019	45
Q33-< Level 3 - Proficiency	5.7333	1.26850	45
Q34-> Level 3 - Proficiency	5.0889	1.39516	45
Q35-Cantilever principle design	5.5111	1.37547	45
Q36-Cantilever concept evolution	2.6667	1.00000	45
Q37-Morphing design scale	2.6222	.74739	45
Q38-Cantilever design morphing	3.2889	1.14062	45
Q39-3R's Methodology	3.1333	.99087	45
Q40-EoF timelines - Design	2.8000	1.34164	45
Q41-Quality of lines - Visual elements	2.1333	1.17937	45
Q42-Morphing design levelling	2.4444	1.01255	45
Q43-3R's Methods morphing	2.8444	.87790	45
Q44-Visual elements patterns - Cantilever principle design	3.4222	1.13796	45
Q45-Screening the VE - Cantilever principle design	2.8222	.86047	45

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Cronbach's Alpha if Item Deleted
Q1-Formgiving fundamentals	161.6444	225.734	-.282	.817
Q3-Geometric to organic	162.0889	222.719	-.169	.813
Q4-Visual elements	162.0889	222.901	-.199	.813
Q5-Product design timeline	162.0889	222.401	-.118	.813
Q6-Cantilever judge	159.5333	212.073	.381	.806

Q7-Material used	159.7778	211.768	.315	.807
Q8-Ecological form	159.2667	206.155	.557	.800
Q9-Recycling methodology	159.5333	207.755	.395	.804
Q10-Ecodesign product	159.2889	210.710	.376	.805
Q11-Ecodesign evolution	159.3333	215.773	.188	.810
Q12-Design era movement	159.1556	216.680	.183	.810
Q13-Manufacturing process	159.0889	216.992	.166	.811
Q14-Material supply chain	159.3556	216.462	.197	.810
Q15-Environmental design	159.6667	216.545	.109	.814
Q16-Heuristic procedural step	159.0667	213.564	.430	.806
Q17-Design beliefs	159.0667	217.109	.217	.810
Q18-Quality of ecodesign identity	159.1333	210.164	.454	.804
Q19-Timeline of form evolution	159.0000	214.045	.294	.808
Q20-Visual elements interpretation	159.2000	213.482	.386	.806
Q21-Product form	159.0444	213.998	.305	.808
Q22-Evolution of form	158.9556	212.134	.484	.805
Q23-Best level < 3 - quality review	159.1556	212.271	.333	.807
Q24-Exceeding level > 3 - quality review	159.0000	212.273	.370	.806
Q25-Quality of lines	158.9556	211.316	.453	.804
Q26-Continuum's quality	158.4222	206.113	.352	.805
Q27-Product form transformation	158.3778	204.786	.290	.809
Q28-Ecodesign identity	157.6889	202.128	.474	.800
Q29-Product form	157.7111	205.892	.353	.805
Q30-Cantilever principle	157.6222	203.013	.379	.804
Q31-Product form identity	158.0667	200.609	.481	.800
Q32-Visual elements understanding	158.1333	203.573	.394	.804
Q33-< Level 3 - Proficiency	157.4000	204.564	.428	.802
Q34-> Level 3 - Proficiency	158.0444	198.998	.528	.798
Q35-Cantilever principle design	157.6222	207.695	.306	.807
Q36-Cantilever concept evolution	160.4667	212.936	.266	.808
Q37-Morphing design scale	160.5111	220.983	.008	.814
Q38-Cantilever design morphing	159.8444	221.089	-.020	.818
Q39-3R's Methodology	160.0000	225.409	-.157	.820
Q40-EoF timelines - Design	160.3333	215.955	.100	.815
Q41-Quality of lines - Visual elements	161.0000	212.136	.238	.809
Q42-Morphing design levelling	160.6889	215.856	.162	.811
Q43-3R's Methods morphing	160.2889	215.756	.201	.810
Q44-Visual elements patterns - Cantilever principle design	159.7111	211.437	.271	.808
Q45-Screening the VE - Cantilever principle design	160.3111	213.674	.290	.808

APPENDIX 16

SPSS Output of Spearman Rho Correlations (Nonparametric Correlations) for The Fieldwork Survey - Scenario 2

Correlations

			Q7-Material used	Q8-Ecological form	Q9-Recycling methodology	Q16-Heuristic procedural step	Q18-Quality of ecodesign identity	Q20-Visual elements interpretation	Q23-Best level < 3 - quality review	Q24-Exceeding level > 3 - quality review	Q25-Quality of lines	Q27-Product form transformation	Q28-Ecodesign identity	Q30-Cantilever principle	Q31-Product form identity	Q32-Visual elements understanding	Q33-< Level 3 - Proficiency	Q35-Cantilever principle design
Spearman's rho	Q7-Material used	Correlation Coefficient	1.000															
		Sig. (2-tailed)																
		N	45															
	Q8-Ecological form	Correlation Coefficient	.510**	1.000														
		Sig. (2-tailed)	.000															
		N	45	45														
	Q9-Recycling methodology	Correlation Coefficient	.548**	.407**	1.000													
		Sig. (2-tailed)	.000	.006														
		N	45	45	45													
	Q16-Heuristic procedural step	Correlation Coefficient	.132	.424**	.156	1.000												
		Sig. (2-tailed)	.387	.004	.305													
		N	45	45	45	45												
	Q18-Quality of ecodesign identity	Correlation Coefficient	.354*	.440**	.345*	.682**	1.000											
		Sig. (2-tailed)	.017	.002	.020	.000												
		N	45	45	45	45	45											
	Q20-Visual elements interpretation	Correlation Coefficient	-.058	.119	.129	.497**	.362*	1.000										
		Sig. (2-tailed)	.703	.438	.398	.001	.014											
		N	45	45	45	45	45	45										
	Q23-Best level < 3 - quality review	Correlation Coefficient	.198	.200	-.040	.242	.269	.083	1.000									
		Sig. (2-tailed)	.193	.189	.793	.110	.074	.587										
		N	45	45	45	45	45	45	45									
	Q24-Exceeding level > 3 - quality review	Correlation Coefficient	.222	.197	.164	.076	.232	.124	.500**	1.000								
		Sig. (2-tailed)	.142	.195	.282	.618	.125	.417	.000									
		N	45	45	45	45	45	45	45	45								
	Q25-Quality of lines	Correlation Coefficient	.232	.167	.380*	.353*	.419**	.573**	.290	.331*	1.000							
		Sig. (2-tailed)	.125	.272	.010	.017	.004	.000	.054	.026								
		N	45	45	45	45	45	45	45	45	45							
	Q27-Product form transformation	Correlation Coefficient	-.040	.127	-.008	.138	.169	.094	.279	.069	.111	1.000						
		Sig. (2-tailed)	.793	.407	.958	.366	.267	.540	.063	.654	.469							
		N	45	45	45	45	45	45	45	45	45	45						
	Q28-Ecodesign identity	Correlation Coefficient	.254	.319*	.272	.431**	.549**	.246	.225	.313*	.391**	.397**	1.000					
		Sig. (2-tailed)	.093	.033	.070	.003	.000	.103	.137	.036	.008	.007						
		N	45	45	45	45	45	45	45	45	45	45	45					
	Q30-Cantilever principle	Correlation Coefficient	-.013	.265	-.024	.256	.206	.021	.214	.105	.231	.389**	.324*	1.000				
		Sig. (2-tailed)	.932	.078	.875	.089	.174	.891	.158	.492	.126	.008	.030					
		N	45	45	45	45	45	45	45	45	45	45	45	45				
	Q31-Product form identity	Correlation Coefficient	.104	.449**	.257	.305*	.405**	.200	.137	.149	.186	.108	.375*	.537**	1.000			
		Sig. (2-tailed)	.496	.002	.088	.042	.006	.188	.369	.330	.222	.481	.011	.000				
		N	45	45	45	45	45	45	45	45	45	45	45	45	45			
	Q32-Visual elements understanding	Correlation Coefficient	.093	.348*	.009	.263	.204	.125	.189	.218	-.073	.576**	.357*	.439**	.488**	1.000		
		Sig. (2-tailed)	.543	.019	.956	.081	.178	.413	.213	.150	.635	.000	.016	.003	.001			
		N	45	45	45	45	45	45	45	45	45	45	45	45	45	45		
	Q33-< Level 3 - Proficiency	Correlation Coefficient	.135	.313*	-.010	.505**	.494**	.151	.324*	.276	.413**	.206	.442**	.519**	.351*	.154	1.000	
		Sig. (2-tailed)	.377	.036	.950	.000	.001	.322	.030	.067	.005	.175	.002	.000	.018	.313		
		N	45	45	45	45	45	45	45	45	45	45	45	45	45	45	45	
	Q35-Cantilever principle design	Correlation Coefficient	-.071	.096	-.095	.328*	.053	.454**	.267	.222	.150	.206	.185	.249	.284	.525**	.279	1.000
		Sig. (2-tailed)	.644	.529	.535	.028	.730	.002	.077	.143	.325	.175	.224	.099	.059	.000	.063	
		N	45	45	45	45	45	45	45	45	45	45	45	45	45	45	45	45

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

APPENDIX 17

An Example of Survey Instrument for The Fieldwork Survey – 45 Items' Questionnaires of Scenario 2

The instrument contents for the subject respondent comprise fourteen pages (Pages 1-2 of 14).

UPM

Sheet No. 13/15

THE CLINICAL SURVEY FORM:
AN INTANGIBLE ECOLOGICAL FORM OF ECODESIGN IDENTITY

THE PURPOSE:

THE MEASUREMENT OF THE INTANGIBLE ECOLOGICAL FORM through the design's perception from ecodesign identity, using the semantics of design thinking by the respondents and IT WILL BE EMPATHICALLY FELT in some beliefs of the ecodesign theory, which is to gauge an accurate answer of the level/find emotion.

CONTENTS

A) A SHORT DESIGN BRIEF:
To describe and explain the design thought of participants.

B) DEMOGRAPHICS:
To show the participation of respondents invalidating the answers and sources of data collection.

C) SECTIONS (45 QUESTIONAIRES):

Section C1 :
To label the variables of product category towards an intangible ecological form identity.

Section C2 & C3:
To recognise some visual elements of product design following the design thinking.

Section C4 & C5:
To measure the perception of design belief (axis X&Y), using a 5 point Likert scale design to validate the intangible ecological form of ecodesign.

Section C6 & C7:
To seek the emotion of a product's form quality (axis X&Y), using a 7 point numerical scale design in the heuristic procedural step.

Section C8 & C9:
To elaborate an intangible ecological form for ecodesign using the level of ratio scales following on the product's form and its functional unit.

IMPORTANT!: The interviewee is required to LEARN the ENTIRE explanation of the short design brief for *"the better understanding of ecodesign identity" answers.*

1

A) A SHORT DESIGN BRIEF

- **The Clinical Survey Objective**

To gauge the morphing of the cantilever design (the semantics of design thinking) using the naming (label/category / multiple choices), rating (semantics scales), and scoring (functional unit) questionnaires: it will empirically investigate the ***designers' perception*** using an object/artefact's identity and its design evolution. Also, the survey evokes an **ecodesign emotion,** referring to the visual elements within an ecological form. The total numbers of items are 45 questionnaires.

- **About The Visual Element in Design**

"In industrial design, the creation of form(s) while designing involves an understanding of how to use basic *visual elements* such as point, line, plane or surface, and volume (see Figure 1), as well as the rules and principles governing the organisation of the composition or structure (Akner-Koler, 2000). Visual elements are part of the attributes of form that create tone and texture, thus imparting visual interest and meaning. Their importance becomes evident through their use in generating images and form(s) that are both two-dimensional and three dimensional". (Author: Abidin, 2012)

Dimensional	Visual	Dimensional	Visual
0-D Point	• Position	1-D Line	Length
2-D Plane / Surface	Height Width	3-D Volume	Height Depth Width

Fig.1: The development of visual elements.

- **About The Cantilever Principle Design**

"The propped cantilever form is established from the beam model or beam equations principle. Bischoff et al (2004) states that today, the beam theory is used in many knowledge disciplines: mechanical engineering, structural engineering, and engineering design technology (See to Fig.2). In the *Dictionary of Architecture and Construction*, two meanings of the cantilever are translates (1) "*a beam, girder, truss, or structural member or surface that projects horizontally beyond its vertical support, such as a wall or column;*" and (2) "*a projecting bracket used for carrying the cornice or extended eaves of a building*" p.169, Harris (2006)".(Authors: Chumiran, Abidin, &Sirat, 2016).

2

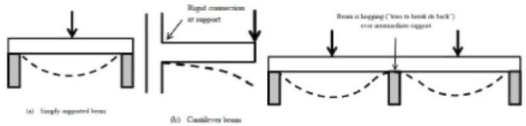


Fig.2: Three types of beam structural foundations.

- **Semantics Design Thinking Theory**

By the intuition of semantics study, product form creation is divided into two categories;

- The tangible form creation (Fig.3) and
- The intangible form creation (Fig.4)



Fiskars – PowerGear Pruner, Colin Roberts (2010)

Fig.3: The tangible form creation

The tangible form refers to the *explicit* semantics of design development from the product form's foundation by "direct" visual and/or mass of production physically, as well-known as an interpolative strategy. (Authors: Chumiran et al., 2018).

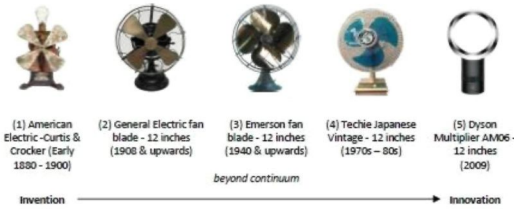


Fig.4: The intangible form creation

Meanwhile, the intangible form represents the *implicit* semantics designs development from the product form's fusion by the "indirect" ecological system of the artefact timeline environmentally and 'beyond continuum' from one of the control images by extrapolative strategy. (Authors: Chumiran et al., 2018).

B) DEMOGRAPHIC

The answers you provide will be used only to analyse your views, and no information linking you to your answers will be provided to the organisation/firm/manufacturer, etc. The questionnaire should take only a couple of minutes to complete.

You must answer all the questions. Your views and answers may not represent the common practice in your project or company. Complete confidentiality is assured, and the survey result will be used strictly for academic purposes.

Please fill in with a tick (✓) in one of the boxes where appropriate.

Gender: ☐ Male ☑ Female

Age: ☐ 18 – 20 years old ☑ 21– 25 years old ☐ 26– 30 years old

Academic Qualification: ☐ Diploma ☑ Degree

Semester: ☐ Dip. Semester 03 ☐ Dip. Semester 04
☐ Dip. Semester 06 ☐ Dip. Semester 05

☐ Degree Semester 03 ☑ Degree Semester 04
☐ Degree Semester 06 ☐ Degree Semester 05

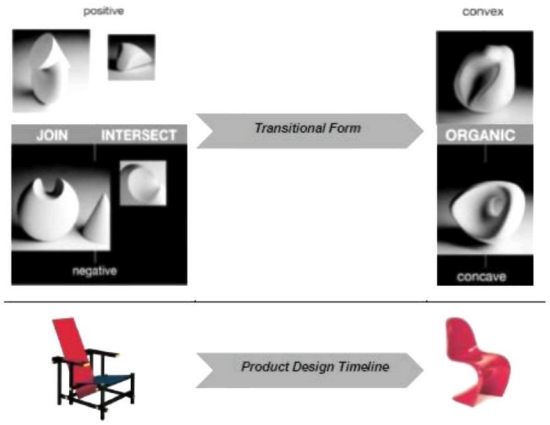
Specialisation: ☐ Product design ☑ Furniture Design ☐ Transport Design

The instrument contents for the subject respondent comprise fourteen pages (Pages 5-6 of 14).

C) QUESTIONAIRES SECTION

SECTION C1: Nominal Questionnaire

Figure 1: Design continuum - The evolution of form (EoF)

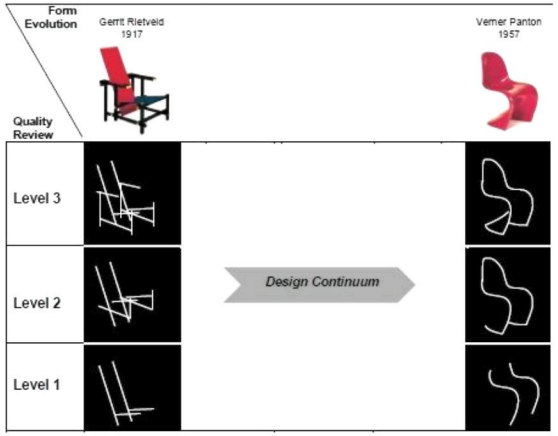


No.	Questionnaires	Please (√) one
1.	Have you heard and know about the fundamentals of forgiving?	☐ Yes ☒ No
2.	Do you believe in the evolution of product form?	☒ Yes ☐ No
3.	Do you understand geometric shifts into the organic form?	☒ Yes ☐ No
4.	The visual elements (VE) play a role in the design evolution. into the cantilever principle design morphing	☒ Yes ☐ No
5.	The design era movement exposes the entire transitional form. evolution according to the product design timeline	☒ Yes ☐ No

5

SECTION C2: Semantic Differential Scale

Table 1: Addressing The Design Thinking



Please (√) one box after each statement;

No.	Descriptions	Semantic Differential Scale						
		Descent	Poor	Slightly	Neither	Adequately	Extremely	Ascent
6.	Cantilever Judge	Not Aesthetic				√		Extremely Aesthetic
7.	Material Used	Not Recyclable			√			Extremely Recyclable
8.	Ecological Form	Not Artistic				√		Extremely Artistic
9.	Recycling Methodology	Not 3R's Method	√					Extremely 3R's Method
10.	Ecodesign Product	Not Environmental		√				Extremely Environmental

6

The instrument contents for the subject respondent comprise fourteen pages (Pages 7-8 of 14).

SECTION C3: Semantic Differential Scale

Table 2: The heuristic of transitional form

Geometric Form ▸ Transitional Form ▸ Organic Form

Adapt (assimilate, dissimilate) and Merge (converge, diverge)

Marcel Breuer 1925 | Mart Stam 1927 | Gerrit Rietveld 1934

Form Evolution



Please (√) one box after each statement;

No.	Descriptions	Semantic Differential Scale						
		Descent	Poor	Slightly	Neither	Adequately	Extremely	Ascent
11.	Evolution of Ecodesign	Traditional		/				Modern
12.	Design Era Movement	Conventional				/		Sophisticated
13.	Manufacturing Process	Manual				/		Automation
14.	Materials Supply Chain	Disposal				/		Renewable
15.	Environmental Design	Global Warming				/		Green Design

SECTION C4: Likert Scale

Table 3: Horizontal Axis - The Heuristic Procedural Step

Geometric Form ▸ Transitional Form ▸ Organic Form

Joint + Intersectional | Adapt (assimilate, dissimilate) and Merge (converge, diverge) | Concavity

Gerrit Rietveld 1917 | Marcel Breuer 1925 | Mart Stam 1927 | Gerrit Rietveld 1934 | Verner Panton 1957

Form Evolution



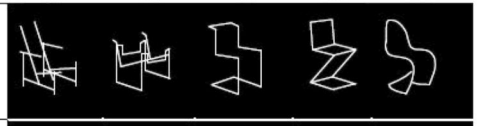
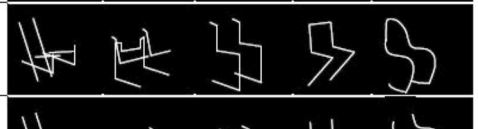
Please (√) one box after each statement, according to the given 5 points Likert scale;

No.	Statements	Extremely disagree	Disagree	Neutral	Agree	Extremely agree
16.	The continuum of the heuristic procedural step allows the designers to screen the product's form evolution.				/	
17.	The lining structure of visual elements (VE) creates a design's belief during the organic form's transformation.			/		
18.	I feel the continuum direction of the heuristic procedural step develops the ecological form evolution to reveal the quality of ecodesign identity.				/	
19.	The timeline of form evolution is equivalent to the product's form history within its design era movement (design object creation).			/		
20.	If this heuristic procedural step interprets the VE for the object's form quality. Then, I feel the pattern of the cantilever principle design has emerged together with an intangible ecological form.				/	

The instrument contents for the subject respondent comprise fourteen pages (Pages 9-10 of 14).

SECTION C5: Likert Scale

Table 4: Vertical axis - The level of quality review

	Criteria 1 ► Basic Structure		Criteria 2 ► Structural Concept & Formal Concept		Criteria 3 Material Concept
Quality Review	Gerrit Rietveld 1917	Marcel Breuer 1925	Mart Stam 1927	Gerrit Rietveld 1934	Verner Panton 1957
Level 3					
Level 2					
Level 1					

Please (√) one box after each statement, according to the given 5 points Likert scale;

No.	Statements	Extremely disagree	Disagree	Neutral	Agree	Extremely agree
21.	I feel the quality review levels can examine our understanding of a product's form and its design identity evolution.					/
22.	I think the visual elements (VE) emerge from our design's belief during the form evolution study in the heuristic study.				/	
23.	I feel that the best level (3) of the quality review creates a basic approach proficiency.				/	
24.	I believe anything exceeding level 3 of the quality review will make a better approach proficiency *(not shown in the above table)*.			/		
25.	If I believe the quality of lines screen the structure of the cantilever principle design, then the visual elements' (VE) levels have sequentially transmitted the product's form identity.			/		

SECTION C6: Numerical Scale

Table 5: Horizontal axis - The heuristic procedural step

	Geometric Form ►	Transitional Form	► Organic Form
	Joint + Intersectional	Adapt (assimilate, dissimilate) and Merge (converge, diverge)	Concavity
	Gerrit Rietveld 1917	Marcel Breuer 1925 / Mart Stam 1927 / Gerrit Rietveld 1934	Verner Panton 1957
Form Evolution			

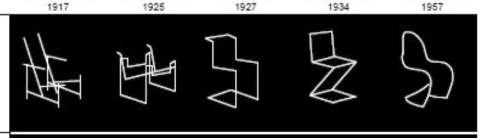
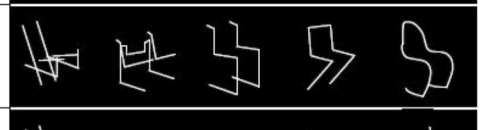
Please tick (√) one box after each question, and answers are given following the above visual aid to assign the specific value according to the 7 points numerical scale;

No.	Questionnaire	7 points of Numerical Scale							
		Adjectives	7	6	5	4	3	2	1	Antithesis
26.	How is the continuum's quality of the heuristic procedural step?	Convergent		/						Divergent
27.	How is the product's form transformation through the VE?	Organic						/		Geometric
28.	Did the quality of design development deliver an ecodesign identity?	Beauty				/				Ugly
29.	How did the morphing of the product's form evolution happen?	Delicate			/					Rough
30.	What emergence is the cantilever principle design looking for?	Simple		/						Complex

The instrument contents for the subject respondent comprise fourteen pages (Pages 11-12 of 14).

SECTION C7: Numerical Scale

Table 6: Vertical axis - The level of quality review

	Criteria 1 ► Basic Structure	Criteria 2 ► Structural Concept & Formal Concept			Criteria 3 Material Concept
Quality Review	Gerrit Rietveld 1917	Marcel Breuer 1925	Mart Stam 1927	GerritRietveld 1934	Verner Panton 1957
Level 3					
Level 2					
Level 1					

Please (√) one box after each question, the answers given are following the above visual aid to assign the specific value according to the 7 points numerical scale;

No.	Questionnaires	7 points of Numerical Scale							
		Adjectives	7	6	5	4	3	2	1	Antithesis
31.	Did the product's form identity happen?	Tangible	/							Intangible
32.	How do you believe the visual elements (VE)?	Explicit		/						Implicit
33.	How about the proficiency of level 3?	Excellent				/				Poor
34.	How about the proficiency at > level 3?	Perfect			/					Ordinary
35.	What did the cantilever principle design look like?	Structure	/							Cluttered

SECTION C8: Ratio - Multiple Choice Questionnaire

Table 7: Horizontal axis - The theory of extrapolative semantics design thinking

Geometric Form ►	Transitional Form			► Organic Form
Joint + Intersectional	Adapt (assimilate, dissimilate) andMerge (converge, diverge)			Concavity
GerritRietveld 1917	Marcel Breuer 1925	Mart Stam 1927	GerritRietveld 1934	Verner Panton 1957
 ►			 ►	
continuum →				
1	2	3	4	5

36. From the designer's point of view, how many times can you screen / imagine the above evolution of the cantilever principle design concept?

☐ 3 Times ☒ 5 times ☐ 7 times ☐ 9 times ☐ >than 11 times

37 For your suggestion, how many numbers of sequences should be in a morphing design scale ideally?

☐ 3 scales ☐ 5 scales ☒ 7 scales ☐ 9 scales ☐ 10 scales

38. For elaboration, how long do you spend in minutes to screen the morphing of the cantilever principle design concept from a design perspective?

☐ < than a min. ☐ 3-5 min. ☐ 6-8 min. ☒ 9-11 min. ☐ > than 12 min.

39. If five scales of morphing design evoke the recycling methodology (3R's Method) in the cantilever form concept. Then, how many material consumptions can be counted/applied in the approach for an intangible ecological form of ecodesign?

☐ 1 material ☒ 2-3 materials ☐ 3-4 materials ☐ 4-5 materials ☐ > than 6

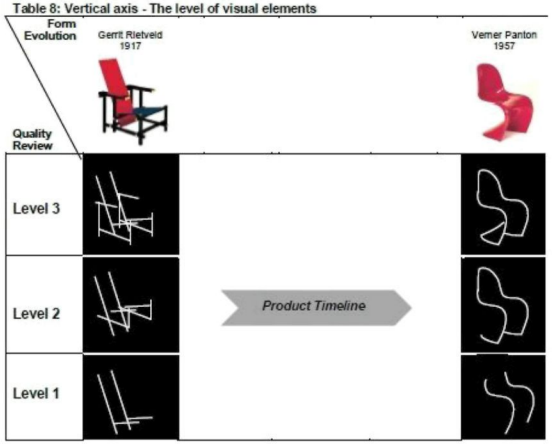
40. How do you feel about the period of design evolution to emerge a cantilever principle of design concept phenomena?

☐ 1-5 years ☒ 6-10 years ☐ 11-15 years ☐ 16-21 years ☐ >22 years

The instrument contents for the subject respondent comprise fourteen pages (Pages 13-14 of 14).

SECTION C9: Ratio - Multiple Choice Questionnaire

Table 8: Vertical axis - The level of visual elements



41. How many repeating lines of visual elements are in each different quality level?

☒ 3-5 lines ☐ 7–9 lines ☐ 11–13 lines ☐ 15-17 lines ☐ > than 19 lines

42. How many numbers of quality stages should be suitably used in the morphing design levelling?

☐ 3 levels ☐ 5 levels ☒ 7 levels ☐ 9 levels ☐ > than 11 levels

43. According to the quality of visual elements, how many jointing points occurred to evoke the 3R's Method in morphing the design structure?

☐ 1-3 points ☒ 3-5 points ☐ 5-7 points ☐ 7-9 points ☐ > than 11 points

44. How many patterns of visual elements (VE) are needed to shape the cantilever principle design?

☐ 1 pattern only ☐ 2 patterns ☒ 3 patterns ☐ 4 patterns ☐ > than 5 patterns

45. How many times did you screen the visual elements of the cantilever principle design?

☐ 1 time only ☐ 3-5 times ☒ 7-9 times ☐ 11-13 times ☐ > than 15 times

Please place a tick in this space (✓) if you would like to receive a brief report of the findings of this study.

Please provide me about your detail as below given that I will use ONLY for this purpose:

a) Name : Fatin Faisal

b) Contact number :

c) Email address : fatin.fatin@gmail.com

Thank you for your cooperation and for taking the time to answer this questionnaire.

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Mohd Hasni Bin Chumiran earned his Bachelor of Art & Design (Industrial Design) and Master of Arts & Design (by Research) from Universiti Teknologi MARA in 2002 and 2016, respectively. He is currently elaborating a PhD focused on the topic Elucidation of Future Designers' Interpretation of Fusion Identity in Ecodesign, which explores the intersection of semantic design thinking and sustainable design practices through a dual-model approach: the support model and the evaluation model. With more than 14 years of industry experience, he has worked extensively in R&D, industrial design, creative and innovative development, and project management, contributing to areas such as ISO 9001 (QMS) and ISO 14001 (EMS) implementations. Presently, he holds the position of Industrial Fellow at the Faculty of Engineering Technology, Universiti Tun Hussein Onn Malaysia (UTHM), where he actively engages in academic instruction and research. His academic interests include industrial design, design thinking, research methodology, sustainable product design (SfPD), new product development (NPD), ergonomics, and manufacturing technology, reflecting his commitment to interdisciplinary design innovation.

LIST OF PUBLICATIONS:

Chumiran, M. H., Zainal Abidin, S., Rahim, W. N., & Vermol, V. V. (2021). Cognitive ergonomics of formgiving as unstructured approaches in furniture design practice. *Environment–Behaviour Proceedings Journal, 6*(SI5), 27–32. https://doi.org/10.21834/ebpj.v6iSI5.2927

Chumiran, M. H., & Zainal Abidin, S. (2021). Design pedagogy: Pictographic design artefacts perceived artificial intelligence elements for product designers. *Environment–Behaviour Proceedings Journal, 6*(SI4), 57–62. https://doi.org/10.21834/ebpj.v6iSI4.2901

Chumiran, M. H., Abidin, S. Z., & Kamil, M. J. M. (2020). Pre–post observation research fosters a preliminary study in product form identity. In *DS 104: Proceedings of the 22nd International Conference on Engineering and Product Design Education (E&PDE 2020)*. VIA Design, VIA University College. https://doi.org/10.35199/EPDE.2020.41

Chumiran, M. H., Abidin, S. Z., Anwar, R., Vermol, V. V., & Sirat, A. (2020). 3R evokes ecodesign identity in ecological system of green manufacturing. *International Journal of Supply Chain Management, 9*(3), 182–190. https://doi.org/10.59160/ijscm.v9i3.3381

Chumiran, M. H., Zainal Abidin, S., Anwar, R., & Alli, H. (2020). Extrapolative morph design thinking as an intangible ecological form to encode the ecodesign identity. *Environment–Behaviour Proceedings Journal, 5*(SI3), 91–97. https://doi.org/10.21834/ebpj.v5iSI3.2538

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