UNIVERSITI TEKNOLOGI MARA

UNINTENDED REASONING: UNDERSTANDING DESIGNER DESIGN ACTIVITY TOWARDS USER INTERACTION EXPERIENCE AND BEHAVIOUR IN MAINSTREAM PRODUCT

ZULKARNIAN BIN HASSAN

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ZULKARNIAN BIN HASSAN

Thesis submitted in fulfilment
of the requirements for the degree of
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CONFIRMATION BY PANEL OF EXAMINERS

I certify that a Panel of Examiners has met on 9th March 2026 to conduct the final examination of Zulkarnian Bin Hassan on his Doctor of Philosophy thesis entitled "Unintended Reasoning: Understanding Designer Design Activity towards User Interaction Experience and Behaviour in Mainstream Product" in accordance with Universiti Teknologi MARA Act 1976 (Akta 173). The Panel of Examiners recommends that the student be awarded the relevant degree. The Panel of Examiners was as follows:

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Professor
Faculty of Art and Design
Universiti Teknologi MARA
(Chairman)

Mohamad Hariri Abdullah, PhD
Professor
The Design School
Taylor's University
(External Examiner)

Norazmi Shahlal, PhD
Senior Lecturer
Faculty of Art and Design
Universiti Teknologi MARA
(Internal Examiner)

Marcin Zbiec, PhD
Associate Professor
Warsaw University of Life Sciences
(External Examiner)

PROF DR HJH ZURAEDA BINTI IBRAHIM
Dean
Institute of Postgraduate Studies
Universiti Teknologi MARA
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Name of Student	:	Zulkarnian bin Hassan
Student I.D. No.	:	2019896352
Programme	:	Doctor of Philosophy (Arts and Design) – AD950
Faculty	:	Art and Design
Thesis Title	:	Unintended Reasoning: Understanding Designer Design Activity towards User Interaction Experience and Behaviour in Mainstream Product
Signature of Student	:	………………………………………………..
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ABSTRACT

Mainstream product design has long prioritised the alignment of human requirements with technological advancement through a human-centred design approach. However, a significant gap persists in addressing unintended human behaviour (UHBE) the unexpected ways users engage with products in their daily lives. In design research, this phenomenon is often examined from a limited perspective across various fields, leaving designers with few methodologies to comprehend the underlying causes, interpret human interaction, and integrate these insights meaningfully into the design process. A more profound understanding of UHBE is therefore essential, as it influences human-product interaction, communication, and the overall user experience, which in turn can shape product innovation and design outcomes. This study investigates UHBE as a central phenomenon in mainstream product design represented by a wash basin product in exploring both user perceptions and designer reflections through the 'consumerism' model, which is deemed to be closer to the user's understanding. Data was collected via a questionnaire survey to examine people's experiences and perceptions regarding the unintended use of products. Further analysis included a visual inventory of user interactions, photo-based research to assess designers' responses to behavioural attributes, and verbal protocol analysis to capture designers' reflective thinking during design activities. Additionally, design syntactic analysis was employed to interpret the structural aspects of design form and its role in establishing unintended use behavioural models. These approaches collectively provide a multi-layered understanding of how designers interpret, respond to, and integrate user behaviour into their creative practices. The findings of Visual Inventory Analysis (VIA) indicate that unintended behaviours closely relate to users' implicit needs for comfort, recognition, safety, and adaptation, while also reflecting designers' interpretations of user experience within the design process. The result of Photo-based research analysis (PBA) reflecting users and designers demonstrate different patterns of perception towards UHBE attributes. The diverse perceptions reflect the gap in understanding of the product, which highlight the importance of integrating both perspectives during the early stages of the design process to enhance usability, functional clarity, thereby supporting human-centered & sustainable product development grounded in real-world interaction. The study emphasises UHBE's ability to inform design thinking, stimulate reflective practice, and enhance methodological approaches in product development through Verbal Protocol Analysis (VPA) and the proposed Unintended Behavioural Design (UBD) Framework for product development strategy based on Design Syntactic Analysis (DSA) findings. It argues that recognising unintended use not only enriches designers' understanding of everyday interaction but also contributes to a more responsive and innovative mainstream product design. The researcher concludes that a hermeneutical and reflective design approach offers a valuable pathway for integrating user behaviour into the design process. By encouraging deeper engagement with UHBE, this study contributes to the expansion of the body of knowledge, has implications for design pedagogy, design thinking, refinement of designer criteria in everyday design practice, and cultivation of creativity in design education, ultimately supporting the development of more adaptive and meaningful product ideas in the development of a conceptual design.

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Abbreviations

DSA	Design Syntactic Analysis
DS-1	Descriptive Study 1
DS-2	Descriptive Study 2
PBA	Photo-based Research Analysis
PS	Prescriptive Study
RC	Research Clarification
RO	Research Objective
RQ	Research Question
RTD	Research Through Design
UBD	Unintended Behavioural Design
UCR	User-Centred Research
UHBE	Unintended Human Behaviour
UX	User Experience
VIA	Visual Inventory Analysis
VPA	Verbal Protocol Analysis
VPAE1	Verbal Protocol Analysis Episode 1
VPAE2	Verbal Protocol Analysis Episode 2
VPAE3	Verbal Protocol Analysis Episode 3

CHAPTER 1
INTRODUCTION

1.1 The Basic Interrelation of Designer, Product, and User

In the context of product design, the relationship between the designer, the product, and the user forms the foundation of the entire design process, which is complex, significant, and dynamic. Essentially, the product acts as an intermediary between the designer's intent and the user's actual interpretation. Users view the product based on their needs by seeing the product's potential as a role in solving everyday problems, as described by Crilly (2005) in Figure 1.1. According to Buchanan (2001), design is a form of integrative thinking in which designers must combine an understanding of humans, technology, and the environment to produce meaningful solutions. Therefore, designers are bound by user needs and the constraints of the product they create (Anwar, 2016; Kamil, 2017; Vermol, 2018. Meanwhile, the product is the tangible outcome of the design process, serving as a physical intermediary and a "medium" that conveys meaning and function and connects the designer's thinking with the user's experience. According to Norman (1988), a satisfactory product should be able to "speak" to users through visual and interactive cues, guiding proper usage, evoking positive emotions, building trust, and enhancing the user's quality of life. Nowadays, users are no longer regarded as passive entities in the context of designers and products; they also assign meaning to a product based on their background, values, and experiences through user-centred research (UCR) and user experience research (UX).

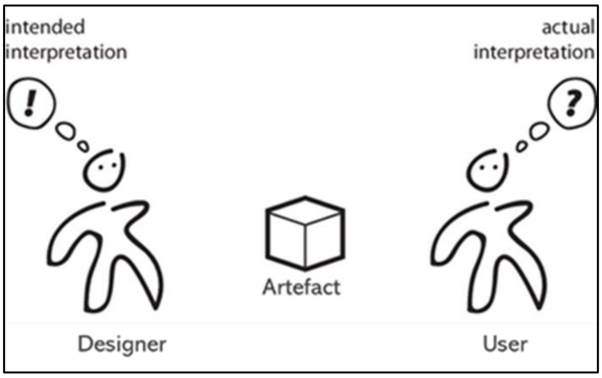

Figure 1.1 Basic Structure of a Communication-Based Model of Design
(Crilly et al., 2008)

In an increasingly challenging world, dynamic changes in design are being driven by UCR and UX research, which encompasses product perception (Hassenzahl, 2010; Wright & McCarthy, 2010), emotion and hedonism (Hassenzahl, 2008), product quality and evaluation methods (Mkpojiogu et al., 2022), as well as specifications and emergent products (Aurisicchio et al., 2011). The nature and complexity of product design have been influenced by various factors, including how users interact with products (Kim et al., 2021; Wakkary & Stolterman, 2016), design development activities (Liem, Abidin, & Warell, 2009; Warell, 2001), and user needs (Hirschman, 1980; Suri, 2005; Norman, 2013; Valkenburg, 2000; Wongkitruangreng, 2018). This situation indicates that the designer-product-user relationship influences the iterative design process (Schön, 1983).

Co-design, a collaborative and responsive concept, increasingly recognises users for providing feedback on designs (Sanders & Stappers, 2008). From an epistemological perspective on design, this relationship (designer-product-user) is not solely about form or function, but it is reflective of humans' interaction with their ‘material’ world (Liem, 2017). As a result, there is a change in the nature of the core elements in product design that fundamentally transforms the product development process to an interdisciplinary and concurrent design approach. This challenge directly affects the professional practice among product providers and designers to accommodate more different qualities in products with technology than ever before. Product designers should expand their perspectives to find a fit between current technology and human behavioural interactions, including the notions of UCR and UX (Liem, 2017). The past decade has seen design research express an interest in product design that emphasises user interaction and experience and thus embraces this approach (Forlizzi & Ford, 2000). As Kim et al. (2021) explain, everyday products are not just about providing functionality and aesthetics; they are also about building interaction experiences, influencing communities, inspiring, and shaping human behaviour to use them in contexts that are diverse or contradictory to the original design intent.

Therefore, it is crucial in design research to ensure that these ‘signals’ and ‘messages’ of ‘interaction’ are integrated into the designer’s process. This approach improves the user experience and builds a stronger connection between the product and its users. By emphasising these elements, designers can develop more intuitive and engaging solutions that truly connect with their audiences. Based on previous studies by various scholars, there is an awareness of the need to critically evaluate, study, and understand the interaction elements between human behaviour and mainstream products across different contexts (Kim et al., 2021; Tromp & Hekkert, 2017; Wakkary et al., 2015). The conceptual foundation of human-behavioural interaction in product design focuses on user-centred products, which involve researching and understanding the user's cognition when using the product to enhance the overall experience (Hirschman, 1980; Hua & Fei, 2009). Essentially, research on human interaction with everyday products involves design researchers critically observing the behaviours of target groups, such as people with disabilities, seniors, or children (Buchenau & Suri, 2000; Norman, 2004; Suri, 2005; Waddington & Wakkary, 2010). Most studies aim to address the explicit needs of these groups, resulting in improvements in human values and user experience. Since then, much research has focused on involving users directly in reenacting exhibited interactions. This indicates that the interaction elements in the product enhance its features in terms of innovation, ergonomics, and human-centred design compared to traditional approaches (Hua & Fei, 2009). However, what is the best approach for studying unintended or spontaneous behaviours exhibited by users when operating the product outside its original context? What strategies are suitable for understanding, studying, and evaluating how unintentional behaviours interact with mainstream products? Specifically, this topic involves complex and limited research from the perspective of human-product interaction.

Therefore, studying unintended interaction requires a reflective design approach, where designers are not only problem solvers but also observers, interpreters, and learners who can influence users' emotions, behaviours, and cultures (Hassan et al., 2022; 2024). Understanding this core connection is vital in research through design (RTD), as it highlights how designers generate, communicate, and reflect on new knowledge (Frayling, 1993; Prochner, 2022; Zimmerman et al., 2007). It encourages designers to question assumptions, revise their intentions, and adapt their solutions based on real-world feedback during experimental setting protocols. By making the user a central, unpredictable agent in the design process, this relationship becomes a key area for inquiry. This approach enables a deeper investigation into the alignment of design intentions with users' actual needs, particularly through unintended behaviours, and how this misalignment can lead to more significant, responsible, and innovative design outcomes.

1.2 User in Product Design Research

In the context of product design, users are regarded as the primary reference point for designers, especially when developing products intended for human interaction. Their opinions, feedback, and lived experiences are critical in ensuring that the final design aligns with actual user needs and usage contexts. This study adopts the term ‘product’ to refer broadly to various types of consumer goods used in daily life, including portable, durable, static, and hybrid products. Over the past decades, the evolution of product design has shifted significantly towards a more human-centric orientation. This shift has led to the emergence of several related terminologies in design literature, such as customer-centred design (Chandler & Hyatt, 2002; Beyer & Holtzblatt, 1998), human-centred design (ISO, 1999; Wakeford, 2004), and user-centred design (Vredenburg et al., 2002). While there are nuanced differences among these terms, they all share a common emphasis on the central role of people, particularly users and stakeholders, in the design process. The fundamental purpose of adopting a human-centred approach to actively engage users during product development. This inclusion enables the gathering of rich, user-driven insights that designers alone might not have anticipated. These insights can range from emotional responses and preferences to practical, everyday needs. According to Laurel (2003), involving users in the early stages of the design process not only enriches it but also helps reduce the risk of market failure by ensuring the product resonates with real-world behaviours and expectations.

Through design research and consumer studies, the terms user and consumer are frequently employed, yet they represent conceptually distinct roles depending on the context of engagement with a product. From a design perspective, ‘user’ refers specifically to an individual who interacts directly with a product, engaging with its features, functions, and physical interface. The role of the user is central to human-centered design approaches, where understanding the user’s behaviours, preferences, and experiential responses is essential for informed design decisions (Sanders & Stappers, 2008; Vermol, 2018; Visser, 2009). Users are often positioned as active participants whose input can meaningfully influence the development of products that are more functional, intuitive, and empathetic to real-world use. In contrast, the term ‘consumer’, particularly within the field of marketing and consumer behaviour, typically refers to individuals who make purchasing decisions and participate in the economic exchange of goods (Kotler & Keller, 2016; Schiffman & Kanuk, 2007). Consumers may not necessarily use the product themselves; instead, their significance lies in their role as market actors, those who respond to advertising, assess product value, and influence demand. Despite these differences, the user and consumer may be the same person in some cases. However, for the purposes of design research, the emphasis is more appropriately placed on the user, whose interactions with the product offer helpful observations about usability and experience. For instance, in the scenario of two users while using a baby bathtub product, the 'user' may be the person (mother) who physically bathes a baby and handles the bathtub, while the 'consumer' could be the individual (baby) who benefits from the uses but does not operate the product (see Figure 1.2). Therefore, in this study, identifying the differentiation between 'user and consumer' is crucial, as it allows for a more precise understanding of human-product relationships and ensures that design strategies are tailored to the actual needs and behaviours of those who engage with the product in practice.

Figure 1.2 Comparisons of "User" And "Consumer" Terms according to the Researcher's Impression. (Product Sample: 3-Stage Bathtub by Snuggle Bugz)

Meanwhile, in this study, the researcher used the term "mainstream product" to refer to an industrial product that is widely accepted, used, and accessible to the general public. It is designed for the mass market, often reflecting the dominant user expectations, preferences, and norms of a particular culture or society. For that reason, this study focuses on industrial product design to visualize the phenomenon of UHBE interaction within users' everyday and daily life uses. These products are typically standardised, commercially viable, and manufactured at scale to meet general user demand. According to Sanders and Stappers (2008), mainstream products are those developed using conventional, user-centred design methods targeted at “average users” to serve a broader population, often neglecting diverse or marginal user needs. Manzini (2015), highlights that mainstream products represent established industrial design solutions aimed at efficiency, affordability, and broad social adoption. Therefore, this study uses an industrial design represented ‘mainstream product’ as the subject for this thesis.

1.3 The Phenomenon of Unintended use of Product

Every day, people interact with and experience multiple products for various purposes. Typically, a product was designed according to the designer’s intention to decorate society and living spaces, as well as to provide users with a well-rounded life and create meaningful days, as depicted in Figure 1.3. However, some users may use a product differently from its original context to fulfil their needs and goals, which could lead to risky situations or injury. When people experience and live with artefacts in their daily lives, it becomes clear that they are interpreted and appropriated within their practical context in ways that are invisible or uncontrollable by the designer (Wakkary et al., 2015). This situation refers to the phenomenon of ‘unintended use of product’.

Figure 1.3 The Phenomenon of Unintended Use of Mainstream Products

According to Merriam Webster (2025), the word ‘unintended’ means ‘not planned as a purpose or goal', while the Cambridge Dictionary (2025) defines 'unintended' as 'not intentional, happening unexpectedly or by accident'. Meanwhile, the term "unintended" referred to Uleman and Bargh (1989) research related to unintended cognition and automaticity in social psychology (Uleman, 1989; Freud, 1955; Norman, 1980). "Unintended thoughts and behaviours often arise without conscious intention or awareness, driven by automatic cognitive processes." (Bargh, 1997). Meanwhile, behaviour is defined as a key human characteristic involving a highly unpredictable and complex process exemplified in human daily life. Human behaviour is dynamic, fluid, and fleeting, which makes it difficult to access without using behavioural science observation methods. The phenomenon of unintended human behaviour (hereafter referred to as UHBE) towards products denotes situations in which people utilise a product in manners that diverge from the manufacturer's designated purpose (or intent by designer), which creates new interaction between individual and object in daily life (Hassan et al., 2022). These situations may encompass straightforward, routine adaptations to more innovative and unforeseen utilisations. Although they are sometimes harmless, unintended uses of products may lead to misuse, which presents potential risks. In other words, 'unintended' itself refers to something that happens as a result of an action which was not the original intention or purpose and that happens unconsciously and pre-consciously.

Bargh and Uleman's book *"Unintended Thought"* explores the activation and influence of thoughts, goals, and behaviours without conscious awareness or intention. Moreover, Suri (2005), in her research *"Thoughtless Acts,"* describes the phenomenon of unintended behaviour towards products to show how humans often perform automatic and unintentional actions, which can affect interactions with objects around them. In consumer research, several scholars have discussed the UHBE phenomenon in the context of consumers (Foxall, 1994; Goldsmith & Foxall, 2003; Hirschman, 1980; Hoffman, Kopalle, & Novak, 2010; Midgley & Dowling, 1978; Ridgway and Price, 1994; Wongkitrungrueng, 2018; Pillai et al., 2022). From their research perspective, the unintended use of a product refers to 'use innovativeness', which describes the creative use of existing products unintentionally or spontaneously (Wongkitrungrueng, 2018). UHBE occurs when people 'perceive' that the product has similar characteristics or will function as needed on time, for a specific purpose, or in a specific situation (Hirschman, 1980). Users demonstrate potential value when they use the product in ways that deviate from the designer’s intention (Pillai et al., 2021). Meanwhile, in the field of design and interaction, Redström (2006) supports the idea of ‘unintended use by unintended users’ because it is almost impossible to take into account, at least systematically, and designs are always used in unintended ways, and the result is not a bad thing' (p. 130). It is considered a feature of appropriation in the use of products by people and is seen as a sign of acceptance of a technology (Wakkary et al., 2015). Dix (2007) also supports awareness of ‘creative misuse’ and the proposed guidelines of designing for appropriation. The appropriation of artefacts generally aligns with Alexander’s descriptions of actions in unselfconscious culture and the objective of achieving a ‘goodness of fit. Alexander (1964), in his seminal work ‘Notes on the Synthesis of Form’, introduced the concept of unselfconscious design, which refers to a design process that occurs naturally within traditional societies without intentional analytical reflection. Within this context, design is not the outcome of structured thinking or modern theoretical frameworks but rather the result of gradual adaptation rooted in collective experience, habitual use, and social learning.

Direct interaction between users and their environment shapes such forms effectively, even in the absence of formal design analysis. This notion aligns with the foundation of unconscious behaviour in design studies, where actions and decisions are made without deliberate reflection. Uleman and Bargh (1989) contend that automatic and unintended processes, beyond the control of conscious cognition, guide much of human behaviour. Within the design domain, UHBE phenomenon is observed when users interact with products intuitively, driven by previous experiences and perceptual familiarity (Norman, 2013). These interactions often occur without users being consciously aware of the specific choices they make, suggesting that product usability and experience can be shaped by deeply ingrained cognitive mechanisms. Meanwhile, Norman’s (1988) cognitive interaction theory explains the relationship between human behaviour and interaction with surrounding objects. He added that behavioural interaction and interactivity help create successful products (2022). Norman (2004) used design capabilities to explain interactivity. Norman’s cognitive interactions, behaviours, and abilities in design theory demonstrate how they reveal the designer’s choices and illustrate user perception through UHBE.

Nevertheless, this approach is not sufficient to explain the growing phenomenon of unintended behaviour, whether due to creative improvisation, contextual constraints, misuse, or spontaneous adaptation (Dujardin, 2017; Hassan et al., 2022; Verbeek, 2005). Unlike unconscious behaviour, which is typically automatic and unconsciously, unintended behaviour may be deliberate but unanticipated, arising from real-world needs, cultural practices, or situational demands. It reveals a gap between design intention and actual user behaviour, exposing the limits of predictive design processes. Studying unintended behaviour introduces a critical and emerging dimension in design research, one that emphasises human-product interactions as contextual, dynamic, and socially embedded. From a designer's perspective, this invites a broader evaluation, not only whether a product is used intuitively, but how and why it may be repurposed or misused. These deviations from intended use carry implications for safety, ethics, and social impact (Friedman, 2000; Hekkert & van Dijk, 2011). Therefore, the study of UHBE towards mainstream products provides a progressive lens through which designers can expand their thinking, anticipate behavioural variability, and approach design with greater empathy and responsibility from the earliest stages of product development.

1.4 Problem Statement

In this study, the statement of research problems is explored through the perspectives of design thinking, human behavioural design study and the psychology of unintended use of product. It considers theories that have been developed and discussed over a span of one century, that focus on the notion of UHBE. The following is an explanation of the facts and theories that relate to UHBE interaction towards mainstream products, which have been widely explored, developed and discussed in wide perspectives. This research focuses on understanding how designers interpret and respond to the phenomenon of unintended human behaviour towards mainstream products. Although there is no specific theory on UHBE, it is encompassed within the theory of unconscious behaviour proposed by Freud (1955) through the Theory of the Unconscious Mind, Norman (1988) "Theory of Affordances in Design", Hirschman (1980) "Use Innovativeness Model", and linked within Schön (1983) "Theory of reflective practice".

User and designer are interacting through the artifact, which is considered the communication medium in the design process. The designer provides ways of interaction with the environment through the artifact, and the user interacts with the artifact to understand those ways of interaction and to use them according to their own goals (Xenakis and Arnellos, 2012). In contemporary product design, the interrelationship between designer, artefact, and user forms the foundation of the design process, increasingly informed by UCR and UX research that addresses perception, emotion, and interaction (Forlizzi & Ford, 2000). Users are now recognized as active meaning-makers who shape product value through experience, which align with Schön’s (1983) reflective integration within the iterative design process. As technological advancement accelerates, design must balance innovation with human behavioural interaction (Liem, 2017). Within mainstream product contexts, this focus has led to growing interest in how users develop interaction experiences that shape behaviour beyond the original design intent (Zhong et al., 2023; Kim et al., 2021; Zamani et al., 2020; Wakkary et al., 2015; Redström, 2006; Suri, 2005). However, the integration linking designers’ design thinking towards unintended behaviour remains overlooked, reflecting fragmentation between design research and consumer behaviour research domains (Pillai et al., 2022; Wongkitrungrueng, 2018). This exploratory study investigates designers' design thinking toward unintended human behaviour in mainstream products, on how they integrate the ‘signals of unintended interaction’ into the design process to enhance user experience and strengthen product functionality.

Based on problem statement, several approaches can be taken, such as: (1) Identifying the attributes that trigger unintended use of products from the user’s perspective to integrate designers’ understanding of the phenomenon, (2) Investigating how designers thinking in interpreting unintended attributes and responding to the phenomenon through reflective practice during ideation, and (3) propose unintended behaviour design conceptual framework as guideline for designers to expand design thinking parameter. Through these proposed approaches, the existing gap between consumer research and design research can be bridged for mutual sustainability. By understanding human experience in the context of UHBE, the process of interpretation and communication of meaning between designers, users, and products will offer new perspectives on the phenomenon (Shannon & Weaver, 1949), as depicted in Figure 1.4.

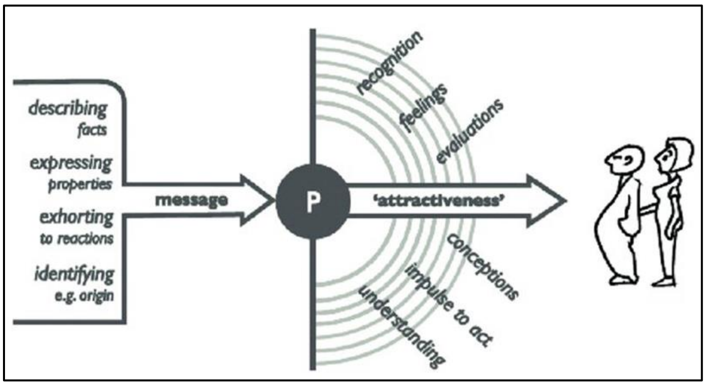

Figure 1.4 Monö's (1997) Model of the Communication Process, based on Shannon and Weaver (1949)

Table 1.1
Systematic Literature Matrix on the Notion of UHBE

Title	**Author/Year**	**Summary of Discussion**	**Research Contribution**
Model of Communication	Shannon-Weaver (1949)	A mathematical model describes communication from a sender to a receiver.	Developing Model
The Unconscious XIV	Freud (1955)	Topological of unconscious human mind	Developing theory
Notes on The Synthesis of Form	Alexande r (1964)	Unselfconscious design Descriptions of 'goodness of fit'	Developing theory
Twelve Issues for Cognitive Science	Norman (1980)	The principle of Cognitive Interaction	Developing theory
"Innovativeness novelty seeking, and consumer creativity'	Hirschman (1980)	Innovativeness behaviour	Developing Model
The Design of Everyday Things	Norman (1988)	design serves as the communication between object and user	Developing theory Discussing Issue
An exploratory investigation of divergent thinking through protocol analysis.	Khandwalla (1992)	Divergent thinking	Discussing Issue
Exploration in Product Usage: A Model of Use Innovativeness	Ridgway and Price (1994)	Use Innovativeness Model	Developing Model
Functional Modelling in a Design Support System	Jensen (1999)	User's emotion within product design	Developing theory
Coping with unintended behaviour of users and products: ontological modelling of product functionality and use	Van der Vegte, et al. (2004)	Unintended Use of Product	Discussing issues
Affordances and Design	Norman (2004)	Interaction and behavioural interactivity in design	Developing theory
Emotional design: Why we love (or hate) everyday things.	Norman (2004)	Emotional interactivity in design	Developing theory
Thoughtless Acts Observation on Intuitive Design	Suri (2005)	Subtle interaction of human with the product	Developing theory
Towards user design? On the shift from object to user as the subject of design	Redstrom (2006)	The interpretation of use and user	Discussing issues
Designing for Appropriation	Dix (2007)	Guideline for Appropriation design	Discussing phenomenon
Designing interactions	Moggridge	Basic principle in	Developing theory

	(2007)	designing product interaction	
Experiencing Interaction Design: A Pragmatic Theory	Wakkary (2009)		
On the function of products	Aurisicchio, et al. (2011)	Emergent Function	Discussing issues
Design Thinking: Understanding How Designers Think and Work.	Cross (2011) (2023)	Designers design thinking	Discussing issues
Tracing unorthodox use – a TRIZ –	Hentschel C. (2011; 2008)	Subtle interaction of human with the product innovatively	Discussing issues
The Core Of "Design Thinking" and Its Application	Dorst (2011)	Designers design thinking	Discussing issues
Design thinking: Past, present, and possible futures.	Johansson – Sköldberg, et al., (2013)	Designers design thinking	Discussing issues
Everyday Design as a Design Resource	Kim and Lee (2014)	Exploring Everyday Designing	Discussing issues
Pragmatism and Design Thinking	Dalsgaard (2014)	Designers design thinking	Discussing issues
Design and the Creation of Value	Heskett (2017)	Designers design thinking	Discussing Theory and Model
"Design and the Creation of Value."	FitzGerald, K. (2017)	Review of Design and the Creation of Value	Discussing issues
Exploring How and Why Customer Unintended use of Product	Wongkitrungrueng (2018)	Unintended use behaviour	Discussing issues
Reviving Everyday Products by Understanding the User Behaviour of Everyday Design	Kim Soyoung et al., (2019)	Exploring Everyday Designing	Discussing issues
Use Innovativeness among the Youth	Pillai et al., 2022	Exploring Everyday Designing	Discussing issues
Understanding Everyday Design Behaviour: An Exploratory Experiment	Kim & Kim, (2021)	Exploring Everyday Designing	Discussing issues
Quality in research through design projects: Recommendations for evaluation and enhancement	Isabel Prochner, 2021	Research through design	Discussing issues

Through a systematic literature review (see Table 1.1), the study on UHBE emerges as a result of rigorous investigation, wherein researchers analyse and deliberate over many arguments and perspectives, as discussed previously. Table 1.1 presents the theories, models, and key discussion topics incorporated in this study to support a robust exploration of the research domain, problem framing, and the development of the proposed methodology.

1.5 Knowledge Gap

Previous studies in consumerism research have pointed out UHBE human behaviour towards products is crucial and have tremendous potential that can assist design team in generating new product concepts through the analysis of user experience and everyday design phenomenon. Similarly, in design research, specifically user experience, many scholars have discussed this potential into their research by developing a framework based on their understanding. Meanwhile, in the real context, it was found that designers are less considering unintended interactions in their new product concept. However, through a literature review, limit discussion about why designers are less considering unintended behaviour or how designers can benefit a phenomenon into novel design. Researchers assert that designerly thinking towards unintended interaction should be explored and understood holistically, in identifying the attributes that influence the behaviour in depth through a comprehensive mechanism. To that end, the researcher intends to examine designer design activities regarding UHBE interaction of mainstream products. Using theoretical and empirical study, this research work hopes to provide a better understanding on how designers perceive the embodied reality of unintended interaction for the sustainability of innovation activities. This research will expand level of knowledge and understanding of the conceptual framework to improve the new design thinking parameters.

1.6 Research Motivation

In recent decades, product design has become increasingly human-centred, with a focus on usability, user needs, and emotional engagement. However, in practice, there remains a noticeable disconnect between the designer's intended use of a product and how users actually engage with it (Wakkary et al, 2015). Users often interact with products in unintended ways, influenced by personal habits, contextual constraints, or creative adaptations. However, unintended interaction frequently overlooked in mainstream design processes and missed the opportunities for design innovation (Pillai et al., 2021; Wongkitruangreng, 2018). Ihde (2008) refers to this as a "designer's mistake" and suggests that designers should take unintended use and its impact on users into account. The gap is clearly evidence towards mainstream products as they are made standardized, mass-produced, and widely for general uses. Observations on UHBE show that users frequently reinterpret a product functions based on individual needs, context of uses, and environmental changes. Yet, there is limited research that systematically addresses this phenomenon from a designer's perspective. Motivated by these issues, this study aims to provide meaningful approaches and integrates the novelty into early-stage of design thinking, as well as to promote empathetic, adaptive, and inclusive design strategies.

1.7 Research Aims and Objectives

The goal of this study is to provide a new parameter of design thinking and the extension to development of new product concept. The purpose of this research is to understand designer design activity towards the phenomenon of UHBE and interaction towards mainstream products. Through the literature, these studies explore possible factors on the notion of unintended use of products that might contribute to the knowledge relations in design research from users' perspective and designer's interpretation. Overviewing research goals established by the researchers to overview research strategy from multiple angles of philosophical research, methodology, design, and other relevant aspects situated around a particular purpose for this research. The research objectives are:

1. To identify attributes of unintended use of mainstream product interactions on users' everyday experiences and behaviour.
2. To evaluate designers' responses towards unintended behaviour attributions through verbal protocol analysis and design activity.
3. To develop an unintended behavioural design framework that integrates unintended attributes into the design development process and strategies.

1.8 Research Questions

This research formulated the research questions (RQ) based on a consideration of the study's background, literature, and research objectives, to assist the researcher in effectively delineating the study's emphasis. It also intends to assess how designers formulate conceptual design concepts which are influenced by their implicit values, beliefs, and experiences of UHBE in mainstream products through their visual interpretations according to the established framework. Thus, these research questions are formulated to illustrate the relationship between the research objectives and the research framework, which can be categorized into three major research questions as a guideline:

RQ1: What are the attributes of users' unintended interaction with the mainstream products that reflect the phenomenon of unintended use of the product?

(This section will address the determination of UHBE attribution through observation activities using a quantitative approach. Objective 1 will answer this RQ)

RQ2: Why is the designer's interpretation of unintended human behaviour regarded as offering invaluable insights into design thinking during the early stages of new product concepts?
(This section empirically studies the design thinking process in design activity procedural. It will also integrate designers' intent and users' perception through laboratory procedures in building new knowledge and design approaches. Objective 2 will answer this RQ)
RQ3: How does understanding unintended human behaviours lead to meaningful conceptual design, inclusive design solutions, and maximizing the value of products?
(This section tends to provide a conceptual framework through design methodology introduced to expand the design thinking parameters, while examining the potential of applicability of the research findings. Objective 3 will answer this RQ)

1.9 Central Proposition of Research

Drawing from a comprehensive content analysis of the background studies, literature review, and problem statement, this research identifies that UHBE in mainstream products plays a significant role and offers substantial potential in enhancing designers' strategic thinking and capacity to generate complex product design concepts. Nevertheless, as highlighted in the initial problem framing, a critical knowledge gap lies in how user perceptions are incorporated into designers' thought processes, particularly in relation to the UHBE phenomenon. This gap demands systematic exploration and deeper understanding. There is also a notable lack of discussion concerning the cognitive and reflective dimensions of designers' thinking specifically regarding how designers perceive, analyze, interact with, and reflect on such behaviours. Therefore, this study first aims to identify UHBE attribution from user perspective, then examine designers' response and design activities in relation to the phenomenon. The findings are positioned to make meaningful contributions to the fields of research through design (RTD) and exploratory design science, particularly in the development of conceptual models and research methodologies.

1.10 Scope of the Study

Based on design science research, the scope of the study was built upon consideration of all factors, including the study period and the current pandemic situation during the study. The scope of this study focuses on examining how industrial product designers interpret and respond to the phenomenon of UHBE within the context of mainstream products. In this study, mainstream product referred as everyday product uses by users in daily life (the subject of the research represented by wash basin product as is based on users votes in preliminary study result) In other words, this study focuses on the integration of (i) design thinking and (ii) UHBE in relation to representative products. The research specifically explores designers' reflective practices and cognitive strategies during the early conceptualization phase, based on users' UHBE attribution. There are two groups of populations involved in this investigation: (i) users' respondent and (ii) designer's participant. First, this pragmatic investigation involved a number of users (randomly) to help identify UHBE attributes in the early stages of the research, as proposed by Prochner (2022). However, the scope of user selection is limited to those who exhibit unintentional behavioural characteristics through a series of random observations. The scope of UHBE focuses on the characteristics of everyday product use outside of its original function, which a product does not changes in term of shape, properties, or technical aspects (based on Kim et al., 2021). In other word, product used on 'function added temporary or permanently'. Thus, this study excludes the context of do-it-yourself characteristic, manipulation of the original product's physical form and features, or combined more than two products technically.

Second, as this study focuses on understanding how designers reasoning towards UHBE in mainstream products, five aspects have been explored from a designer's perspective, including: (i) to determine the nature of unintentional interactions; (ii) to analyze responses to the phenomenon of UHBE interactions in mainstream; (iii) to identify designers' thinking and interactions with mediators; (iv) to describe designers' reflective practice in design activities related to UHBE interactions; and (v) to evaluate the conceptual model of UHBE. Therefore, in the context of designer's participant, this study limited to the industrial designers (product) and academia, as well students from industrial design to examine the pattern of design thinking towards UHBE phenomenon. The participants from the industry primarily focus on product design and development, such as industrial design and ceramic industrial products. In line with Cross's (2006) suggestion, this study aims to assess designers' (from different level of experiences) ability to think, perceive, analyze, and reflect simultaneously while engaging in spontaneous sketching activities. Therefore, this study forms four stages of designers, namely Junior designers (industrial design students), Intermediate (young product designer), Senior designer (establish designer / academia), and Expert designers (professional) to examine the patterns of designers reasoning. In this study, each user and designer being scoped according to research requirements and level of expertise.

1.11 Limitation and Delimitation

This section discusses the constraints or restrictions in this study that are beyond the control of the researcher. Therefore, the researcher sets the delimitation of this study to remain focused and manageable. This delimitation will control and help determine the scope of this study. This study acknowledges several things that may affect the applicability and generalizability of the research results. Therefore, several delimitations have been set based on limitations throughout the research through pragmatic inquiry. First, the limitation is related to the empirical data collection method to obtain the number of user participants randomly and widely during the research period to answer the survey forms that were distributed, especially those who were willing to fill out the questionnaire and contribute photos related to the scope of the research. The constraints influenced by pandemic factors that restricted meetings, movements, and data collection activities at the beginning of the study. Therefore, the random sampling method is used to collect data through social media observation and direct observation as the delimitation set for this study. In addition, the age limit of the participants is also limited to 20 years and above to ensure that the user participants understand the context of the study, as well as to avoid conflicts of interaction (under ages) during the pandemic context in the movement control order (MCO). Second, there are limitations on designers who are willing to participate in interviews and experimental activities that have been set. These include selecting participants who have extensive knowledge in design, relevant experience, and skill levels in this research activity, as well as limited access to firms and design institutions. Furthermore, factors such as promotion, change in work discipline, and skill mastery were challenging to tolerate during the experiment. Therefore, the designers were selected using snowball sampling to collect a number of participants in this research as a delimitation set. The categories of designers involve in this study consist of four levels of experience in design fields such as Junior design students, intermediate designers, senior designers, and expert designers, who are over the age of 20 and above. Third, limitations also involve a fixed space for conceptual design and experimental activities required in this research. Therefore, a mobile lab experiment is set in this research to facilitate the movement of participants and researchers. A mobile lab is an experimental setting designed to standardize a series of experiments for each design participant to ensure the quality of research findings.

1.12 Significance of the Study

Design research can be understood to a systematic investigation that aims to understand, explore, and generate knowledge within design processes, human behaviour, and contexts. Most researchers propose a hypothesis, build a model, conduct repeatable experiments, observe events, and verify the hypothesis in pure scientific research. However, heuristic design may not always work due to uncertain human behaviour (Warell, 2001). In doing research that involves human behaviour investigation, Reason (1994) recommends the co-operative inquiry research approach, as it can integrate action and reflection, theory and practice in order to address issues. Reason proposed four basic principles that are interrelated between aspects of knowledge; (i) Propositional Knowing: Theoretical knowledge acquired through formal learning and literature, (ii) Practical Knowing: The ability to carry out actions based on propositional knowledge, (iii) Experiential Knowing: Understanding gained through direct experience and interaction with the real world, and (iv) Presentational Knowing: The expression of knowledge through artistic or symbolic mediums, such as drawings, stories, or metaphors. Based on Reason's (1994) proposal, Warell (2001) sees similarities with the approach as proposed by Cross (2006) regarding the acquisition of design knowledge, and suggests three research components that can built new knowledge, namely (i) research into design: through various types of observations, (ii) research for design: to create tools (computer-based), design methods, and forms of emphasize, and (iii) research through design: abstracting from self-observation and other observations while designing, hypothesizing, and testing. Meanwhile, Hansen and Andreason (2002) developed three components in design theory, including the design process, design objects, and factors that influence design to explain how they may aid research process and create new knowledge related to human behaviour and interaction. In the field of design research, all three categories of knowledge acquisition have been discussed by Warell (2001; 2009). He emphasized that the determination of research methods in design, particularly related to human behaviour, is encompassed within these three approaches.

Based on Warell's (2001) proposition, this research focuses on knowledge construction based on UHBE were adopt an approach proposed by Reason (1994), Hansen and Andreasen (2002), and Cross (2006) as guidance for the design research methodology. Firstly, the research element is aligned with the study of designers' design thinking, focusing on how designers' reason, think, interact, plan, solve problems, and make decisions (adopting approach proposed by Hansen and Andreasen (2002). Secondly, as suggested by Warell (2001), this study conduct empirical design research data collection methods through participants observation. Thus, Cross (2006) proposal were referred to broaden the view and understanding of the design process, how designers respond to the phenomenon of UHBE, and patterns of idea generation based on problem framing, as supported by Prochner (2022) 'research through Design' (RTD) approach. Thirdly, the process of understanding the phenomenon through user perception and experience as proposed by Reason (1994) will critically conduct to meet research objectives and research questions. This study can be classified as exploratory research in nature focuses on contributing to the existing knowledge through a triangulation approach to trigger new knowledge on research topic. The procedures employed in this study encompass; literature content analysis, visual-inventory, photo-based research, surveys, and verbal protocol during design activity.

In this study, there are two elements of the research: theoretical and empirical. The theoretical study is mostly based on designers' design activity which critically examined the UHBE towards mainstream products. The researcher used psychological, design theories, and consumerism perspective to analyze unintended behaviour interactions between humans and products. Through investigation of the theoretical data, the researcher would gather enough evidence and understand the theoretical framework that may not be clear in current scholarly publications. The findings derived from theoretical research hold significant value for the existing body of knowledge in the field of design sciences to (i) learn and comprehend theories from previous research;

(2) assess existing findings, methodology, gaps, and issues related to the theories referred; and (3) Identify the theoretical framework, formulate research questions and objectives, and construct an empirical design approach to address research questions. There are three research objectives constructed in this study (1) to identify attributes of unintended use of mainstream product interactions on users' everyday experiences and behaviour, (2) to evaluate designers' responses towards unintended behaviour attributions through verbal protocol analysis and design activity, and (3) to develop an unintended behavioural design framework that integrates unintended attributes into the design development process and strategies. These research objectives will support the three research questions formulated in this study. This research is significant in providing design education references. The key insight from the study will significantly contribute to the academic sector, industry design context, methodology in design research, new proposal for design and non-design stream education, as well as for product development strategies.

1.13 Expected Benefit from the Study

This research applied a pragmatic (qualitative and quantitative) approach to interpret the true meaning of research exploration in finding implicit factors that underlie UHBE and user experience towards products. In the problem statement, the researcher argues that the designer's design thinking which specifically focuses on UHBE towards mainstream products becomes an important knowledge gap to explore. In research based on user experience, when the understanding of human factors is mastered, the potential for users will also be revealed. User experience design research is built on the mastery of user understanding, so research that does not use user factors as its subject is considered as unable to fully create user experience research. Through the interaction design platform and user experience in this research, it enables researchers and designers to appreciate the creative branch of the actions highlighted by users. It also creates awareness and opens up the potential for design development. Designers now face a critical situation in focusing on the real needs of users on product design based on how users use it. Therefore, through the actual interpretation of the context of consumer use of daily products, researchers are able to obtain direct evidence without losing valuable information or misinterpretation. Based on video demonstrations, information obtained benefits researchers to deepen their needs, challenges and interpretations when interacting with everyday products. Additionally, researchers can verify intentions as well as understand their UHBE in detail.

This validation shows the reliability of the findings, and the information derived from research findings is proved. In the current development, the conventional method in the mentality of the industrial world that produces design based on experience and designer intent, then testing it on users, then using that feedback to improve the design is still prevalent in many design teams and design organizations. It is certainly not an ideal approach to create a design that matches the user experience, especially in evaluating the UHBE. This situation should be refined with a new method by prioritizing the real needs of users in their daily product interactions. In addition, understanding the conceptual framework is also expected to provide significant value as a new parameter in design thinking. Thus, this study is expected to contribute significantly towards the exploratory study of design science in the context of the conceptual framework of knowledge and methodology proposed in this research. Therefore, through the interaction of user experience, one may learn more knowledge in understanding the unintentional behaviour for other research purposes.

1.14 Thesis Outline

This thesis is organized into Four main stages and Six chapters. For more expedient study of the thesis, an outline of the contents is given as following:

1.14.1 Stage 1: Identification Stage

Chapter 1: Introduction

This chapter is an introduction to the work that has inspired the researcher to further investigate the topics. It provides insights of background and context of the study, “user” and “designer” introduced to the term of experience in design discussion and defined as the main stakeholder that would colour most of the literature in relation to the user experience to the product.

Chapter 2: Literature Review

This chapter covers a comprehensive evaluation report found in the relevant area of the literature studied. The review provides a basic summary of previous research such as the design definition, product design challenges, understanding the phenomenon, human behaviour in relation to design intent, and the conceptual framework of unintended interactions in design. Furthermore, this chapter discusses the features of design thinking in design practice of designers as part of the mechanisms that contribute to the creation of product ideas. It helps to go beyond the search for identification and UHBE relations among the reviewed literature to provide context, develop an integrated framework, justification, and enable researchers to outline of research gap

1.14.2 Stage 2: Development Stage

Chapter 3: Research Methodology

This chapter discusses research construction and strategy, which involve several models of philosophy, paradigm, design method procedures, activities and other relevant information that were constructed by the researcher in accordance to provide systematic problems, method of data collections and analysis as stated from the previous background of thesis mentioned. The researcher aims to give the work plan of research in describing, explaining, and predicting the phenomena of unintended user experience and the way it is interrelated to product influences. All research methods used by the researcher are essentially planned. However, they were valued-neutral to avoid bias. These include the theoretical procedures; experimental studies, tools selection and selection of subject sampling in generating standard pre-requisite of activities planned. Nonetheless, this is inclusive of the effort of strategizing for ethics approval before commencing further interviews and experiments with the user.

1.14.3 Stage 3: Application Stage

Chapter 4: Data Collection, Analysis Procedure, Research Finding and Discussion

In this chapter, the focus is given on the activity conducted by the researcher looking into participatory research activities. This chapter includes the activity involving users' 'data' and designers' procedural activities which become grand highlights of this research. The fundamental discussion on this chapter centers on investigating how activity goes through and gives meaning to respondents' actions; actions to be the focus and how the same actions may appear in different activities from another respondent. Further, this chapter describes the data analysis methods used in the activity study conducted. The analysis includes statistical analysis, the usage of transcription of recorded interviews to diagramming techniques and grounded-based coding activities.

This discussion involves a series of designers' ideation sketches and description to the influence of user experience.

1.14.4 Stage 4: Refinement Stage

Chapter 5: Research Summary, Contribution, Application, and Recommendations for Future Study

In this chapter, the value and novelty of the research being discussed, and giving recommendation for future research in the area is presented.

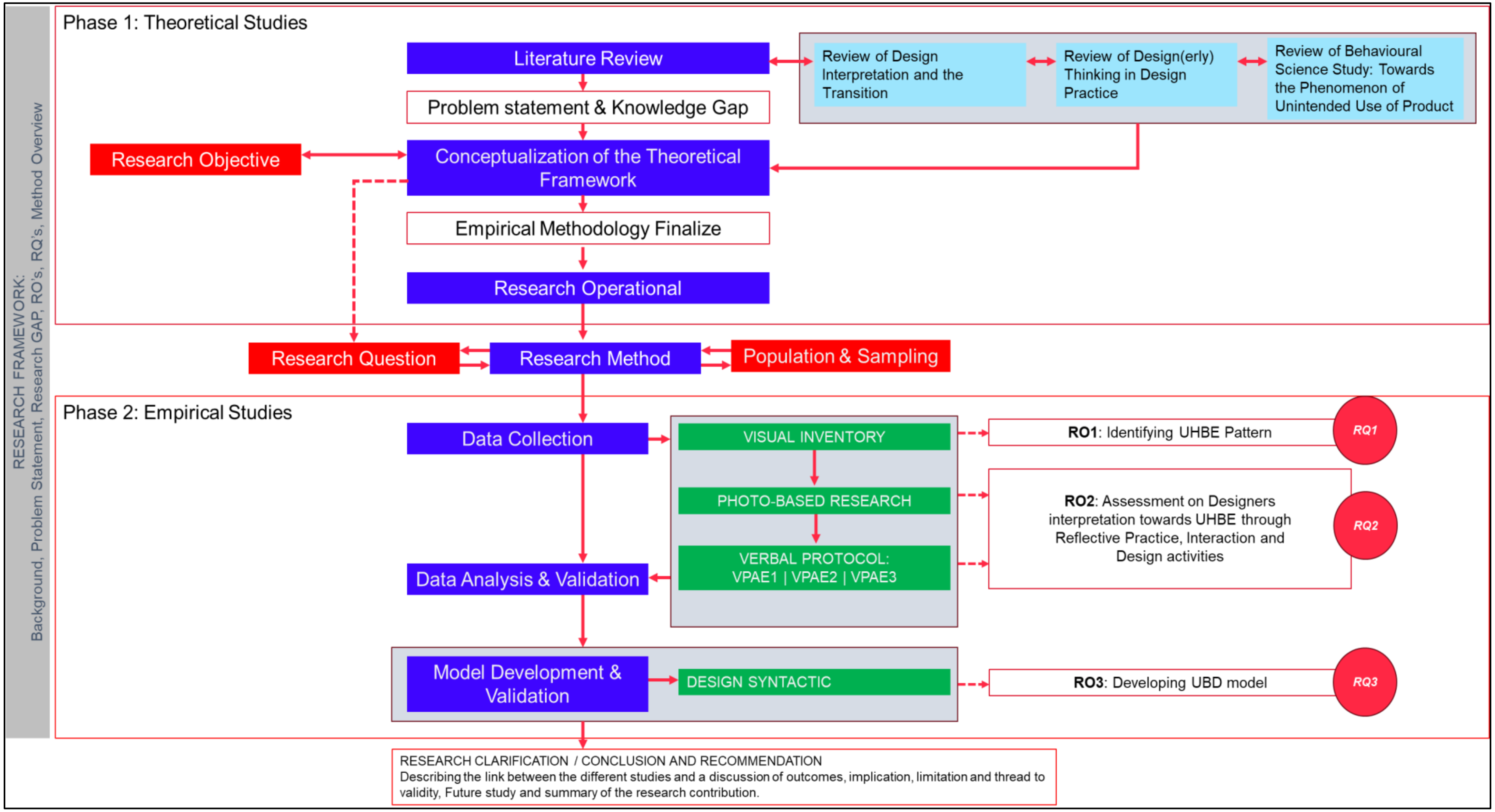

Figure 1.5 A Summary of Research Framework to address Research Questions and achieve the Research Objectives of this study

CHAPTER 2
LITERATURE REVIEW

2.1 Outline

A literature review is a crucial tool for identifying gaps in knowledge and addressing problems in a specific field (Creswell, 1994; Andreasen, 1998). It helps strengthen knowledge through precise, detailed, and in-depth understanding. Theoretical frameworks constructed by previous researchers contribute to the understanding of the current study. Andreasen, Hansen & Cash (2015) suggests that elements of such a framework can contribute to the construction of a research paradigm encompassing conceptual frameworks, theories, methodologies, and facts. Therefore, this chapter is crucial in reflecting the researcher's understanding in presenting and discussing the literature review related to the field of knowledge and adapting it in the body of the research work. In this chapter, researcher discusses the main literature review related to the understanding of UHBE towards mainstream products, and current strategies of design thinking as a response to the context of uses. The understanding is crucial to examine how designers interpret UHBE interactions as a value and potential in producing inclusive, responsive and innovative conceptual designs.

Research on human behaviour through product design has been widely discussed in the fields of design science and consumer psychology studies (Li et al., 2025; Zhuopeng & Kamil, 2023; Pillai et al., 2022; Kim, 2020; Vermol, 2018; Wongkitrungrueng, 2018; Kamil, 2017; Anwar, 2016; Wakkary et al., 2015; Kim & Lee, 2014). It includes focusing on the involvement of users and designers in research activities to obtain views or confirmation of the issues and problems being studied. Various approaches are used to achieve objectives, while benefiting certain target groups. However, comprehensive discussions on the phenomenon of unintended use of products in design thinking are still unclear from the context of behaviour, motivation in action, designer response in action, methodology, and appropriate assessment used for holistic understanding, especially how the roles, experiences, and interpretations by users and designers can be explored that can be utilized in design activities. The question that arises is – how and how?

Through the identification of factors and motivations of users towards behaviour, attributes of UHBE can be identified, analyzed and explored as design resources, as discussed earlier by Kim and Lee (2014). Furthermore, there is an increasing interest in consumerism and psychology research, especially in relation to UHBE research towards everyday products (Pillai et al., 2022; Wongkitrungrueng et al., 2018; Ronacher, 2015). Therefore, the researchers aim to find a middle ground and reflect on the comparison of views between user groups and designers towards understanding UHBE in the process of building a holistic design research model that can be applied to design thinking. To that end, a review of the literature review in the field is intended to help researchers formulate a theoretical framework. This chapter is divided into three sections; (i) Design Interpretation and Transition, (ii) Design Thinking in Design Practice, and (iii) Behavioural Studies: The Phenomenon of Unintentional Product Use, which illustrated systematically diagram in the Figure 2.1.

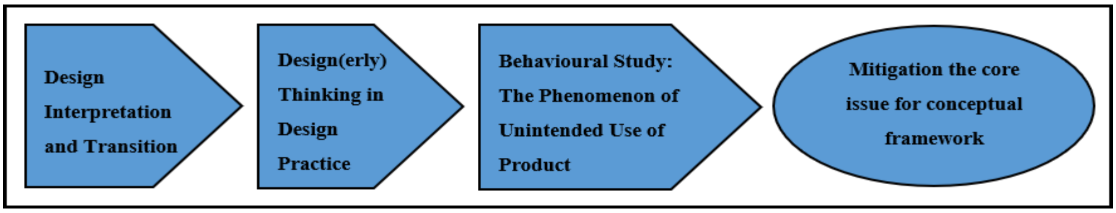

Figure 2.1 Literature Review Workflow

2.2 Section I: Design Interpretation and the Transition

The first part of the literature provides a description of the design direction and the transition of designer(ers) role, aiming to trace the development of design from a broad perspective encompasses: the definition and evolution of 'design' activities, the transition of design(er) roles, product design process, contemporary challenges in product design, product appearance and form language in design, roles of human factor in product design, conceptual design and the role of sketching in product development and design syntactic framework.

2.2.1 The Definition and Evolution of 'Design' Activities

Through the discussion of interpreting the definition of design from various perspectives and fields including industrial design, product design, and design engineering, it becomes evident that the term has been debated extensively among scholars. Design holds multiple definitions depending on philosophy, knowledge, and context. According to Merriam-Webster (2025), design means "to create, fashion, implement, or construct according to plan; to conceive and plan in mind; to have as a purpose for a particular function or purpose." Blessing and Chakrabarti (2009) define design as the activity that generates and develops a product starting with a requirement, product idea, or technology, and ending with the complete documentation required to realise the product while fulfilling the needs of users and stakeholders. The term design is not limited to the final product but encompasses the complex process of problem solving, conceptual development, and meeting specific needs.

Ornas (2007) explains that design can be understood on three levels as an adjective, a noun, and a verb. As an adjective, it refers to a particular category of products with unique characteristics. As a noun, it describes a set of parameters that allow certain functionalities to be realised, which may be embodied in the finished product or represented through documentation such as a technical drawing. As a verb, it refers to the act of designing (Lawson (1997. Within research, design is a multifaceted term that spans disciplines, activities, methodologies, tools, and goals (Pahl & Beitz, 2007; Blessing & Chakrabarti, 2009). Friedman (2000) notes that design addresses concern differ from sciences, while Ulrich and Eppinger (2012) view it as the process of generating and refining concepts with criteria that influence a product's physical form. They highlight design as a structured process in product development that includes problem identification, solution generation, and iterative improvement, an approach rooted in engineering science that is now widely applied in consumer product development.

From other perspective, design is an activity aimed at developing the description of an entity and advancing toward problem solving (Mostow, 1985). Buchanan (1992) links it to the concept of "wicked problems" and defines it as a plan for arranging elements to achieve a particular purpose. Morris (2016) describes an arrangement of elements to fulfil an intended function through a series of steps undertaken by individuals or teams. Simon (1969) describes it as an intentional act to transform an existing situation into a preferred one, emphasising the transformative nature of design. Dorst and Cross (2001), followed by Cross (2006, 2011), interpret design activity as a form of reasoning and sense making. This process integrates actions and thoughts in line with Schön's theory of reflective practice (Johansson-Sköldberg et al., 2013).

In interaction design and user experience, Norman (2013) explains that design concerns on how things work, how they are controlled, and the nature of interaction between people and technology. He argues that design effectiveness depends not only on the designer's intentions but also on cognitive, emotional, and contextual factors in product use. Norman notes that users often interact with products in ways that differ from the original design intention, opening possibilities for interdisciplinary studies such cognitive, technical, social, and cultural aspects. Human factors strongly influence the way design being designed. In modern design practice, knowledge of human capabilities and responses is essential, especially in addressing the needs of human in the twenty-first century. In conclusion, the definition and understanding of design have evolved from a purely technical view toward a more holistic and human-centred perspective. Contemporary design is not only systematic and structured but also reflective and responsive to environmental and user behaviour patterns, including in the study of unintended human behaviour (UHBE).

2.2.2 The Transition of Design(er) Roles

"In the 21st century, the world moving to more and more complex problems that do require the talents of a designers" (Don Norman, 2022)

In the 21st century, the role of the designer has evolved significantly in response to global social, technological, and economic changes. From being technical problem solvers and form creators, designers are now viewed as social facilitators, behavioural analysts, and catalysts for innovation. Traditionally, engineering design focused on functionality, technical performance, and production requirements (Pahl & Beitz, 2007; Hubka & Eder, 1996), with designers acting as technical experts who organised system elements and product components to meet specific objectives. This role began to shift when design practice incorporated user empathy, social meaning, and cultural interpretation. Lawson (2006) characterises designers not only as problem solvers but also as "problem framers" who define and shape the way problems are understood. This aligns with Cross's (1975) view that the post-industrial era could introduce uncertainty in the direction of design. Lawson (2006) proposed three possible scenarios for the future: designers maintaining a conservative and isolated role, eliminating design as a professional practice, or mediating between both extremes. These scenarios are subject to unpredictability depending on process requirements and decision-making demands in complex environments.

Dorst (2011) emphasises that designers operate in contexts where problems and solutions co-evolve through iterative processes. Increasingly, designers are recognised as agents of social change. Similarly, Friedman (2000) asserts that designers influence the interactions between humans, technology, and the environment through the values embedded in design. For instance, Aman et al. (2017) researched how designer design problem-based solutions towards a Wudu' (Ablution) workstation for Muslim users that integrated human interaction into design strategies. The modern role also requires the ability to organise complex information into forms that are understandable and usable. In the era of digital and smart technologies, designers engage in user experience (UX) design, service design, and human-computer interaction (Norman, 2022). Designers not only create products but also shape experiences and narratives that connect with users on an emotional and cognitive level (Norman, 2022).

Beyond producing artefacts, designers contribute to strategic decision-making within organisations. Munshi (2003) and Johansson-Sköldberg et al. (2013) highlight the importance of designers in organisational innovation and user-driven development. These expanded roles demand analytical skills, reflective thinking, and sensitivity to social contexts, moving design beyond the domains of aesthetics or technology. In mainstream product development, the evolving role of designers has significant implications for design research. A design must not only fulfil its intended function but also anticipate alternative or unintended uses by users. Norman (2013) suggests that variations in user behaviour should be viewed as opportunities for product improvement. Designers are therefore encouraged to build interpretive flexibility into their work and to function as researchers who deeply understand the complexity and unpredictability of user contexts. Schön’s (1983) reflective practice model urges designers to critically evaluate their own actions as a means to improve practice, an approach supported by Norman (2013) and Morris (2016), who argue that understanding unexpected product use is a valuable input to the design process.

In product design, the role of the designer shifts in response to technological trends, environmental changes, and evolving human needs. Product design has historically existed alongside human creativity, serving to inspire, empower, and enhance everyday life. Cross (2001) identifies human creativity as a driver for the creation of products that meet daily needs. Designs are developed to fulfil user requirements, and their functions are continuously assessed by those users (Hwang & Baek, 2012). According to Warell (2001), product design aims to address specific problems with defined purposes, requirements, and constraints. As needs change, design is renewed or adapted to maintain relevance, creating positive experiences at each point of interaction. Product design can influence thought processes, emotions, and decision-making, and those that prioritise user understanding are more likely to produce tangible and meaningful outcomes (Veryzer & Borja de Mozota, 2005).

In conclusion, the new era of design discipline posits designers as intermediaries between users, technology, culture, and social systems. They are not only creators of products but also interpreters of human needs and evaluators of design's impact on society and the environment. This shift underscores the importance of multidisciplinary expertise, empathy, and adaptability in shaping the future of design practice.

2.2.3 Product Design Process

The design process has evolved in line with the paradigm shift in design research. In the context of design research, the process is no longer linear from problem definition to a final solution but encompasses a complex and iterative system that is human-centred and responsive to technological, social, and market challenges (Valkenburg, 2000). The process is influenced by factors such as market development, technological change, and the nature of the design firm. Classical engineering design models by Hubka and Eder (1996) and Pahl and Beitz (2007) emphasise a systematic and structured approach, consisting of task clarification, conceptual design, embodiment design, and detail design. This method ensures that quality, functionality, and safety are maintained, particularly for technical products. Ulrich and Eppinger (2012) expand on this by integrating market and user needs, proposing a model of product development that includes concept development, system design, component development, system integration, and commercialisation. In general, the product design process involves six stages: 1) Investigation of customer needs. 2) Conceptualisation of a design. 3) Preliminary refinement of a design. 4) Final concept selection of a design. 5) Production of control drawings. 6) Coordination with other relevant members who are involved in the project. Each stage aims to fulfil the requirements of both manufacturers and users while considering the essential dimensions of product design.

Dreyfuss (1967) outlines the multifaceted considerations of product design, form development, and user interaction, ensuring functionality, aesthetic appeal, cost-effectiveness, efficient production, and environmental responsibility. Five key dimensions influence successful product design; (1) Utilities focus on functionality, ease of use, maintenance, and novelty of interaction, (2) Aesthetics concern product appearance, differentiation, and emotional appeal, (3) Costs address resource allocation and trade-offs between quality and price, (4) Production relates to manufacturing efficiency, assembly, and packaging, and (5) Product life cycle considers sustainability, life-cycle design, and environmental impact (See Figure 2.2).

Dimensions	*Objectives*
Utilities	• Ease of use • Ease of maintenance • Quality and quantity of interaction • Safety • Novelty of interaction
Aesthetics	• Product differentiation • Pride of ownership, image, fashion • Communication
Costs	• Cost benefits and trade-offs • Appropriate usage of resources
Production	• Manufacture and assembly • Appropriate usage of raw materials • Tooling • Packaging
Product life-cycle	• Life-cycle design • Material selection

Figure 2.2 Product Design Objectives, (adopted from Dreyfuss, 1967)

In industrial and product design, aesthetics, emotions, and user experience are as important as technical functionality (Lawson, 2006; Norman, 2022). Designers must consider how products are felt, used, and interpreted, starting from human needs and returning to the user (Dreyfuss, 1967). Norman (2022) views design as a symbolic bridge between user cognition and use, benefiting all stakeholders. Modern design processes must also address sustainability, recyclable materials, and production efficiency (Morris, 2016; Mostow, 1985). Cross (2011), Dorst and Cross (2001), and Buchanan (1992) emphasise reasoning, exploration, and abductive thinking, proposing solutions even before problems are fully understood. Ulrich and Eppinger (2012) highlight the role of product design in shaping company identity, where consistent product style, distinctive appearance, and emotional value foster strong branding and positive consumer perceptions.

Arnellos, Spyrou, and Darzentas (2007; 2010) view design activity as a cognitive construction process with an interactive nature that supports meaning-based actions among participants. Meaning creation occurs when users and systems interact to generate new functions, aesthetic experiences, and emotional responses, influencing form in product development (Xenakis, 2013), as depicted in Figure 2.3. Through artefacts, designers express intent, while users interpret and adapt them to meet their goals. Ulrich and Eppinger (2012) note that product design, distinct from engineering and industrial design, is a relatively recent discipline involving the development of functional items for mass production. Monö (1997) defines it as creating products compatible with human use and environmental context. Product designers are trained in form, drawing, materials, manufacturing processes, and marketing, enabling them to contribute concept sketches, models, and renderings in development. Effective product design ensures that products are significant, valuable, and marketable, with ergonomics and aesthetics serving as measures of its importance.

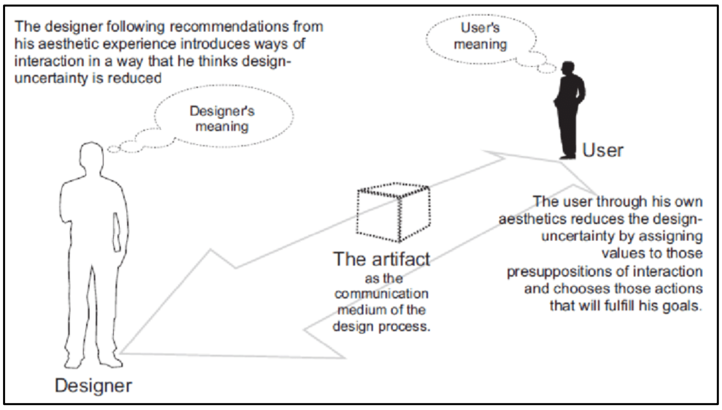

Figure 2.3 The Design Process. (Xenakis, 2013)

The postmodern era, with rapid technological advancement, has expanded product design towards user experience, influencing how designers think and create (Forlizzi & Ford, 2000). Furthermore, when designing a product, the product designer must consider many factors, including material selection, manufacturing method, marketing strategy, cost and practicality, and how easy the product is to use and understand (Norman, 2004). In most cases, they emphasised not only the look of their masterpiece but also the overall experience of the product. According to Liem, Abidin, and Warell (2009), it is frequently difficult for designers to keep all experienced aspects in mind, to understand how customers perceive and "read" the product, to design for specific experiences, to plan strategically with respect to the "sensory brand," and to prioritize between desired intended experiences. Product design is a multidisciplinary, knowledge-intensive work activity that is becoming increasingly important in today's fast-paced, globally competitive environment. Because it defines the characteristics and performance of services or goods to consumers, product design is critical to organisational success. Product design's goal is to create a good or service with excellent functional utility and sales appeal while staying within a reasonable cost and time frame.

To conclude, the new era of design discipline positions designers as intermediaries between users, technology, culture, and social systems. This shift has shaped designers as individuals who not only understand what needs to be designed but also make assessments of why and how design can affect people and their environment.

2.2.4 Contemporary Challenges in Product Design

"The best kind of design isn't necessarily an object, a space, or a structure: it's a process- dynamic and adaptable". (Donald A. Norman, 1998)

In the postmodern era, product design faces increasingly complex challenges that extend far beyond conventional approaches to product development. Rapid technological advancements, evolving user needs, environmental concerns, the digital economy, and shifting cultural values that prioritize meaning and experience have transformed design into a strategic activity. Product designs are no longer limited to the creation of physical objects, but has become a multidimensional practice integrating form, function, and social context. This transformation demands a broader understanding of what constitutes design and how it should be conducted. One of the most challenges in contemporary product design is to balances multiple factors simultaneously. Designers must consider into functionality, aesthetics, usability, emotional engagement, sustainability, production costs, and product life cycles (Ulrich & Eppinger, 2015; Andreasen, 1998). Product design must be cost-effective while minimizing environmental impact, a dilemma that requires technical innovation alongside social and ecological awareness. Globalization further intensifies this complexity, as products increasingly cater to diverse cultural contexts, making sensitivity to varying user behaviours critical for success.

Meanwhile, the growing demands on design have positioned it within a multidisciplinary space. Effective product development now requires collaboration across engineering, psychology, anthropology, business, and data science. Andreasen (2004) underscores the importance of such interdisciplinary approaches, while Norman (1998) emphasizes the role of user-centered design in aligning technical solutions with user expectations and emotions. On the other hand, research methodology such as ethnographic studies, usability testing, and interactive prototyping has thus become essential for uncovering the realities of product uses. Additionally, another key challenge is managing interpretation and uncertainty. Users often interpret products in unforeseen ways, sometimes leading to unintended or alternative uses (Wakkary and Maestri, 2007; Suri, 2005; Dix, 2007). These practices highlight the importance of flexibility and adaptability in design, allowing products to accommodate multiple meanings without compromising essential functions or safety. McAloone (2000) argues that designers must carefully structure the internal logic of a product so that its form, function, and interactions can adapt to diverse real-life scenarios. This involves creating layered narratives that support varied emotional and cognitive relationships between users and products.

Design research has emerged as a critical response to these evolving challenges. Ulrich & Eppinger (2012) and Cross (2006) stress the need for approaches that bridge theory and practice, often employing methods such as verbal protocol analysis, behavioural simulations, and case studies. Frameworks like Research through Design (RtD) and Constructive Design Research enable the exploration of design processes in real-world contexts, where uncertainty, constraints, and market pressures shape decision-making. Within this framework, unintended use or behavioural adaptation becomes a valuable source of innovation, revealing new opportunities beyond a product's intended scope. Sustainability adds further pressure to the design process. Today's designers must address functional complexity and heightened user expectations while integrating environmentally responsible practices (McAloone, 2000; Andreasen, 1998). Yet, many design methodologies remain rooted in earlier models and may lack empirical validation to fully address these contemporary concerns (Gericke &

Blessing, 2011). As a result, ongoing refinement of research approaches is essential.

Historically, humans have always engaged in design to respond to changing needs (Cross, 2001). In traditional societies, design and making were integrated, but industrial production separated the two, requiring precise specifications before manufacturing (Warell, 2001). Today, product design has matured into a distinct discipline that ensures products are useful, meaningful, and marketable. Beyond ergonomics and aesthetics, product design also shapes brand identity through consistent visual and experiential qualities. Practitioners must therefore balance material choices, production methods, marketing strategies, costs, and user experience, while anticipating diverse modes of interaction. The central role of design lies in translating complex, and often competing, requirements into coherent product concepts. Designers must plan and execute creative solutions that respond to physical, cognitive, social, and aesthetic needs. As Buchanan (1999) argues, the greatest challenge for design research is enabling designers to operate across fields and return with insights relevant to practice. In this context, design is not merely about making objects but about orchestrating experiences that embed meaning and value within everyday life.

Ultimately, integrating insights into everyday human behaviour is vital for advancing product design. Understanding how people interact with products in routine contexts reveals gaps between intended and actual use, uncovers hidden needs, and anticipates misuse or adaptation. Such knowledge supports the creation of products that are not only technically robust and aesthetically appealing but also meaningfully embedded in the lived realities of users. By aligning design thinking with behavioural insights, product design can move beyond solving immediate functional problems to shaping experiences that adapt to evolving lifestyles and contribute positively to cultural and environmental contexts.

2.2.5 Product Appearance and Form Language in Design

Product appearance encompasses elements such as form, functionality, aesthetics, symbolism, and semantic function, all of which play an essential role in design thinking and product development (Monö, 1997; Warell, 2001). In general, product appearance functions as an attractive force that engages users and shapes their emotional experience, functional perception, and symbolic interpretation of a product

(Norman, 2004; Hekkert, 2006). According to Monö, 1997, product appearance serves six distinct consumer roles: (1) aesthetic communication, (2) symbolic meaning, (3) functional information, (4) ergonomic usability, (5) design attraction, and (6) categorization. Consumers value product appearance not only for its aesthetic and symbolic appeal but also for its ability to communicate quality, usability, and categorization.

1. Form and Visual Language

   In design, form is viewed as a visual language that conveys meaning and communicates the designer's intent (Chen & Owen, 1997; Johnson, 2010). Its interpretation is shaped by cultural background, social context, and user experience. The idea of "form language" refers to how visual elements such as lines, shapes, and colors combine into a recognizable system. Monö (1997) notes that products embody communicative signs, making each design a language. Aesthetics reflects the sensory impact of form on human perception. Form represents an object's overall shape and structure, while style refers to its distinctive qualities, including texture, color, and material.

2. Form Elements and Entities

   Product form is rarely accidental but is intentionally shaped by design considerations. Warell (2001) introduced the concept of a "form element," a unit within a product that functions as part of the overall perceptual structure. These elements can exist at multiple levels, ranging from small components to entire assemblies. Similarly, Chen and Owen (1997) identify "visual form" as the discernable aspects of a product visible to the eye, and they distinguish between form, style, and visual style. Warell (2001) also defines the "form entity" as an active unit within the product that contributes to both semantic and syntactic functions by shaping user perception without physically transforming during interaction.

3. Semiotics and Signs in Product Design

   Monö (1997) emphasizes that product perception relies heavily on signs, most often visual, but also encompassing other sensory modalities such as hearing, smell, and touch. Semiotics, defined as the study of signs and sign systems, helps explain how products communicate meaning (Monö, 1997). Within product design, semiotics allows designers to understand how users interpret products as communicative artifacts. Semantics, as a subfield of semiotics, focuses specifically on the message conveyed by signs. For Monö (1997), a sign represents the intersection of the sender, the product, and the receiver, and may communicate description, expression, exhortation, or identification.

4. Gestalt Principles and Visual Perception

   Gestalt theory offers a key framework for understanding how users interpret product appearance. Its principles: unity, balance, continuity, and proximity, enable coherent, comprehensible design (Monö, 1997). Gestalt emphasizes perception of the whole rather than separate parts. For example, people group nearby objects (proximity), recognize symmetry, associate similarities, and distinguish figure from ground. These cognitive mechanisms allow intuitive and rapid interpretation of product forms. Monö (1997) highlights that gestalt extends beyond physical form to all perceptual experiences the mind organizes into meaningful wholes. Influenced by experience, expectation, and motivation, gestalt principles help designers shape visual patterns that communicate product function and meaning effectively.

5. Product Symbolic and Semantic Functions

   In product appearance, visual and functional elements are the most important elements in product design. In addition, it also functions as a symbol that carries meaning, culture, and emotion. Warell (2001) emphasizes that the integration of technical functions and semantic aspects in product design is important. It is in line with the purpose of fulfilling practical properties and conveying a certain message and identity. Semantic functions also help enhance the user experience and relationship with the product.

The following is a detailed explanation of the four semantic functions according to Monö, (1997).

1. Semantic function: To describe a sign can as a semantic function be used to describe the functionality of a product, based on the interpreted gestalt (Monö, 1997). Sometimes it is enough to incorporate a small detail which 14 communicates the intention to a user and other times it is better to design a feature that boldly deviates from the rest of the product, to gain the user's attention. Monö (1997, p. 84) presents a hypothesis: "The better known the sign, the greater the number and degree of variations it can stand". This implies that a strong sign of a product

feature allows other features to be altered, without risk of losing original message.

2. Semantic function: According to Monö (1997), expressive semantic functions communicate a product's qualities, such as heavy, compact, or fragile, and may also convey emotional traits, like happy or angry. Product character is linked to this function and can be described using polar adjective pairs, e.g., hard–soft or expensive–cheap. Chen and Owen (1997) apply such pairs in shaping visual styles by grouping design features, including form elements, joining relationships, detail treatments, materials, colors, and textures. Warell (2001) defines a form entity as emphasizing semantic interaction and functionality, expressed through principles such as proximity, symmetry, rhythm, proportion, balance, harmony, and contrast.
3. Semantic function: To exhort Exhorting semantic functions are intended to provoke a reaction from the recipient (Monö, 1997). The product form or gestalt is a key factor for product understanding, and by creating a coherence to user expectations, frame of reference and needs the exhorting semantic function can be easily recognized and utilized. Monö (1997) further develops this argument, stating it is crucial that the various exhorting functions are cohesive to achieve the desired effect. By using the gestalt impression, the exhorting semantic function in connection to a feature represented by a strong sign, the semantic functionality can be strengthened (Monö, 1997).
4. Semantic function: To identify A products' identity is defined by Monö (1997, p. 103) as "a whole with certain functions and properties, intended for a certain purpose". By consciously and carefully choosing cohesive identity carriers, a heritage and context can be conveyed externally. An identifying property is the products origin, purpose, affiliation, placing and category, which could as an example include logotypes, product names, trademarks, forms, colors, packaging, figures, arrangements and icons (Monö, 1997). Consistent use of design features generates a powerful and united brand image which differentiates a company from its competitors.

In summary, product appearance plays a critical role in shaping user experience, not only through aesthetics but also through functionality, symbolism, and ergonomics. Theories of form, semiotics, and gestalt perception collectively explain how users interpret design elements and attribute meaning to products. By integrating these perspectives, designers can create products that are not only visually appealing but also communicatively effective and cognitively accessible. This underscores the importance of form language and visual perception in aligning product design with human experience.

2.2.6 Roles of Human Factor in Product Design

Human factors (HF), also referred to as ergonomics, is a scientific discipline that focuses on understanding and improving human interactions with products, equipment, environments, and systems. It is a field of study concerned with aligning work and tasks to the capabilities and limitations of people. The primary aim of ergonomics is to ensure that equipment, tasks, information, and environments are designed in relation to human needs and interactions. This perspective is illustrated in Table 2.1, adapted from the work of Dempsey, Wogalter, and Hancock (2000). Murrell (1965) emphasized that the relationship between individuals and their working environment should be systematically examined through scientific investigation. In this context, the term "environment" refers not only to the physical setting in which work occurs, but also to the equipment used, the techniques applied, and the way tasks are organised, whether undertaken individually or in collaboration with a team. These elements are intrinsically linked to human characteristics, including capacities, limitations, and inherent nature.

Table 2.1
The Author's Definition of Human Factor

Author	**Definition**
Grandjean, 1980:	is the study of work-related behaviour. This study examines how people operate in their physical spaces—the most crucial ergonomics principle: fitting the task to the person. Ergonomics integrates physiology, psychology, anthropometry, and engineering theory.
Howell & Dipboye (1986)	Person-machine system design.
The New Encyclopaedia Britannica (1986)	application of information on physical and psychological characteristics to the design of devices and systems for human use. Its data and principles apply to activities of the home, the workplace, and recreation." (p. 136)
Meister; D. (1989)	is the study of how humans accomplish work-related tasks in the context of human-machine system operation and how behavioural and non-behaviour variables affect that accomplishment.
Sanders, M. S., & McCormick, E. G. (1993)	It has two main goals. The first is to improve work and other efficiency. This includes improved usability, reduced errors, and increased productivity. Safety, reduced fatigue and stress, comfort, user acceptance, job satisfaction, and quality of life are the second goal. … designing for humans. Also identifies and utilises human behaviour, abilities, limitations, other qualities to develop productive, safe, comfortable, effective tools, machines, systems, tasks, jobs, and surroundings.
Chapanis, A. (1995)	uses knowledge of human abilities and limitations to the design of systems, organizations, jobs, machines, tools, consumer products for safe, efficient, comfortable human use.
Hancock,2 A. (1997)	… is that branch of science which seeks to turn human-machine antagonism into human-machine synergy.

Helander, M. G. (1997)	The scientific field of human-artifact interaction and system design focusses on human participation. It designs workplace and leisure systems, tools, and procedures. Design activities connect systems, occupations, products, and settings to people's physical and mental skills and limits.
Polish scientist, B. W. Jastrzebowski (1857)	recommends ergonomics research. Karwowski (1991, 2001) says the research covers all human activities, including work, enjoyment, reasoning, and dedication. Many scholars studied artifact-human interaction. Human-centered design requires "investigation phase" (user research). Design wisdom will show the designer's response to design difficulties before they "design." A different field, HFE explores human-artifact interactions. Science, engineering, design, technology, and management of human-compatible systems are united by this concept. Karwowski (2005) explains HFE theoretically. These systems encompass natural and artificial products, processes, and environments.

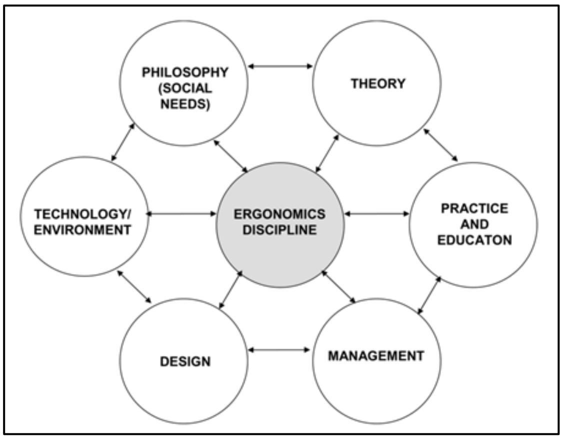

Figure 2.4 General dimensions of Ergonomics Discipline. (Karwowski, 2005)

Karwowski's (2005) diagram (Figure 2.4) presents ergonomics as a multidisciplinary field located at the intersection of theory, practice, design, management, technology, and social needs. Its primary aim is to 40mphasiz human well-being while supporting system performance through integrated knowledge. This framework is also valuable in understanding UHBE within product design. Theory provides conceptual models explaining human abilities, limitations, and interactions with products, but it must also account for unanticipated user behaviours. Such deviations, central to UHBE, highlight gaps between theoretical assumptions and real practices. Practice and education play key roles in translating ergonomic knowledge into applied methods. For example, usability testing and training help to identify potential misuses before products are released to the market. However, unexpected behaviours may still occur, which emphasized the importance of feedback and continuous observation. Management reflects emphasized responsibility, where consideration of unintended uses during early design stages can reduce risks and reveal opportunities for innovation. Design, as the most visible domain, transforms ergonomic principles into tangible products. Beyond addressing intended functions, design should also anticipate flexibility, adaptability, and alternative scenarios of use. UHBE frequently reveals unmet needs, which can inspire more inclusive and resilient solutions. Technology and environment further add to this complexity, as evolving tools and shifting contexts foster behaviours that may not have been foreseen by designers. Finally, philosophy and social needs emphasize the cultural and ethical dimensions of ergonomics, ensuring relevance across diverse interpretations. The holistic model not only enhances usability and safety but also frames UHBE as a valuable dimension of product design research. Ergonomics, as a scientific discipline, seeks to enhance the human condition, though it often balances the tension between individual well-being and system efficiency. Comfort, safety, and satisfaction are widely valued, yet conflicts arise when personal needs clash with organisational objectives. Wilson (1995) notes that ergonomists hold responsibilities to both workers and employers, leading to potential ethical dilemmas. Stanton (2005) stresses the need for clarity in professional loyalties when managing such challenges. Ergonomists design and evaluate tasks, products, and environments to suit human needs, abilities, and limitations. The discipline adopts a holistic, human-centred approach that integrates physical, cognitive, social, organisational, and environmental aspects (Karwowski, 2005; Stanton, 2005). Within this scope, three domains are often highlighted: practical ergonomics, ergonomics knowledge, and ergonomics thinking and acting (Karwowski, 2005) (Figure 2.5). With technological progress, ergonomics increasingly aligns engineering with human experience, producing designs responsive to user dimensions, capabilities, and expectations.

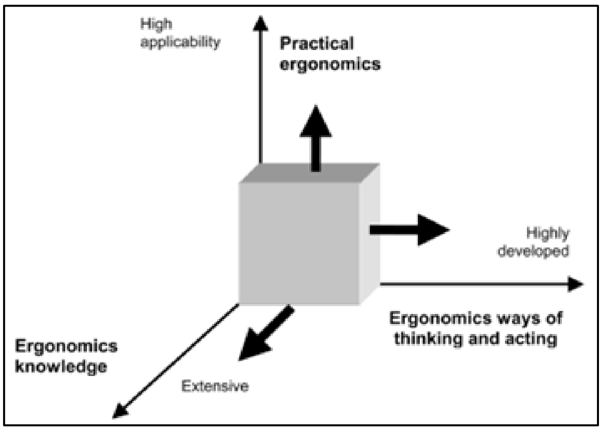

Figure 2.5 Desired goals for Ergonomics Literacy. (Karwowski, 2005)

2.2.7 Conceptual Design and the Role of Sketching in Product Development

Conceptual design is a critical phase in product development because it establishes the foundation and direction of the entire process. At this stage, ideas are assessed against product specifications and the problems to be solved until the most suitable concept is identified. Understanding the importance of each requirement is essential, as this allows designers to make appropriate compromises. While many ideas may meet the requirements, they do so at different levels of performance. Conceptual design influences nearly 90 percent of development cost, unit cost, efficiency, usability, and other factors, meaning product success is largely determined at this stage. It also serves as a bridge between recognising user needs and arriving at the final design solution. Activities such as idea generation, alternative exploration, and synthesis of function and form are central to this process (Pahl & Beitz, 2007; Ulrich & Eppinger, 2012). During this phase, design logic develops through reasoning, empathy, and the exploration of functions not explicitly identified. Cross (2006) notes that conceptual design is the stage where designers make critical decisions on functional elements, operating principles, and system configuration. It is also a space where possibilities emerge, shaping expectations of how users may interact with or deviate from the intended product function, alongside technical considerations.

In engineering design, conceptual design establishes systematic links between user needs and functional solutions (Hubka & Eder, 1996; Blessing & Chakrabarti, 2009). It involves mapping both technical and psychological functions (Warell, 2001). In product and industrial design, however, this phase extends further by addressing aesthetic, emotional, narrative, and interpretive dimensions. Designers therefore consider not only product functionality but also user perception, feelings, and interpretations (Norman, 2013; Buchanan, 1992).

Morris (2016) highlights that conceptual design must consider not only form, materials, and ergonomics but also cost-effectiveness, sustainability, product life cycle, and environmental impact. These factors should be integrated into a cohesive framework to ensure innovative value while addressing user needs. The conceptual stage is also the origin of disruptive innovation, where designers explore ideas that challenge established norms (Johansson-Sköldberg et al., 2013). Friedman (2000) emphasises that conceptual design involves social meaning and value in addition to function or aesthetics. Designers address ill-defined problems by generating transformative proposals (Dorst, 2005). Through framing problems and evaluating alternatives, conceptual design informs product improvement and performance decisions (Self, Evans, & Kim, 2016). This stage demands advanced design thinking, often articulated through extensive sketch exploration (Cross, 2001; Bilda & Gero, 2007). Cross (2001) describes this as a "reflective conversation with the situation," where unintended consequences and new insights emerge, guiding deeper considerations of functionality and added features.

The creation of form during sketching requires an understanding of visual elements such as point, line, plane, surface, and volume, supported by compositional principles (Abidin, Sigurjónsson, & Liem, 2008). Baskinger (2008) identifies six goals of sketching: transforming intangible ideas into tangible information; enabling inclusive discussion; revealing relationships between ideas; building a design vocabulary; suggesting and exploring possibilities; and clarifying design meaning. Similarly, Buxton (2007) explains sketching as a process that supports design ideals rather than simply achieving a correct solution. While many ideas may arise, their value depends on how effectively sketching enables generation, exploration, and refinement. Buxton further positions sketching as a divergent process that expands possibilities, followed by convergence as concepts are narrowed toward final decisions.

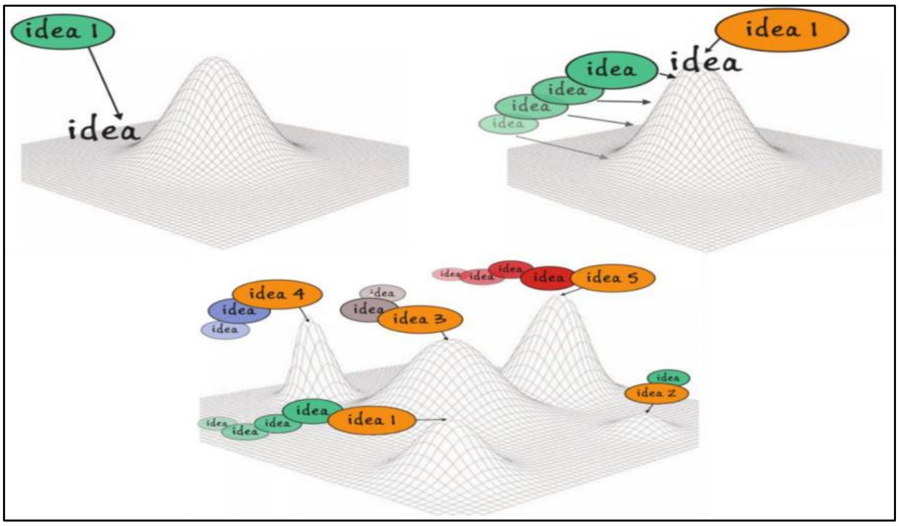

Figure 2.6 Getting the design right – from 1 idea to possible opportunities, adapted from Buxton (2007)

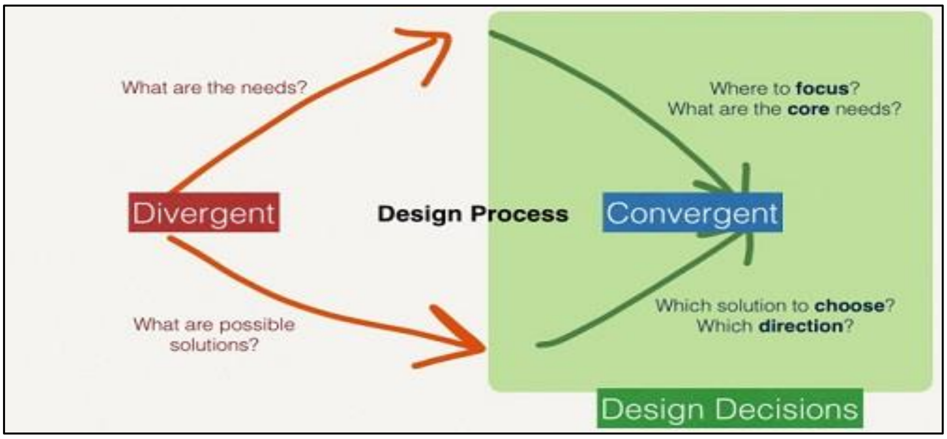

Figure 2.7 Divergence and Convergence Design Process, adapted from Buxton (2007)

"... there are techniques and processes whereby we can put experience front and centre in design. My belief is that the basis for doing so lies in extending the traditional practice of sketching." Bill Buxton, 2007

Theoretically, the conceptual design process aids designers to find unintended consequences, and the surprises that keep the design exploration going in what Schon and Wiggins (1992) called the "reflective conversation with the situation", that is characteristic of design thinking (Cross, 2001). However, in maintaining such design exploration, as Schon and Wiggins (1992) called the "reflective conversation with the situation", that is characteristic of design thinking (Cross, 2001), there is a concern about the focus of contemporary designers as highlighted by Schön's (1983).

On the other hand, sketching is widely emphasized as an essential skill for product designers. It is used to generate, document, communicate, and present ideas by translating textual specifications into visual forms (Ullman 1997; Cross, 2011). Research on design thinking shows that designers often convert text into visuals during their process. In the early stages of a design project, sketching helps emphasize ideas, explore alternatives, and initiate creativity. Hand-generated sketches support abstract thinking, refine intangible ideas, and provide a foundation for further development (Baskinger, 2008). It allows rapid communication and creates a stronger impression for clients and collaborators.

Academic studies link sketching to design thinking and creativity, framing it as a tool for reflective conversation between designer and drawing (Tovey et al., 2003; Schön and Wiggins, 1992). It helps emphasize thoughts, refine concepts, and solve design problems. Sketches are perceived differently depending on the strokes used, with techniques such as over-sketching emphasizing features. Research suggests that teams allowed to sketch often produce higher-quality solutions. In the conceptual stage, sketches are intentionally vague and ambiguous, encouraging reinterpretation and iterative refinement. While many agree on its value, some scholars argue that emphasis can be equally important and that the absence of sketching does not always reduce the quality of early design solutions. In large collaborative projects, manual sketching may be replaced or supplemented by other visual or cognitive tools.

Buxton (2007) observes that sketches do not need to be visually perfect and can take many forms such as figures, diagrams, or imagery. In conceptual design, sketches act as external representations that express thoughts, facilitate new ideas, and structure design concepts (Bilda and Gero, 2007). The uncertainties present in sketches often trigger changes in their structure, driving innovation. Additionally, it has been asserted that sketches play a key role in two phenomena that occur during early design activity: (1) emergence, which refers to fresh thoughts and concepts that could not have been anticipated or planned before sketches; and (2) reinterpretation, which refers to the ability to alter, develop, and create new mental images while sketches are being made (Menezes and Lawson, 2006).

Sketching has long been central to design practice, evolving since before the Renaissance to address increasingly complex challenges (Cross, 2001). Tovey, Porter, and Newman (2003) describe design as beginning in the mind's eye, with sketches capturing mental images. Abidin, Warell, and Liem (2011) highlight sketching as a tool for exploring mental imagery through freehand techniques. Regular sketching encourages relaxation, reduces creative barriers, and inspires new ideas. Cross (2001) explains that sketching allows designers to explore both problem and solution spaces simultaneously, aligning potential solutions with identified challenges. Sketches often combine drawings with numbers, symbols, and text, which support analysis and concept generation. Schön (1983) describes this as a reflective conversation with the situation, enabling designers to test outcomes and refine ideas. This process strengthens design thinking and problem-solving. In conclusion, sketching is a powerful method within conceptual design, translating abstract ideas into tangible concepts and fostering innovative, meaningful products.

In the context of this research, user behaviour and perception can be used as a source of information, inspiration, and challenge in the product development process.

This phase is very important because it is a space where designers can build initial hypotheses based on observational data on UHBE and test them iteratively through reflective reasoning and design dialogue. Furthermore, UHBE can be seen not as a problem to be eliminated, but as a signal of potential new uses, which can be captured in the conceptual phase and re-incorporated as valuable functions. Therefore, understanding unintended use of product will put conceptual design role even more critical as it shows how the actual product is used outside the designer's expectations, and it requires the conceptual phase to accommodate diverse user constraints and interpretations (Dorst & Cross, 2001).

2.2.8 Research through Design

To resolve ambiguity in assessing the quality of research through design (RTD), Prochner (2022) established a quality indicator framework derived from multiple research paradigms (positivism, constructivism, pragmatism) by analysing 25 RTD papers to evaluate the applicability of the proposed indicators. The primary objective is to assist RTD investigators in methodically designing, reporting, and evaluating their investigations. His investigation revealed a deficiency of consensus regarding the evaluation of RTD, attributable to its unique characteristics and varied methodologies. RTD frequently generates knowledge that is contextual, intuitive, and difficult to recreate. Prochner (2022) identified five primary kinds of quality indicators for RTD research based on that research; (i) Traceability: clarity of the research process (replication, transparency); (ii) Interconnectivity: relationships between research elements and context (internal validity, credibility); (iii) Applicability: usability of results in other contexts (transferability, impact); (iv) Impartiality: the researcher's stance on bias (objectivity, theoretical alignment); (v) Reasonableness: justification of methodological and theoretical choices (reliability, dependability). Prochner (2022) determined in his analysis that the pragmatism indicator was the most frequently utilised aspect, albeit often not explicitly referenced in RTD research. Conversely, the traceability and applicability aspects emerged as the primary strengths of RTD research, while the reasonableness and impartiality aspects received comparatively less focus from RTD researchers. While the results of RDT are challenging to generalise due to their limited external validity, they are frequently applicable and significant within certain situations. Certain researchers cite the utilisation of qualitative methodologies and co-design as a means to enhance the credibility of their research. Nonetheless, there exists potential for enhancement that might be proposed to guarantee that RTD attains quality and operates systematically.

2.2.9 Design Syntactic Framework: The Integration of Product Form and Technical Functionality Analysis

Modern product design requires a holistic approach that integrates technical functionality, visual aesthetics, and user comprehension in a balanced manner. Within this context, a variety of approaches have emerged, proposed by design scholars to analyse product design in alignment with the specific demands of their respective disciplines. This section examines the significance of the Design Syntactic Analysis (DSA) framework introduced by Warell (2001), which is founded upon several preceding approaches, including Engineering Design Science, Design Semiotics, Form Aesthetics, and Visual Perception Studies.

Scholars from diverse domains have developed approaches to integrate form, meaning, functionality, and technical aspects in product design. Visual perception studies provide a detailed perspective on how humans process and interpret visual information in relation to design. Gibson and Walk (1960) argued that visual perception is a natural part of human development, shaping how users perceive and interact with products. Although this research deepens understanding of perception, it does not present a comprehensive framework for analysing structural form in products (Warell, 2001). Another approach, form aesthetics analysis, focuses mainly on the aesthetic qualities of design, such as form, colour, and texture, often without linking them to product functionality. Cross (2001) explains that this method is influenced by both classical and modern aesthetic principles, as well as art movements like Bauhaus, which emphasise simplicity and functionality. Warell (2001) also supports the value of this approach in producing visually appealing designs. However, he cautions that it tends to overlook the role of user interaction and the meanings embedded within design, which are crucial in shaping overall product experience.

In industrial product development, the relationship between product form and technical functionality is recognised as essential for achieving design excellence (Ulrich

& Eppinger, 2012). Within engineering, Engineering Design Science represents a systematic approach that prioritises technical and functional aspects of products. This method expanded significantly during the twentieth century with the introduction of computer-aided design (CAD), which enabled the creation of precise models. The process generally includes research and analysis, conceptual design, detailed design, prototyping, testing, implementation, and evaluation with iterative refinement. It plays a central role in engineering and large-scale manufacturing industries (Pahl & Beitz, 2007). Although effective in ensuring technical quality, this approach often struggles to balance functional and technical requirements with aesthetics and user perception (Warell, 2001). As Warell observes, classical engineering design methods emphasise functionality and performance but frequently neglect the formal and semantic qualities of products, which are equally important in shaping user experience and creating meaningful design outcomes.

In contrast to the semiotics approach proposed by Vihma (2007), the DSA framework is regarded as more comprehensive. Vihma observes that design semiotics has largely examined how products communicate meanings through signs, yet it rarely offers structural models explaining how form elements relate syntactically (Vihma, 2007, p. 223). Design semiotics is rooted in semiotic theory by Ferdinand de Saussure and Charles Sanders Peirce, which views design objects as signs carrying specific meanings. According to Vihma (2007), its development can be traced through four stages. The early stage investigates objects and their communicative aspects. The pre-semiotic stage examines product semantics without explicit semiotic theory. The trans-linguistic stage applies linguistic models to design objects. Finally, the semiotic stage introduces semiotic models for analysis, accompanied by detailed explanation and structured teaching in design institutions. Although design semiotics offers valuable insights into how users interpret and assign meaning to products through form, colour, texture, and other elements, it tends to focus primarily on linguistic dimensions while overlooking functional aspects of design (Warell, 2001). Collectively, these four stages have contributed significantly to the development of product design knowledge. However, when applied in isolation, they present limitations in addressing contemporary design challenges. Warell (2001) stresses that much prior research lacks a robust theoretical foundation, which is necessary for advancing models, methods, and tools to support a more holistic understanding of product design.

This situation reflects that the aesthetic and engineering domains have often operated in isolation when producing artefacts. While the technical performance of a product may be robust, aspects related to usability and market appeal are not always conveyed in a holistic manner (Cross, 2001). Warell & Nåbo (2000) suggests that these gaps should be addressed through integration, not only to improve product quality but also to enhance a company's competitive advantage. Such integration involves the formulation of a shared conceptual framework that facilitates effective cross-disciplinary communication, aligns project objectives, and minimises inefficiencies and rework (Roozenburg & Eekels, 1995; Warell, 2001; Pahl & Beitz, 2007; Norman, 2013). In response to the needs, Warell (2001) emphasises the importance of integrating industrial design and engineering design activities to produce holistic product design solutions that account for technical, ergonomic, and aesthetic factors throughout the development process. To underscore the critical requirements for modern industrial product development, Warell (2001) outlines several key needs identified in current research and practice (see Figure 2.8), namely: (1) the unification of form and technical workings, (2) better interaction between industrial design and engineering design, (3) common model for product form, and (4) holistic methods for form design development.

Key Need	Explanation
1. Unification of Form and Technical Workings	It is essential to address product form (appearance) and technical functionality (how it works) as an integrated whole from the outset of the design process. Treating form as an afterthought often results in products that are less usable, cost-inefficient, and commercially unsuccessful. Early collaboration ensures a more coherent and user-appealing outcome.
2. Better Interaction between Industrial Design and Engineering Design	Strengthening interdisciplinary collaboration between industrial designers and engineering designers is critical. Historical specialization has led to a division of competencies, but current product development demands an integrated approach to address both aesthetic and technical requirements effectively.
3. Common Model for Product Form	Miscommunication across disciplines frequently arises from differing perspectives on design objectives. The development and application of a shared conceptual framework would facilitate mutual understanding, align project goals, and minimize the risk of design inefficiencies and rework.
4. Holistic Methods for Form Design Development	Conventional design methodologies, while effective for technical development, often neglect human-centered and aesthetic aspects. A holistic design approach that integrates usability, aesthetics, and technical requirements within a unified methodology is necessary to achieve comprehensive and competitive product solutions.

Figure 2.8 Key Structural need for Unification of Form and Technical Workings, Industrial Design and Engineering Integration, adapted from Warell (2001)

In line with the need for a structured approach in industrial product development, design research has highlighted the importance of understanding theories on how humans interpret product form. The development of product semantic frameworks has historically emphasised meaning in design through analyses of aesthetics, semiotics, and perception (Butter & Krippendorff, 1984; Monö, 1997). These frameworks represent a key methodology in industrial design, offering a structured means of evaluating symbolic and communicative qualities in products and providing insight into user interaction and perception. However, a gap remains between interpreting design through subjective messages and understanding form elements as intentionally structured by designers. To address this, Warell (2001) emphasises the need for a systematic framework that focuses directly on the structure of form elements. He subsequently introduced the concept of Design Syntax, a complementary framework aimed at examining how visual form and technical function can be deliberately organised and cohesively integrated in product development.

"The design syntactics framework provides tools to describe and interpret product form in terms of form elements, their relationships, and the meanings derived from these relationships." (Warell, 2001, p. 12)

DSA is a systematic approach for analysing and developing the visual form of products by integrating aesthetic and functional aspects in a cohesive manner (Abidin et al., 2014), as it combines the theoretical and practical strengths of all preceding approaches, which is to support the industrial design process by providing a theoretical and methodological framework that enables designers to understand, analyse, and synthesise product form more effectively. According to Warell (2001), truly communicative design requires not only an understanding of meaning, or semantics, but also a clear comprehension of the composition and organisation, or syntactic of form elements. The integration of syntactic and semantic design results in the use of a shared design language, a set of principles and vocabulary that bridges disciplinary gaps. It includes three main components: (i) Alphabet: the basic form elements that build the physical product; (ii) Syntactic: the rules that govern how these elements are composed into larger, meaningful structures, and (iii) Semantics: the meaning that users derive from these structures (Warell, 2001; Löwgren & Stolterman, 2004).

By integrating the elements of a common framework consisting of the "alphabet" (basic shapes), "syntax" (the combination of shapes), and "semantics" (the message conveyed), design teams can communicate ideas clearly and reduce misunderstandings (Löwgren & Stolterman, 2004; Warell, 2001). In practice, this is evident in style guides that define how brand-specific curves or interface elements should align across product families, ensuring coherence while allowing creative flexibility. Whereas product semantics highlights user interpretation, design syntax provides a systematic basis for defining, analysing, synthesising, and evaluating product form. It not only considers external appearance but also structural aspects such as connections, openings, intersections, textures, and graphics (Vihma, 1987), reinforcing both aesthetics and technical performance (Warell, 2001). Within this framework, Warell introduces three tools for analysing, describing, and evaluating form design: (1) form functionality analysis, (2) form development or syntactics, and (3) design format handling (see Figure 2.9).

The design syntactics framework proposed by Warell has been widely employed by design practitioners and scholars as a tool to support the specification, analysis, synthesis, and evaluation of visual form design during the form development process, whether for product development or design research. Each tool has a specific role and procedure aimed at delivering solutions that not only address the functional and structural aspects of form but also define the composition and content of a visual form design, which may relate to internal, external, or product family factors. This framework forms the foundation for the form analysis approach adopted in this thesis.

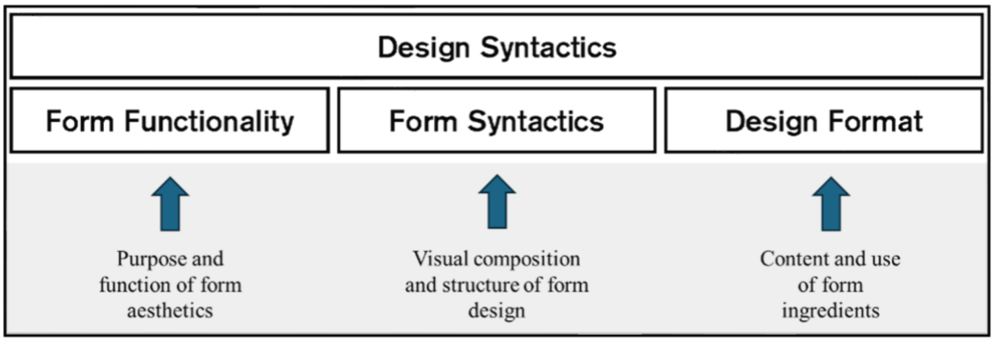

Figure 2.9 The Framework of Design Syntactic, adapted by Warell (2001)

Form Functionality

Form functionality in design syntactics highlights the interactive role of visible surfaces, where contours serve ergonomic, semantic, or structural purposes (Vihma, 1995). Critiquing conventional engineering analysis, Warell and Nåbo (2002) propose a dual-method procedure: direct functional identification and design intent analysis.

Warell (2001) further introduces a flexible form functionality classification that integrates both technical and aesthetic evaluations, adaptable to the product's needs (Figure 2.10).

Function class	Function type			Examples of descriptive verbs
Technical functions (internal product functions)	Operative	Primary	*Transforming*	Transform Transmit Rotate
		Secondary	*Communication* *Interface* *Power* *Control* *Protection*	Regulate Convert Supply
	Structural			Connect Support Restrain
Interactive functions (human-product interaction functions)	Ergonomic			Protect Enable Facilitate Fit/Suit
	Communicative	*Semantic*		Express Describe Identify Exhort
		Syntactic		Refer Connect Unite Discern Balance

Figure 2.10 Function Classes of Products, Human-Product Interaction, and example of Descriptive Verbs, adapted from Warell (2001)

Direct functional identification (Figure 2.11) involves observing the product to identify functions from distinct classifications. The analysed item can be the product itself or an image, sketch, or cad model, depending on availability and size. The procedure follows basic of three steps as below:

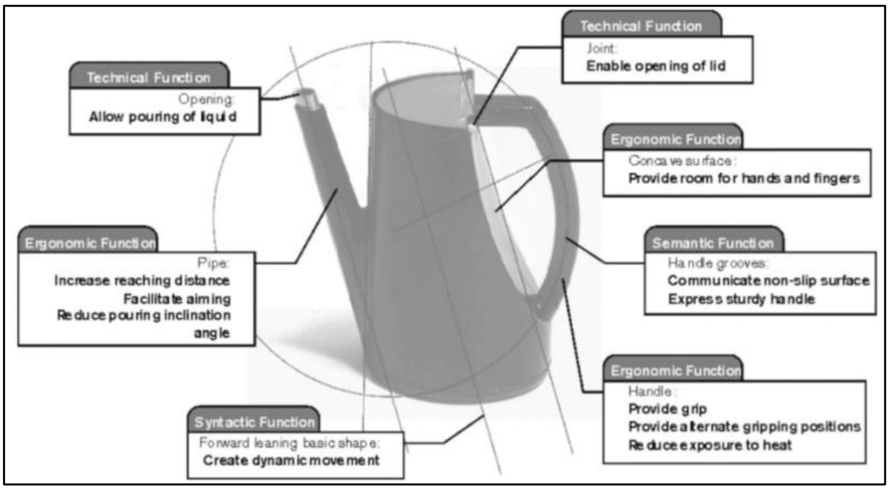

Figure 2.11 Direct Functional Identification of the SAS Coffee-pot, adapted from Warell (2001)

Although direct functional identification provides a rapid method for being functionally familiar with the product, design intent analysis offers a more comprehensive insight into the design and its functional components. The technique can be systematised into a manual form-based instrument. Unlike direct functional identification, the product is examined segment by segment (or subsystem by subsystem). In design intent analysis, the analysis covers all functional aspects of the product under study, including technical and interactive functions as illustrated in see Figure 2.12.

Col.	A	B	C	D	E	F	G	H	I
Row No.	**Question** "Why is the solution/feature/ mean present?"	**Purpose/Reason/Cause (design intent)** "In order to..."	**Function statement (verb + noun notation)** "What does the solution/feature do?"	Main	Structural	Additional	Ergonomic	Syntactic	Semantic
1	Why is a pot needed?	...enable serving seated aircraft passengers from main coffee container in cabin kitchen	Hold liquid	X					
	Body								
2	Why is there an opening in the top of the pot body?	...enable (re)filling	Allow filling			X			
3	Why is the cross section of the pot elliptical in shape?	...facilitate (re)filling from tap in cabin kitchen	Facilitate filling				X		
4		... create an visual composition in balance with other form solutions	Couple form elements					X	
5		...facilitate serving by occupying less space when serving	Decrease bulkiness				X		
6		...lighten the visual impression of the pot body	Express lightness						X
7	Why is the pot body made of plastic?	...increase the longevity of the appearance (no dents)	Decrease visual aging						X
8	Why is there a cutout concave curve surface of the pot body facing the pot handle?	...give room for hands and fingers of different sizes	Fit hand				X		
9		...counter-weight the curvature of the pot handle	Balance visual composition					X	
10	Why is the bottom welded to the pot body?	...enable injection-molding of the pot body	Connect parts		X				
	Lid								
11	Why is there a lid?	...retain heat	Reduce heat loss	X					

Figure 2.12 Example of Functional Analysis (Design Intent) of the SAS Coffee-pot, adapted from Warell (2001)

The combination approach of direct functional identification and design intent is in line with usability methods in human–computer interaction, where heuristic evaluation is enriched with cognitive measures to reveal both superficial and deep structural issues.

Form Syntactic / Form Development

The form development approach serves as a versatile tool for analysing and enhancing product form at the operative level. Drawing from Gestalt psychology, Warell applies factors such as similarity, proximity, good curve, common movement, symmetry, prior experience, area, and enclosedness to guide the active synthesis of design (Monö, 1997). These concepts, originally explanatory models of perception, were transformed by Warell (2001) into practical tools for styling and development.

Balancing these tendencies is essential for achieving visual coherence, enabling designers to simplify structures, refine weak designs, and differentiate products effectively. This approach allows form to be comprehended, evaluated, and refined throughout the design process. Furthermore, Warell conceptualises form syntactic as a constitutive model describing the organisation and configuration of form structures, linking aesthetic architecture, communication, and functional elements across four hierarchical levels: superior Gestalt, intermediate features, lower-level ingredients, and product identity (Warell, 2001; Warell & Nåbo, 2002). These four levels can be identified based on the following levels:

1. The Superior Gestalt represents the highest hierarchical level (global) in product form analysis. It encompasses overall configuration and dominant visual impression of product, integrating various form elements into cohesive whole (external shape).
2. Characteristic shapes refer to prominent form elements that are essential to the product's function and aesthetic appeal. The shapes are typically associated with specific functional components, forming form entities with interconnected and referential syntactic functions, and play a crucial role in conveying the product's intended purpose (internal shape).
3. A significant curve is recognized as a component distributed across the product. The characteristic curve serves as a key element of the form, establishing relationships among form entities and linking discrete, spatially separated elements. The form elements generate visually cohesive entities, which are fundamental for promoting unity and harmony within the overall form of the product (product component).
4. The Fifth Element refers to unique, often subtle, design features that serve as brand identifiers or convey specific symbolic meanings. The elements are typically consistent across a brand's product range, reinforcing brand recognition and continuity (brand symbolic).

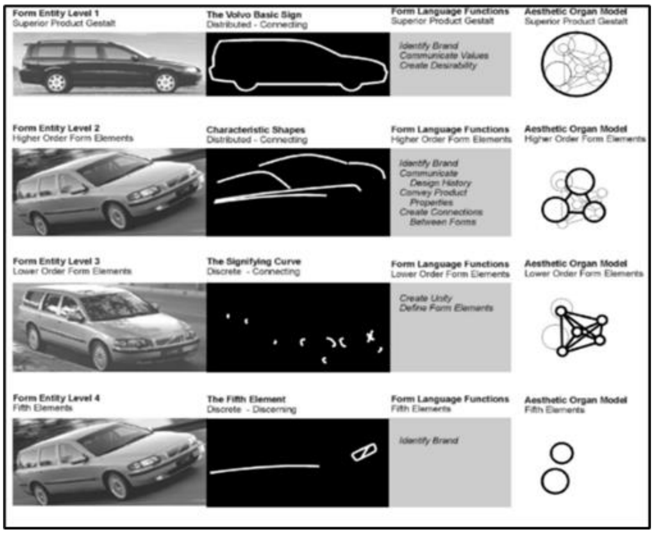

Figure 2.13 Form Entities Characteristic Form Elements, Communicative Functions, and Superimposed Aesthetic Organ Model for the Volvo V70, adapted from Warell (2001)

Figure 2.13 shows form syntactic reasoning and a cohesive design framework with Volvo V70 Station Waggon stylistic DNA examples of form entities, aesthetic components, and elements. Warell (2001) lists four hierarchical form entities: typical form elements, communicative functions, and overlaid aesthetic organs. The superior gestalt represents global form entities at the highest level. Extended shoulders, car body curves, and door handles, lighting, and grille details are distinctive forms. Volvo's fifth element, the diagonal grille, represents the brand. Evaluation integrates syntactic patterns with semantic meaning, emphasising consistency, selectivity, and completeness. This method evaluates the visual impact of the product form by questioning initial form solution, generates better or different form solutions that fulfil the same function efficiently by considering visual, ergonomic, and technical aspects.

Design Format

Design format represents both the content and philosophy of form, encompassing product style, identity, and visual language, as well as stakeholder requirements that shape brand perception, product class, and market positioning. Karjalainen (2007) highlights design format analysis as a qualitative method adaptable to various design contexts. Its primary function is to maintain visual identity across a brand's product range, reinforcing brand aesthetics and communication. As a blueprint for product identity, design format provides coherence and recognisability. Warell and

Nåbo (2000) describe the design format, or "design concept template," as a company's style philosophy that guides the choice and organisation of form elements, establishing a distinct form language. Subtle cues in details, compositions, curves, themes, and interfaces can differentiate a manufacturer's products from competitors. A comprehensive application of form, form functionality, and design format establishes both a theoretical and practical foundation that integrates aesthetic appeal, ergonomic effectiveness, and technological performance in industrial design.

Designers utilise form elements, which link aesthetics and functionality, from sketch to final product (Andreasen, 1998; Warell & Nåbo, 2000). While negotiating meaning, structure, and user interaction, these entities progress from crude sketches to detailed prototypes. Thus, combining a syntactic structural approach to design with a communicative understanding of product semantics allows a complete design process that combines technical precision and artistic expression. The Warell (2001) Design Syntactic Analysis technique has helped product design by offering an analytical framework for numerous design dimensions. It opens up product design with its three primary components: Form Functionality, Design Syntactics, and Design Format. DSA's complete tool helps designers learn how users interpret form and how to build things that clearly and consistently communicate purpose and identity from concept to realisation. This convergence helps create new product concepts that are functional, manufacturable, meaningful, useable, and emotionally resonant.

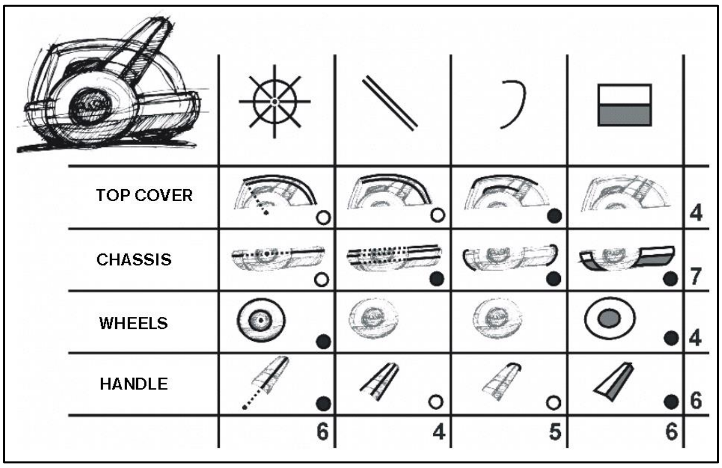

Figure 2.14 Descriptive design format analysis and assessment of a single product (Electrolux Home Products Operations), adapted from Warell (2001)

Figure 2.14 illustrates an example of a design format or concept template for

Electrolux Home Products Operations (Sweden) AB, established according to the manufacturer's specifications. It highlights the application of styling principles in each section, such as the form elements on the top part of the vacuum cleaner cover, which convey reinforced styling features. In addition, the design of a single physical component can incorporate form elements corresponding to various styling characteristics.

2.2.10 Summary of Section I

In conclusion, this study shows that product design is shaped by historical progress, technological innovation, and cultural context. The change of designer responsibilities shows how designers are now mediators of meaning, innovators, and translators of complicated human and environmental requirements. This shift emphasises the need for a more holistic design research knowledge. In mainstream product design, the design process has interconnected phases that go beyond linear problem-solving and use iterative, reflective, and exploratory methods. This makes product design challenges multi-dimensional, requiring technological expertise and social, cultural, and ethical awareness. These problems demonstrate that product design is a strategic and creative process that requires rigorous reasoning to achieve meaningful, user-oriented, and sustainable results. Meanwhile, product appearance affects user perception, emotional involvement, and design communication. Appearance mediates value, utility, and identity in popular practice. Integrated human factors guarantee design solutions are responsive to user needs, ergonomics, safety, and inclusive accessibility. Thus, a successful design must balance symbolic, cognitive, and functional dimensions, as shown by this synthesis. Conceptual design and drawing stress the power of early ideas in product development, while sketching helps visualise ideas, test assumptions, and refine them. This technique encourages creativity and collaboration, solidifying its place in product design. Finally, the design syntactic framework, which merges product form and technical functioning analysis, provides a formal framework for design coherence evaluation. This paradigm emphasises methodical approaches to innovation and functional reliability by matching formal language with technological objectives. These components show that product design demands a compromise between creativity and systematisation, human-centeredness and technological limits, visual expression and functional performance. Design research may improve design knowledge and practise and boost designer's role in solving current problems and defining future innovations by comprehending interconnection elements.

2.3 Section II: Design(erly) Thinking in Design Practice

This section will present and discuss the relevant contributions of knowledge areas through components related to design thinking from various angles including design thinking strategies in design practice, design dialogue, the role of product appearance, forms of reasoning, and the nature of design expertise. Design thinking strategy and frameworks including visual-based research, reflective practice in product design, verbal protocol approach, design syntactic framework, and co-operative inquiry are also covered. Current findings will elaborate on each sub-section.

2.3.1 Design Thinking

The cognitive processes of designers during the design phase are crucial to the design discourse. Design thinking is a human-centered approach to problem-solving initially developed for the creation of innovative products but subsequently applied to address systemic and complicated "wicked" problems. In 1946, Architect and Engineer Magazine coined the phrase, which design academics began to utilise in the 1980s (Rowe, 1987; Dorst, 2015). Since the 1990s, design thinking has been conceptualised as a mindset, toolbox, methodology, and process (Dorst, 2011). Silva, Zancul, and Oliveira (2020) assert that the extensive origins and interdisciplinary use of design thinking contribute to its conceptual vagueness. Herbert A. Simon's The Sciences of the Artificial (1969), Robert McKim's Experiences in Visual Thinking (1973), Bryan Lawson's How Designers Think (1980), and Nigel Cross's Designerly Ways of Knowing (1982) represent seminal contributions. These works offered an intellectual foundation for comprehending design thinking as a transdisciplinary, dynamic process that impacts contemporary theory and practice.

Rowe's Design Thinking (1987) popularised the term by explaining methodologies used by architects and urban planners. By 1991, global symposiums on design thinking explored its evolution and theoretical grounding, while Faste (1993) described it as "a method of creative action." Buchanan (1992) gained recognition for addressing complex challenges, and Kelley (1991) extended its practical applications. Since then, design thinking has expanded beyond its initial fields, serving as a tool for creativity and human-centered problem-solving. It assists managers in innovation across products, processes, and business strategies (Bucolo & Matthews, 2010). Design activity integrates cognitive processes such as perceiving, contextual interpretation, solution formulation, and problem resolution. Psychomotor activities like sketching and drawing support these cognitive functions, yet its essence remains cognitive. Cross (2001) defined design thinking as a problem-solving methodology, while Eastman (2001) emphasised its human role in generating knowledge through theory and practice. With technological advances, design thinking now combines intuitive, exploratory, and empathetic approaches to address unstructured problems (Abidin, 2020).

The emphasis of "designerly thinking," introduced by Cross (2001), emphasises the unique critical reasoning employed by designers compared to the linear logic and experimental testing of scientists and engineers. It is flexible, open, and heuristic, allowing exploration of multiple valid solutions in uncertain contexts while maintaining a deep understanding of design requirements. In product design, this approach extends beyond technical problem-solving to creating new value through meaning, emotion, and user experience. Design thinking can be understood through 3 interrelated perspectives:

1. Problem-solving process: referred to as the process of solving complex problems. Rowe (1987) in his book "Design Thinking" explains how designers manage unstructured problems through heuristic strategies and create alternative solutions.
2. Cognitive thinking: understood as a unique form of cognitive thinking (Cross, 2001) that involves the formation and reframing of problems (problem framing), the exploration of creative solutions, as well as continuous reflection activities on the results and the design process itself (Dorst & Cross, 2001).
3. Systematic approach to innovation: L. Bruce Archer (1965) emphasized a systematic design approach that includes the process of analysis, synthesis and evaluation in solving design problems, which marks design thinking in a systematic scientific and technical stream.

2.3.2 Design Dialogue: Design Thinking from other Perspectives

The rise of creative thinking and the introduction of new methodologies in the

1960s marked a pivotal moment in the evolution of design thinking, which began to be emphasized as a distinct approach to solving problems through creativity. Early contributors included John E. Arnold (1959) with *Creative Engineering* and L. Bruce Archer (1965) with *Systematic Methods for Designers*, both of which provided foundational perspectives on the subject. In *Creative Engineering*, Arnold (1959) identified four principal areas of design thinking;

1. Creation of new functions: Solutions addressing emerging needs or reinterpreting existing needs in novel ways
2. Performance improvement: Achieving higher efficiency and quality
3. Cost reduction: Lowering production costs without sacrificing quality or functionality
4. Product durability: Extending the lifespan and usability of products.

This approach covers incremental innovations, which improve performance, and radical innovations, which create new functionalities. Arnold highlighted the balance among all dimensions for effective design, while Archer (1965) stressed systematic methodologies that integrate ergonomics, cybernetics, marketing, and management science to expand design efficiency and scope. He further emphasized systematic planning as a foundation for creative design. Recent studies show that design thinking is now applied beyond traditional design disciplines. According to Dalsgaard (2014), dialogue around designerly knowing and acting remains essential. Design thinking has also become a widely used "buzzword," with many publications underlining its role in management and corporate innovation. Dorst (2011) noted that, although calls for precise definitions are growing, scholars value preserving diverse perspectives. He also explored frame creation as a design method in management. Kelley introduced design thinking into business in 1991, and it has since evolved into a problem-solving paradigm in education, healthcare, and IT.

Simon's (1969) paradigm concentrated on contextual adaptation, whereas Schön's (1983) approach highlighted reflection-in-action. This aligns with Rittel and Buchanan's (1992) wicked problem framework, which categorises problem-solving into definition and resolution stages. Krippendorff (2006) emphasized design thinking as a process of meaning-making through products (Johansson-Sköldberg et al., 2013). Johansson-Sköldberg et al. (2013) differentiate between two forms of cognition:

designerly thinking, which emphasized the practices, skills, and theoretical reflections of professional designers, thereby connecting theory and practice; and design thinking, which extends these principles beyond the realm of design, particularly into management. Management-focused adaptations frequently diminish creativity to a mere toolkit, overlooking professional expertise and reflective practice (Adams et al., 2011). To establish a robust theoretical foundation, Johansson-Sköldberg et al. (2013) identify five major perspectives influencing *designerly thinking*:

1. Design as the Creation of Artefacts (Herbert Simon)

   Herbert Simon (1969) argued in The Sciences of the Artificial that design solves problems via objects. Simon, an economist and cognitive scientist, defined design as an intellectual process that improves current conditions. Designers, like scientists and engineers, use methodical, goal-oriented methods based on constrained rationality. His prescriptive approach to design emphasised logical problem-solving, distinguishing it from the natural sciences. Simon's cognitive framing is prominent in engineering, computer science, and decision theory, despite his rationalist epistemology's neglect of interpretative, contextual, and intuitive aspects of practice.

2. Design as Reflective Practice (Donald Schön)

   Donald Schön's (1983) reflective practitioner model contrasted Simon's rationalist approach of design. Schön believed, influenced by philosophical pragmatism, that professional knowledge comes through reflection-in-action, when practitioners experiment and reinterpret issues in complicated, ambiguous circumstances. He emphasised the iterative and situational aspect of design practice by prioritising experiential learning and tacit knowledge above technical rationalism. This perspective suggests that designers use activity to develop knowledge rather than applying ideas. Practice incorporates reflection, making design a contextual and interpretive investigation. In design education, reflective discourse informs studio-based pedagogy, critique, and iterative development and aligns with organisational learning theories.

3. Design as the Framing of Wicked Problems (Richard Buchanan)

   Buchanan (1992) developed design as a tool for solving wicked issues from Rittel and Webber (1973). Design addresses complicated, ill-structured, and socially dependent issues rather than finding answers. Buchanan believed designers use heuristics to explore, frame, and reframe design challenges. His view of postmodern complexity and indeterminacy posit the designer as an interpreter and synthesiser of systemic and emergent processes. His work defines four design domains: symbolic/visual communication, material items, actions/services, and complex systems. This approach expanded design beyond industrial products to incorporate service design, systems thinking, and organisational transformation. He emphasises design's social and ethical aspects shifting it from a method to a philosophy.

4. Design as Practice-Based Knowing (Lawson & Cross, 2006)

   The empirical study of design cognition and process has been advanced by architects Nigel Cross and Bryan Lawson. Using observation and protocol analysis, they study how designers think and act during the design process. Design's thinking, problem-solving, and recurrent processes set it apart (Cross, 2006, 2011; Lawson, 2006). Cross (2011) proposes that designers use abductive reasoning to generate several concepts and limit them down, even under uncertainty and restriction. Lawson (2006) describes cyclical and recursive design patterns in which designers change representations and prototypes to externalise cognition and improve issue comprehension. This discourse supports Schön's philosophical reflection by offering empirical evidence of design cognition's micro-practices, affirming design's epistemic culture.

5. Design as Meaning-Making (Krippendorff, 2006)

   Klaus Krippendorff (2006) defines design as semantic and hermeneutic in the fifth discourse. The meanings of the item in distinct social and cultural settings are the focus of this approach. Krippendorff's semantic turn views design as a process of producing, negotiating, and interpreting meaning, using things as communication tools rather than goals. This concept, based on language, semiotics, and interpretivism, views design as a discursive and communicative act that creates meaning via usage, interaction, and debate. Recognising users' subjectivities, identities, and cultural contexts challenges instrumentalist design. The hermeneutic approach affects human-centered and participative design. Verganti's (2009) design-driven innovation emphasized symbolic and experiential value, where novelty comes from new meanings assigned to existing technology or behaviours.

The five discourses give a varied designerly perspective. It ranges from rationalist (Simon, 1969) to hermeneutic (Krippendorff, 2006), 63mphasiz viewpoint (Lawson and Cross, 2006) to reflective (Schön, 1983), abstract postmodernism (Buchanan, 1992) to empirical observation. Although not exclusive, they represent different research interests and methods. Table 2.2 illustrates a summarises of the epistemological foundations and primary contributions.

Table 2.2
Comparison of Five Discourses of Design Thinking, adapted from Johansson-Sköldberg et al. (2013)

Founder	**Background**	**Epistemology**	**Core Concept**
Simon	Economics & political science	Rationalism	The science of the artificial
Schön	Philosophe & music	Pragmatism	Reflection in action
Buchanan	Art history	Postmodernism	Wicked problems
Lawson & Cross	Design & architecture	Practice perspective	Designerly ways of knowing
Krippendorff	Philosophy & semantics	Hermeneutics	Creating meaning

Tovey (1997) describes *designerly thinking* as paralleling industrial design through five aspects: tackling ill-defined problems, solution-focused problem-solving, constructive thinking, translating abstract requirements into concrete objects, and using "object languages" to communicate. This pluralism presents both challenges and opportunities, necessitating careful epistemological positioning and promoting mixed approaches that integrate rational analysis, interpretive inquiry, and situated practice. The future of design research may lie in synthesising these discourses into coherent frameworks bridging theory, practice, and innovation. Table 2.3 indicates the design thinking timeline, adapted from Lewrick et al., (2018).

Table 2.3
The Design Thinking timeline, adapted from Lewrick, Michael, Patrick Link, Larry Leifer. The Design Thinking Handbook. Hoboken, NJ: Wiley, (2018)

Author	**Definition of Design thinking**
Pre 1960	The origins of design thinking lie partly in the development of creativity techniques in the 1950s. The earliest scholars include William J. J. Gordon (1961) Alex Faickney Osborn (1963) "Creative technique", Morris Asimow (1962) "engineering", Christopher Alexander (1964) "architecture", L. Bruce Archer (1965) "design industry", John Chris Jones (1970) "product and system design"
1970s	Don Koberg and Jim Bagnall's book "The World Traveller" introduced the'soft systems' design method for 'daily life' challenges. Horst Rittel created the phrase "wicked problem" for multidimensional, difficult situations. D. Bruce Archer adds, "There are ways of thinking and communicating by design that are different from scientific and scientific ways of thinking and communicating, and just as powerful as scientific and scientific research methods when applied to

	its kind of problem." Simon introduced design thinking in The Sciences of the Artificial in 1969.
1980s	The rise of human-centred design and the rise of design-centred business management. Donald Schön published The Reflective Practitioner to establish "an epistemology of practice implicit in artistic, intuitive processes, and the practitioner leads to situations of uncertainty, instability, uniqueness and conflict of values."
1990s	The first Symposium on Research in Design Thinking was held at the University of Delft, the Netherlands, in 1991. The first design consulting company was established "IDEO" by combining three major industrial design companies representing companies that practice (1) the design process, (2) based on design methods and (3) design thinking.
2000s	Design thinking gained popularity in the early 21st century when the business press popularised it. Business books explain how to develop a design-focused workplace that fosters creativity. Design management researchers include Richard Florida (2002), Daniel Pink (2006), Roger Martin (2007), Tim Brown (2009), Thomas Lockwood (2010), and Vijay Kumar (2012). With that development, the design methodology was developed and adapted to design in other domains, including services, starting the service design movement.
2005	Stanford University Design School begins teaching design thinking as a general approach to the advancement of technical and social innovation.
2010s 2015	Jenna Leonardo, Katie Kirsch, Rachel H. Chung and Natalya Thakur from Stanford University's design school recommend design thinking to young girls across the United States by championing "Girls Driving for a Difference".
2018	Jeanne Liedtka's Harvard Business Review calls for "functional design thinking" in business.

Theories of design thinking underscore the significance of comprehending human behaviour in contemporary design. Simon's rationalist methodology underscores the necessity for formal techniques to address practical constraints, but real-world situations often necessitate Schön's reflective, action-oriented inquiry. Buchanan perceives wicked situations as intricate human requirements influenced by social, cultural, and environmental factors. Lawson and Dorst discovered that design cognition encompasses iterative exploration and representation, which entails observing, comprehending, and predicting user behaviour. According to Krippendorff's semantic shift, design serves as a channel for creating and negotiating meaning, with user experiences and cultural contexts affecting product value and acceptance. The methodologies highlight critical aspects of quotidian human behaviour research: behavioural unpredictability, cultural diversity in meaning construction, and adaptive problem framing. The design approach must include cognitive, introspective, systemic, and interpretive approaches. Design thinking research necessitates interdisciplinary collaboration among behavioural sciences, anthropology, sociology, and systems theory. This combination provide design strategies more technically proficient, socially impactful, ethically grounded, and attuned to the complexities of human existence.

2.3.3 Deductive, Inductive, and Abductive: Forms Reasoning in Design Thinking

Reasoning is a cognitive activity that shapes how people respond to situations in all aspects of life, and design activity relies heavily on designers' reasoning processes. Understanding the role of reasoning is therefore essential to explain how design occurs. Rittel (1973) argued that patterns of reasoning can only be identified at the micro level of the design process and suggested that reasoning between designers often takes an argumentative form, making it possible to study through their interactions. Abductive reasoning is the logic of idea generation, assuming the existence of possibilities regardless of truth or falsehood. Inductive reasoning supports theory-building by predicting future outcomes from past observations, while deductive reasoning proves what must be true beyond reproach. From a logical perspective, design reasoning is theorised through these three types: (1) abductive; (2) inductive, and (3) deductive (Dorst, 2011; Roozenburg and Eekels, 1995), with abductive reasoning considered the most dominant in design, as illustrated in Figure 2.15.

Type of design reasoning	Dorst equation
Induction	WHAT + ??? leads to RESULTS
Deduction	WHAT + HOW leads to ???
Abduction 1 (Closed problem solving)	??? + HOW leads to VALUE
Abduction 2 (Open problem solving)	??? + ??? leads to VALUE
Framing	WHAT $\underline{\text{+ HOW leads to VALUE}}$
	FRAME

Figure 2.15 Design Reasoning Patterns (Dorst, 2011)

Designers have been through the process of dealing with open and complex design problems since time immemorial. The complexity of solving complex problems leads designers to rise to the challenge by creating "frames" according to their "mold", and how design organizations deal with that "mold". However, it is impossible for design thinking to be understood, or to find commonalities in a very diverse array of design practices, without first referring to the core challenges of design (Dorst, 2011). Therefore, the steps to understand how designers work and practice some design practices, the core challenges of design should be understood first in design thinking research. Designers should be skilled in identifying and understanding the basics and different types of reasoning in formal logic before understanding more complex challenges (Dorst, 2011).

Formal logic has three elements: Objects requiring attention are referred to as "things" or "players."; the regulations or protocols that dictate issue resolution are also essential; and ultimately, evaluate the observable results of the circumstance. Dorst (2011) classifies formal logical thinking in the following manner, that academic reasoning encompasses deduction, induction, and abduction. The human deductive problem-solving method involves ascertaining "what" and "how" to anticipate and produce "results." In induction, the phenomenon is recognised, although the operational mechanism responsible for the observed outcome remains unidentified. Proposals about the underlying principles of operation or Innovative methodologies that may elucidate the hypothesis and resolve the equation.

Dorst asserts that scientific "discovery" is contingent upon inductive reasoning. This strategy entails establishing a hypothesis and subsequently conducting thorough tests to refute it. This comprehensive assessment is guided by a form of logical reasoning. Consequently, inductive reasoning facilitates scientific discovery, whereas deductive reasoning corroborates and reinforces it. These two analytical reasoning techniques forecast and elucidate prevalent occurrences. In contrast to Abduction, two forms of reasoning exhibit shared characteristics and emphasise value production. The following table is a form of Abduction as stated by Dorst (Table 2.4).

Table 2.4
The Comparison of the Formal Logic of Abduction-1 and Abduction-2, adapted from Dorst (2010)

Abduction-1	Often associated with the "closed" approach to problem-solving used by organisations in several sectors. The equation implies that the desired goal, or "value," and the procedure, or "how," to achieve it are already determined. However, the object, service, or system is missing. Identifying the "what" aspect establishes the problem parameters and solution space. Designers and engineers use this approach to create value-generating designs that meet working criteria.
Abduction-2	Sometimes connected to a "open," problem-solving strategy, where complexity originates from a lack of understanding about the exact actions needed to get the desired result. Given the ambiguous operational framework, known as the "working principle," which helps achieve the intended value, there is debate on the exact object of creation. This forced the simultaneous creation of a "working principle" and a "thing" (an object, service, or system), shifting from Abduction-1 problem-solving to design methods.

Dorst differentiates between Abduction-1, which yields tangible outcomes, and Abduction-2, which contextualises challenging situations. Abduction-2 assists Junior designers in generating ideas, while experienced designers reframe problems to address complex challenges, and assesses their validity. Design reasoning is a creative methodology for conceptualising, developing, and assessing ideas to produce innovative products, services, and systems. Design thinking integrates inductive, deductive, and abductive reasoning to facilitate desired, legitimate, and feasible decision-making, hence enhancing designers' work. Design thinking reasoning is supplementary and non-linear. Designers employ inductive, deductive, and abductive reasoning to examine user behaviour, evaluate assumptions, and develop innovative solutions. Reflective behaviours and hermeneutic understanding of user context accomplish this. Cross (2011) presents a contemporary design thinking methodology that amalgamates several thinking modalities to produce ideas that fulfil functional, emotional, cultural, and economic criteria.

2.3.4 Structured and Unstructured Approaches in Design Thinking

In recent years, substantial research has been devoted to exploring the concept of design thinking and examining how designers think and work (Brown, 2009; Cross, 2011; Lawson, 2006; Lawson & Dorst, 2009). The term design encompasses both the process of designing and the final outcome. Abdullah (2007) describes design as a "powerful weapon" enabling design firms to differentiate their functions and products through consistency, heritage, brand, and identity. Consequently, the success of a product is often determined by the extent to which designers apply design thinking and develop a deep understanding of the design. Cross (2011) asserts that design thinking involves a sophisticated comprehension of problems and solutions situated in real-world contexts, encompassing activities such as problem framing, idea generation, prototyping, and critical reflection on the resulting solutions. Lawson and Dorst (2009) emphasise that designers employ design thinking as an iterative process, navigating between problems and solutions to enhance the accuracy, feasibility, and relevance of the design outcome. In achieving design objectives, designers adopt various strategies tailored to the specific demands of the project. Across these studies, Cross (2011) consistently identifies three fundamental strategic elements underpinning design thinking:

1. Taking a broad 'systems approach' to the problem, rather than accepting narrow

problem criteria.

2. ‘framing’ the problem in a distinctive and sometimes rather personal way.
3. designing from ‘first principles.

Different reasoning approaches produce varied outcomes in design, influence user perception, and offer distinct advantages to organisations. Designers continuously redefine and frame problems throughout their design thinking activities, employing holistic thinking while sketching, drawing, and modelling potential ideas across the design process (Goldschmidt, 2003). Abidin (2020) categorises a designer’s thinking into two contrasting directions: structured and unstructured. The product design process may draw upon either structured or unstructured parameters, depending on the professional designer’s cognitive style, as illustrated in Figure 2.16.

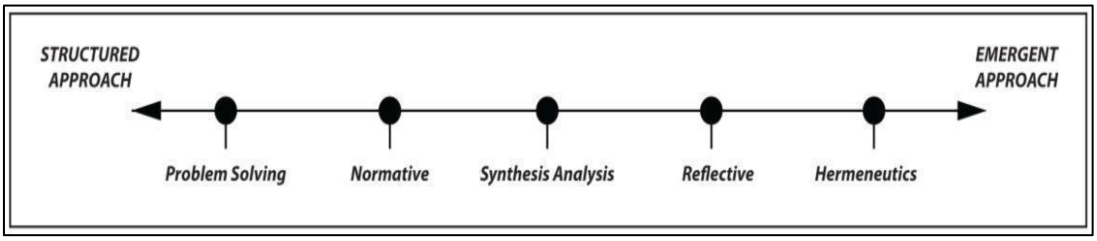

Figure 2.16 The Structured and Unstructured approach in Design Thinking Process, adapted from Abidin (2020)

Structured thinking refers to the systematic execution of all design activities, from the initial generation of ideas to the final development stage, conducted in an emphasized and carefully planned manner. In contrast, unstructured thinking encompasses design activities that are flexible and adaptable to overlapping situations and processes, drawing extensively on the designer’s experience, intuition, and creativity. Within this framework, design thinking is emphasized into five distinct approaches: problem solving, normative, synthesis–analysis, reflective, and hermeneutic, as detailed below.

1. Problem-solving: Product design relies on problem-solving (Newell and Simon, 1961). This formal and practical strategy uses innovative and focused thinking, defined goals, and logical reasoning to solve present and future design problems (Abidin, 2020). Based on mechanical engineering principles, this method systematically breaks down the primary problem into smaller, manageable components that are handled through subprocesses to obtain a durable solution. Design problem-solving is complicated, dynamic, opaque, and multidimensional. To solve such problems accurately and effectively, designers must identify and address their key qualities. Figure 2.17 shows how problem-solving may lead to product design for functional and meaningful results.

Figure 2.17 Sample of product using Problem-Solving approaches by RCA Design Products: “A seating system integrated with an intuitive playground is designed to stimulate intergenerational…”

2. **Normative**: Normative thinking involves following conventions and standards based on actual responsibilities and functions (Abidin, 2020). The logical design problem-solving method involves informed action, beliefs, attitudes, morals, and aesthetics (Rowe, 1987). Normative design requires precise methods and working specifics for certain tasks. It’s the generation of concepts that follow criteria to satisfy key needs. Philosophy-based design adheres to the concepts of multiple design disciplines while being acceptable across them. Common standards underpin normative thinking. Okwenclosures products (Figure 2.18) were created around human experience and interaction.

Figure 2.18 Sample of product using Normative approaches: A uniquely modern range of tuning knobs with stylish and colourful clip-in marking elements (product by Okwenclosures)

3. Synthesis-analysis: Synthesis and analytic design include problem searching, investigation, discovery, composition, integration, and fictional problem solving (Sim and Duffy, 2003). Tim Brown (2019) says design thinking analyses and emphasized. According to Nigel Cross in Lawson's 1980 research, scientists address issues analytically, whereas designers use synthesis. Analysis breaks down difficult issues into smaller sub-problems, whereas synthesis combines key aspects into a cohesive whole. Every analysis involves synthesis, and every synthesis is guided by past analysis. Scientific, methodical, and procedural analysis includes critical assessment (Abidin, 2020). In contrast, the synthesis technique lets designers modify implementation to the selected model. For instance, the Labu Sayong water pitcher (see Figure 2.19), developed through rigorous research and development.

Figure 2.19 Sample of product using Synthesis-Analysis approaches: Labu Sayong Water Pitcher, adapted from Hassan & Yasin (2021)

4. Reflective: Reflection highlights the design process and past problem review. Reflective thinking helps designers rethink concepts and find better solutions for future projects. This method evaluates if decisions are acceptable for solving design challenges. Schon and Wiggins (1992) argued that reflective thinking and communication have a conversational pattern of seeing-moving-seeing. Schon called reflective problem-solving logical and action theory-aligned (Schon, 1992; 1995). Reflective thinking lets designers use their experiences to solve problems and generate new ideas. Through analytical thought and practical experience, designers may plan more effectively and improve their abilities. As a result, the reflective approach not only addresses immediate design needs but also contributes to the long-term development of professional expertise (see Figure 2.20).

Figure 2.20 Sample of product using Reflective approaches by Nordic Ceramic Bathroom Sink Balcony Wash Basin Pool Black Edge

5. Hermeneutics: Hermeneutic thinking in design involves understanding and following intuition based on design knowledge, experience, assumptions, and designer-object interaction (Darke, 1979). This methodology helps designers clarify and narrow ideas by understanding objectives, procedures, and problem-solving methodologies. Hermeneutics involves evaluating a portion to determine its significance in the entire and then viewing the whole to see how each part fits. Hermeneutically, designers use intuition to pursue a purpose, see potential, and alter knowledge as ideas become design forms. Hermeneutics is used in law, history, religion, architecture, environmental studies, archaeology, and sociology. This viewpoint deepens design solutions and promotes cultural and contextual significance. Figure 2.21 shows a hermeneutic clay vase with contemporary shape and artistic interpretation. These methods emphasize design thinking, which adapts to the designer’s goals, environment, and experience.

Figure 2.21: Sample of product using Hermeneutic approaches: Open hand ceramic vase, adapted from Nordic Inc (2023)

Mosely, Natalie Wright, Cara Wrigley, 2018 proposed design thinking approaches according to design expertise. Table 2.5 lists a comparison of the design thinking approaches according to design expertise based on research by Mosely et al., (2018).

Table 2.5
Design Thinking and Design Expertise Comparison, adapted from Mosely et al., 2018 (synthesised from Dreyfus, 2004; Lawson & Dorst, 2009; Dorst 2006)

Design Thinking Types	Description	Design Expertise Levels	Description
Result-Focused	Following 'the rules of the game', concentration on design conventions; customs and habits; the set ways of working	Naïve	Choosing from a set of prescribed solutions and rules driven
Convention-Based	Following 'the rules of the game', concentration on design conventions; customs and habits; the set ways of working	Junior	Understands that design problems are individual and situated and reacts to them. Possess design language acquisition
Situation-Based	Understanding the design situation or context and creating a response specific for that particular setting. E.g. Identifying the 'core problem' of the problem situation	Advanced Beginner	Able to steer the development of the design problem. Sees the bigger picture
Strategy-Based	Understanding the design situation or context and creating a response specific for that particular setting. E.g. Identifying the 'core problem' of the problem situation	Competent	Can tolerate ambiguity and can actively steer the development of the design problem
Experience-Based	Understanding the design situation or context and creating a response specific for that particular setting. E.g. Identifying the 'core problem' of the problem situation	Expert	Has an implicit recognition of situations and a fluent, intuitive response
Developing New Schema	Designing the process itself and creating a design situation for themselves. A developed way of working that is imposed upon the problem. E.g. Reframing the design problem to develop something new	Master	Practice is at a level of innovation and pushes the boundaries of the field.
Redefining the Field	Designing the process itself and creating a design situation for themselves. A developed way of working that is imposed upon the problem. E.g. Reframing the design problem to develop something new	Visionary	Work is explicitly aimed at redefining the design field.

2.3.5 The Nature of Design Expertise

In the process of understanding the design thinking practices of designers, several aspects need to be identified to see the patterns of their respective practices. This is because each designer thinks according to their level of knowledge and expertise through different methods. Lawson and Dorst (2009) suggest that design practice should be understood in a layered and diverse way, based on differences in the types of design activities, levels of expertise, and layers in design practice. This understanding creates a conceptual framework that allows for the assessment of the design thinking approaches used, which show differences in various contexts and fields of design. To begin with, the level of experience and knowledge of designers can be classified into 8 levels, as proposed by Lawson and Dorst (2009).

1. Naïve: Dorst (2011) asserts that the state of design, which is primarily exhibited by many design students, is suitable for use daily in conventional circumstances. According to Dorst, beginner design students struggle to express what they know or want because they lack a design language and have a moderately shallow set of design principles.
2. Junior: In accordance with Dorst (2011), the exploration of what design is, how the "game" of design can be understood, and what the right methods in design were determined at the state of Junior (undergraduate design student). In educational settings, the Junior state entails searching for the underlying principles of "good design," which aim to replace the singular instances of the designer.
3. Advanced Beginner: The recognition of a design problem is found to be highly individualised and situated for an advanced beginner, according to Dorst (2011). This level of design problems is found to be less amenable to the use of standard solutions than the Junior state.
4. Competent: Dorst (2011) asserts that skilled designers can control and comprehend all typical situations that occur within the design domain. In this situation, the designer has complete control over the project due to their ability to direct how the design problem develops.
5. Expert: According to Dorst (2011), "expert" refers to "better" rather than "specialised" in the context of the study. A skilled designer, in Dorst's opinion, is recognised for a particular methodology or set of characteristics that are conveyed in his or her design output. An expert is often described at this stage as having an automatic ability to recognise situations, quick, intuitive thinking, and strong responses.
6. Master: In accordance with Dorst (2011), the method of working with master designers has advanced to a point of innovation that may have called into question the conventional method of expert working. However, master design work is viewed as representing fresh information in the field and is disseminated in various ways.
7. Visionary: A visionary designer, according to Dorst (2011), explicitly defines or even redefines the design field they are working in. The situation may not even result in completed designs; instead, it will be expressed through publications, exhibitions, and design ideas.

Dorst (2011) posits that the seven tiers of design proficiency align with seven professionalised design thinking methodologies: choice-based, convention-based, situation-based, strategy-based, experience-based, the creation of new schemata, and the redefinition of the field. These methodologies, assets, and competencies vary. Lawson and Dorst (2009) assert that layers of design practice elucidate the application of design thinking. Design reasoning is essential for comprehending project, methodology, and practice. Design thinking is most evident at the project level, as designers concentrate on specific design initiatives. Certain projects are vital to the design process, but others provide revenue for design firms. Design thinking is seen in the distinctive and systematic project support strategies of companies. In practice, design is regarded as an intellectual and significant endeavour that shapes professional identity and maintains the discipline's impact.

Roozenburg and Eekels (1995) argue that working with abductive reasoning, which represents the central challenge in design, requires designers to develop and professionalise specific methodologies. These methods help define the scope of design thinking and practice. Similarly, Lawson and Dorst (2009) contend that the repertoire of design thinking can be described by distinguishing between types of design activities, levels of expertise, and layers of practice, which they identify as key carriers of design thinking. Based on this view, the range of design thinking and practice can be categorised beginning with the types of design activities as follows:

1. Formulating: Blizzard et al. (2015) and Dorst (2011) argue that formative design processes detect and define important concerns in a unique way. Schön (1983) describes "framing" as taking a significant approach to an issue. Dorst describes "framing" as a complicated series of statements that describe an issue and implicitly adopt certain ideas. Designers must frame and reframe to grasp Abduction-2's design. Design challenges with inherent inconsistencies, instability, and ambiguity need framing. Always interpretable. Framing permits interpretation and reinterpretation to create design-thinking. Determine the problem's cause to support the solution's practicality. Designers also frame and reframe equation issues by identifying the erroneous, misread, or updated ingredient.
2. Representing: Kleinsmann et al. (2017) and Dorst (2011) suggests using various platforms, such as words, sketches, or advanced visualisation tools, to represent challenges and solutions in design activities. Sketching ideas, critically examining

them, making modifications, and then taking another step back helps designers develop them (Schön, 1983). Designers can employ numerous representations simultaneously. Because each representation may highlight different key parts of the growing solution, the dilemma arose.

3. Moving: Morgan (1997) and Dorst (2011) defined "moving" as problem representation and resolution in design utilising words, sketches, and advanced visualisation techniques. They may be new or improved versions of "moves" the designer already knows.
4. Evaluating: Kleinsmann et al. (2017) and Dorst (2011) emphasises the importance of continual evaluation in guiding design projects. In the early stages, when problems and solutions remain unclear, evaluations are best approached through subjective appraisal. Once the project direction becomes more defined, assessments should shift toward a more formal and objective basis. Nonetheless, designers are often encouraged to suspend judgment and explore riskier possibilities. Premature evaluation of emerging ideas can stifle their development, hindering further exploration and project progress.
5. Management: Chen and Venkatesh (2013), Kleinsmann et al. (2017) and Dorst (2011) argues that managing tasks such as conceptualising, representing, moving, and assessing within the design process requires a refined skill. Valkenburg and Dorst (1998) further observed that design projects combine a linear problem-solving approach with an iterative learning process shaped by reflection-in-action and reflection-on-action. Consequently, design projects are inherently difficult to plan and manage.

The comprehensive approach to design practice, encompassing project, process, and practice, demonstrates its variety and iterative characteristics. Formulating, portraying, manoeuvring, evaluating, and administering illustrate how designers delineate difficulties, cultivate concepts, and refine solutions in dynamic contexts. These findings are essential to my thesis on popular product design as they elucidate how designers integrate creativity with practical constraints to address complex issues. This framework offers a robust conceptual basis for comprehending how product designers employ knowledge and reasoning to develop innovative but feasible solutions through the integration of expertise, activities, and levels of practice.

2.3.6 The Core Skills of Design

According to Moggridge (2007), the five key design skills include synthesising solutions by considering all relevant constraints, framing or reframing challenges, envisioning alternatives, choosing the best choice, and visualising or prototyping potential outputs. These abilities may seem sequential, but Moggridge stresses that design is iterative and flexible. Design is complex, and procedures often involve cycles of inquiry and refinement. Moggridge claims that design thinking uses both explicit and implicit information from a designer's experience. Designers make decisions using subconscious intuitions after learning by doing. They can manage complicated issues while developing, analysing, and improving forms. Drawing on gestalt psychology, Warell (2001) shows how designers use similarity, closeness, symmetry, and continuity to organise and simplify complicated shapes and differentiate goods. By making gestalt perception an active design tool, designers develop clear and unique product style. Munhall (2008) believes perception impacts how objects are viewed and interpreted.

Problem-solving has traditionally dominated design research. Motte, Andersson, and Bjarnemo (2004) suggest that design is an activity that tackles open-ended issues, not only problem-solving. Their two main paradigms are sequential problem-solving and descriptive model for design activity. This concept defines a problem as the evolving gap between an observed condition and a desired state, which has no preset solution. Design involves building and implementing solutions to this imbalance. This follows Dewey's (1933) five-step approach, which begins with detecting a problem, then locating and characterising it, offering remedies, reasoning through implications, and testing ideas via observation and experimentation. Structured procedures can increase success, however Lipshitz and Bar-Ilan (1996) warn that Dewey's paradigm lacks empirical confirmation.

Lawson (2006) compares scientists and designers to understand problem-solving styles. Scientists study issues systematically, looking for underlying norms to solve them. In contrast, designers generate and test several solutions until they find one that works. Scientists utilise problem-focused tactics, whereas designers use solution-focused strategies (Cross, 2000). This implies that design requires flexibility since solutions disclose issue features. Cross (2000) notes that designers often frame their issue understanding with conjectures or guesses about possible solutions. These conjectures reduce the search space and provide early design suggestions. Proposing preliminary solutions helps refine problem descriptions since problems and solutions are interrelated. Sketches help externalise ideas, stimulate introspection, and permit iterative investigation. Schön (1983) called this a reflective discussion with the situation, when designers interpret, test, and modify their ideas to new discoveries.

Thus, design practice thrives on uncertainty, iteration, and reflection, rather than prescriptive approaches or rigid models. Tacit knowledge and intuition are crucial to synthesis, framing, and visualization. Problem-solving in design demands disciplined thinking coupled with creative exploration beyond logical analysis. Designers employ a unique form of inquiry that blends reason with creativity, explicit processes with tacit knowledge, and problem-focused with solution-focused strategies. This synthesis highlights design thinking's cognitive and practical aspects. Designers leverage rigorous reasoning and experimental methods to manage complexity, intuition, and coherence in open-ended tasks. The ability of design to balance various methods underscores its ongoing importance as a discipline that transforms uncertainty into creativity.

2.3.7 Reflective Practice

Design decisions are based on the designer's expertise and ability to reflect in actions and thoughts throughout the process. The reflective practice approach provides a critical thinking process where designers reflect on their activities during or after an activity to improve comprehension, performance, and design outputs. Schön (1983) pioneered reflective practice in professional contexts, notably in ambiguous and complicated design issue circumstances. Schön, a philosopher and urban planning professor, disputed technical logic after watching professional practice. He claimed that standard design approach encouraged design process generalisations, which limited designers. Schön said this traditional method often caused designers to ignore task structure and key process-task relationships in certain design contexts. Professional designers learn by action and reflection in unpredictable environments, incorporating experience into design decisions. Schön argued that reflection-in-activity, a sort of knowledge integrated in intelligent action, accounts for the distinctive nature of design problems. Developing knowing-in-action habits via purposeful and directed contemplation is reflection-in-action. Schön’s theory combines constructionist knowledge of human vision and cognition with design, engineering, and psychoanalytic insights. According to Valkenburg and Dorst (1998), Schön’s reflective approach requires designers to subjectively perceive the design challenge and its surroundings. The paradigm of reflective practice relies on designers' capacity to combine activity with critical judgement to choose the best design approach.

Wakkary (2005) states that Schön’s reflective practitioner prioritises problem-setting to overcome conventional problem-solving’s constraints. Schön calls drawing scenarios frame experiments to uncover difficulties and develop solutions. Designers interactively frame the problem and determine the elements they focus on, leading to a solution and reflections. Designers analyse essential characteristics of a problem, frame the difficulty, take steps towards a solution, then reflect on those efforts. Move-testing experiments that combine action and contemplation help designers build a worldview from their experiences. Valkenburg and Dorst (1998) say Schön’s technique was often tacit and unable to articulate within technical reasoning. By creating the four design tasks and how they interact, Valkenburg and Dorst develop the reflective practise mechanism, as illustrate in Figure 2.22.

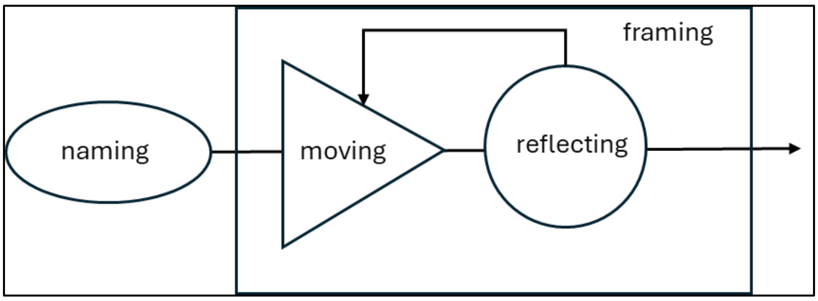

Figure 2.22 The Mechanism of Reflective Practice, adapted from Valkenburg and Dorst (1998)

According to Figure 2.22, the mechanism aims to simplify Schön’s theory and integrate it into protocol data to provide a clearer description of designers’ activities and their reflective practice. This mechanism enables the systematic recognition and coding of distinct activities involved in reflective practice. Valkenburg and Dorst (1998) propose that the mechanism can be applied to code protocols as follows:

1. Naming: occurs when the designer identifies specific components of the design task as crucial, searching for relevant objects, and is represented graphically as

an oval.

2. Framing: refers to justifying a (sub)problem or (partial)solution to explore further, creating a context to focus on, and is depicted as a box.
3. Moving: involves experimental actions such as generating ideas, sketching, sorting information, or comparing concepts while assessing the frame and solving design issues, represented as a triangle.
4. Reflecting: occurs when the designer consciously engages in reflection on prior experiences or activities, depicted as a sphere.

To describe the nature of team designing, Valkenburg and Dorst (1998) developed new descriptive methods based on these mechanisms. These methods were applied to analyse the activities of two product design teams. The findings revealed that the descriptive approach enables a concise explanation of design tasks while retaining essential elements necessary to understand design progress. Furthermore, the method highlights various patterns of team behaviour, generating interest in a more comprehensive investigation of collaborative design practices and the dynamics underlying team interactions during the design process.

In summary, Schön's (1983) theoretical framework for reflective practice has been instrumental in establishing design as a coherent field of study. According to Cross (2007), examining design as a discipline requires engagement within its cultural context and through the reflective practice of designing. Schön aimed to develop an epistemology of practice that captures the implicit, creative, and intuitive processes practitioners employ in situations characterised by uncertainty, instability, uniqueness, and value conflicts. He argued that design possesses its own knowledge and ways of knowing (Cross, 2007). Schön's theory can be operationalised to study designers' activities through the reflective practice mechanism proposed by Valkenburg and Dorst (1998), which provides a systematic means to identify and code the distinct activities inherent in designers' reflective practice.

2.3.8 Visual-Based Research: Mediators Stimuli in Design Research

Visual-based research is becoming increasingly important in the social sciences and is beginning to emerge as a significant approach or tool in design research. In the context of design research, this approach is used as a visual documentation tool, which contributes to a deeper understanding of user behaviour, product form interpretation, and the reflective design process. Historically, the use of photos in research began in the fields of visual anthropology and sociology. Since the 20^{th} century, researchers have used photographs as a tool to document culture, environment, and social interaction. According to Harper (2002), the visual approach provides researchers with the opportunity to "re-look" at phenomena and build understanding from a more contextual and narrative perspective. In design research, this approach is then adapted to understand the relationship between humans and the objects they use in their daily lives. Visuals serve as material evidence that shows human interaction, use, and behaviour towards products.

In recent years, there has been a growing recognition within the field of general social science study that image-based research holds significant importance as a kind of the "social". Gillian Rose, in her book "Visual Methodologies: An Introduction to Researching with Visual Materials," stresses that images are not just descriptive tools but are embedded with social, cultural, and technological meanings that require deep analytical engagement (Rose, 2012). Rose encourages researchers to investigate "the agency of the image" and its socio-cultural context that highlighting the interplay of power relations and visual representation. In addition, visual and sensory materials can be used to understand participants lived experiences, integrating visual research with broader ethnographic methods (Pink, 2015). As a result, this methodology enables the development of a critical analysis that pertains to visual representation and the broader context of visual culture. In design research, visual approaches help researchers identify important elements in the study by:

1. Documenting user behaviour: As introduced by Suri (2005) through Thoughtless Acts, images are used to identify informal or intuitive actions by users towards products and their environments.
2. Capturing interpretations of form and function: Images allow for visual analysis of product form, symbolism, and semantic meaning as described by Warell (2001) in the study of product morphology.
3. Design reflection and synthesis: In reflective research, photos and design sketches are often used by designers as assessment and documentation tools in design thinking activities (Schön, 1983; Valkenburg & Dorst, 1998).

In qualitative research, methods such as photo elicitation, auto-photography, and visual ethnography serve to stimulate reflection and narrative from participants (Pink, 2013). Meanwhile, for contemporary research, visuals are used as primary data and interpretive tools that can create individual interpretation processes through interview activities or survey studies. Pauwels (2010) emphasises the need for a systematic approach in visual research by examining the context of image production, content, and reception by users or participants. In this context, visuals may record unintended behaviours that users may not verbalise. In the context of this research that focuses on the study of unintentional behaviours among users, the visual approach can function as an empirical tool to record evidence of alternative uses of mainstream products. Through visual analysis supported by theories such as affordance (Norman, 1988) and thoughtless acts (Suri, 2005), designers can identify important elements based on unintentional interactions for the creation of new ideas.

Based on the perspectives, a more holistic analysis that composed of text and visuals is very helpful for researchers in collecting comprehensive research information. Therefore, using visual stimuli or photos in research investigating human behaviour is important and relevant to obtain data in a holistic, reliable and efficient manner.

2.3.9 Verbal Protocol Approach

Dorst and Dijkhuis (1995) and Cross (2006) popularised verbal protocol analysis (VPA) for designer cognition research. Rationally, Google Scholar shows over 500 design research citations for these methods. Ericsson and Simon's seminal work on VPA for cognitive process research (Ericsson & Simon, 1993). Dorst and Dijkhuis (1995) used VPA to compare design paradigms and understand designers' cognitive processes. Later, design research pioneer Cross (2006) called for VPA to study designerly methods of knowing. Abidin (2012) emphasises VPA's significance in developing design cognition and practice. VPA provides comprehensive data on cognitive processes, revealing cognitive activity underpinning design problems that observation alone cannot (Ericsson & Simon, 1993). Researchers can observe cognitive strategies and decision-making in real time using concurrent verbal protocols. VPA provides a complete view of the design process by revealing how designers address problems (Cross, 2006), adaptable to multiple design goals and situations, and making it a versatile design research tool (Dorst & Dijkhuis, 1995). VPA reveals how designers think, problem-solve, and choose (Cross, 2006; Cross, Christiaans, and Dorst (1996); Abidin, Christoforidou, and Liem (2009). Chi (1997) defines VPA as quantifying subjective or qualitative coding of verbal utterances. Ericsson and Simon (1993) state that most design literature recognises VPA as essential to modern research methodologies, especially in applied situations. VPA strongly influences survey and interview designs. That's suggested.

"A single verbal protocol is not an island to itself, but a link in a whole chain of evidence, stretching far into the past and the future, that gradually develops, molds, and modifies are scientific theories. It needs to be processed with full attention to these linkages" (Ericsson & Simon, 1993, p. 280).

The development of the VPA involved the merging of verbalization, sketching, and video-audio recording using a camera (Akin & Lin, 1995). In contemporary cognitive studies of designers, protocol analysis has emerged as a prominent approach and is often employed as a study tool in this field. According to Kannengiesser, Gero, Wells, and Lammi (2015), The VPA method deviates from conventional interview practices by employing a distinct approach that does not prompt respondents to engage in introspection over their actions but rather encourages them to simply articulate their actions. The coder will do an analysis of the protocol in order to identify the cognitive process, based on the acts. Oral reports are formulated using specific guidelines to encourage participants to engage in verbal expression and articulate their thoughts when prompted with minimal intervention from the researcher. In the study conducted by Abidin, Christoforidou, and Liem (2009), it was found that the technique under consideration necessitates the provision of training to participants in order to familiarize them with the practice of articulating their internal thoughts, which is typically an internalized process. Additionally, it constructs a visual representation of users' conceptualization of their interactions with various things. Both verbal and nonverbal communication are inherently connected to language and cannot be dissociated from the utilization of linguistic elements in individuals' interactions with others. According to Ericsson and Simon (1993), protocol analysis uses vast and consistent verbal data, which inspired the VPA approach. Chi (1997) argues that protocol analysis and verbal analysis differs despite their similarities. There are several sorts of variants in "Chi's":

1. Teaching and Data Collection: Data gathering differs between think-aloud and describe approaches first in how participants are instructed. Ericsson and Simon (1993) explain that think-aloud protocols require participants to verbalise their thoughts, disclosing attentive information like actions. Chi (1997) says instruction or eye-tracking can demonstrate focus. Verbal explanations show logic, but straight replies increase performance. The verbalisation instruction does not affect task execution but helps researchers record participants' thoughts.

2. Study Focus and Goals: The second distinction is the study's objective. Protocol analysis maps participant solution paths to predicted problem states to track problem initiation and resolution. This method compares problem-solving processes to theoretical state sequences. Verbal analysis, on the other hand, seeks to understand how people think and solve problems rather than confirming solution sequences.

3. Protocol analysis requires more effort than verbal analysis, which uses similar techniques such segmentation and coding. Protocols entail creating an optimal task template, simulating brain tasks, and coding predetermined elements and operators. Finding instances and references starts verbal analysis, which is less structured. Protocol analysis is template-driven and laborious, while verbal analysis is more flexible and interpretive, according to Chi (1997).

4. Methods of Validation: Methods of validation vary. Protocol analysis verifies cognitive processes by matching verbal stages to the study model's state sequence. Verbal analysis employs quantitative and qualitative coding and statistical tests to support theories. Additionally, qualitative analysis of the structure and its relationships to other metrics confirms validity. Each method confirms findings using its analytical framework.

The outcome differs from verbal analysis because it derives from a structured procedure. Chi (1997) explains that in protocol analysis, researchers aim to determine how individuals approach problem-solving throughout the process. By closely examining the order in which choices are made, researchers can gain insights into the strategies employed by participants, as different aspects of the study model may influence various activities and contexts. Speech sequences are particularly significant at the micro level, revealing details about problem-solving methods. In contrast, verbal analysis focuses on knowledge representation, and the sequence of statements is less critical. Utterances are viewed as reflections of underlying cognitive structures, and sequencing is only relevant when tracking changes in mental representations over time. Overall, verbal analysis captures the expressed knowledge and reasoning of participants rather than the procedural order of problem-solving steps. VPA is well recognized as a prominent observational research approach for the examination of design activity (Cross, Christiaans, and Dorst, 1996). VPA is a technique used to quantify the subjective or qualitative coding of the content of verbal utterances. The approach is employed to elucidate the somewhat enigmatic cognitive capacity possessed by designers (Abidin, Christoforidou, and Liem, 2009) (see Figure 2.23).

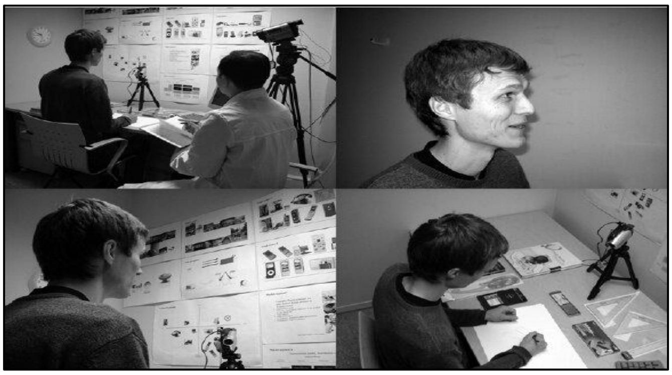

Figure 2.23 Verbal Protocol Analysis Experiment setup on the Lab, adapted by Abidin (2009)

Initial representation	Could you add something so that you couldn't close this thing because there would be something in the way when you try to fold it this way…
Run	But if this thing goes this way, then it is in a position to allow the ear to enter…But then I just don't know how it should be folded… cause if it is folded this way then it will come out here… then it should be folded unevenly somehow… You should fold it oblique.
Changed representation	It wouldn't make any difference one way or the other. It would fold the same way, and come out on this side the same way

Figure 2.24 Example of Mental Simulations, adapted by Hansen and Andreasen, (2002)

A structural approach centred on assessment and decision-making has eliminated infeasible or suboptimal alternatives to centre human design efforts around this study. Abidin, Bjelland, and Oritsland (2008) found that this strategy may reduce design solution-finding. This technique prioritises assessment during design and reflects the common statements in most design models. Figure 2.24 shows how design evaluation activities simplify confusing design problem solutions (Abidin, Christoforidou, and Liem, 2009). Figure 2.25 (see next pages) shows that giving designers a complete assessment of human design activities when looking for design solutions may inspire them to consider many viewpoints when selecting, assessing, and making decisions.

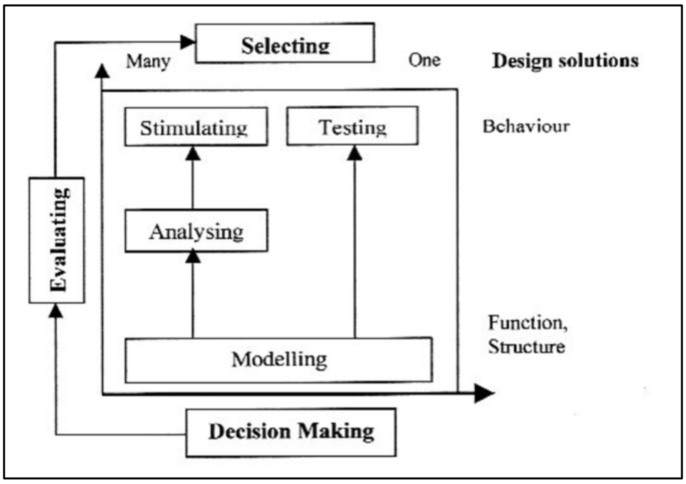

Figure 2.25 Design Activities and their Relationship (Hansen and Andreasen, 2002)

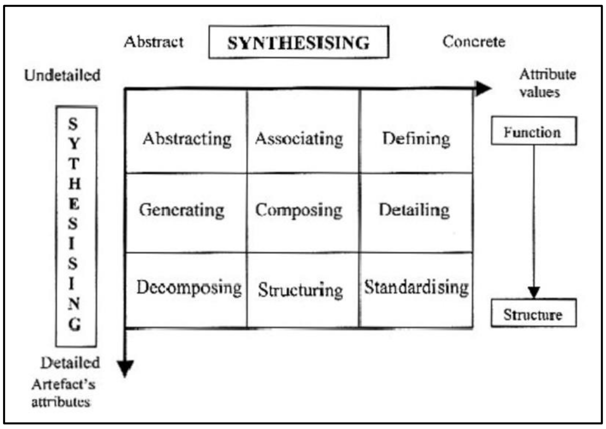

Figure 2.26 Taxonomy of Design Definition Activities (Andreasen, 1991)

Design activity involves some of the highest cognitive capabilities of humans. All typical individuals possess the capacity to utilise such abilities; nonetheless, it is inside design activities that these skills are often tested to their fullest extent, and the most proficient designers evidently demonstrate extraordinary levels of capability. Sim and Duffy (2003) assert that synthesis represents the pinnacle of design activity. Synthesis is regarded as a compound activity, encompassing the search, investigation, and finding of design solutions, as well as their composition and integration. Figure 2.26 illustrates a taxonomy of design definition activities, wherein synthesising results from the abstraction and generation of design concepts, as well as the structuring of these concepts into a cohesive whole. This picture is derived from the graphical model of Andreasen (1991) and Hasen and Andreasen (2002), (see Figure 2.26) featuring two axes labelled abstract/concrete and undetailed/detailed. In a study utilizing VPA, the researcher systematically organizes, analyses, and establishes relationships across many forms of expressions to mitigate the inherent subjectivity associated with qualitative coding. In recent years, Chi has asserted that VPA has been employed for the purpose of elucidating code and facilitating comprehension of the underlying meaning sent by the content, sentence by sentence. The objective is to determine whether the provided explanation constitutes a conclusive statement, a monitoring statement, or a statement of lesser significance. Furthermore, within the realm of VPA, the researcher incorporates subjective experiences inside a disordered setting, subsequently undertaking an analysis of quantitative data derived from this disordered circumstance. The advantages and disadvantages, along with the methodologies for VPA, are extensively elucidated in their scholarly publication.

2.3.10 Co-operative Inquiry

Every collaborative design methodology is influenced by its assumptions on participation and contribution. Participants in human-centered design (HCD) often provide guidance through structured activities but do not directly identify the problem or engage in evaluation and design decisions. Conversely, participatory design (PD) advocates for "authentic involvement" (Robertson & Simonsen, 2012b). This perspective posits that everyone have the potential for creativity and significance (Sanders & Stappers, 2008). Participant interests are significant and essential, with their creative acts and reflective discourse influencing the design process (Robertson & Simonsen, 2012; Sanders & Stappers, 2014). Participatory Design underscores context and practice via its socio-technical methodology. Practice constitutes the everyday activities of individuals (Robertson & Simonsen, 2012b). Previous ethnographic studies demonstrated that experience aids in understanding work environments and recognising design modifications. Contemporary perspectives acknowledge practice as an epistemological foundation of participatory design, since daily acts embody lived experiences and influence design (Robertson and Simonsen, 2012).

Respect and reciprocity enhance the cooperation in professional development. For project success, participants and professional designers must possess complementary yet distinct knowledge (Drain and Sanders, 2019). Professional designers offer technical expertise, facilitation abilities, and the capability to coordinate the collaborative process, whereas participants contribute practical knowledge that shapes design objectives and evolving solutions (Sanders and Stappers, 2008). Consequently, PD prioritises reciprocal learning and creativity above the capture of user data (Smith et al., 2017). PD possesses several disadvantages despite its potential. Wang and Oygur (2010) assert that several professional development objectives lack empirically validated benefits, but Bødker et al. (2022) underscore the importance of recognising both tangible and intangible learning outcomes for participants. Literature emphasises process and collaboration above product development. Drain et al. (2021) investigate methods to enhance collaboration and empowerment, whereas Drain, Shekar, and Grigg (2018) suggest that participants' incapacity to articulate or illustrate concepts may restrict their engagement. Deliberate facilitation of participant interactions is essential, as contextual diversity obfuscates results. Participants assess tangible prototypes with greater specificity than abstract scenarios (Drain, Shekar, & Grigg, 2018). Physical things serve as potent intermediaries that shape design. Product development has seldom advanced past the experimental "fuzzy front end" of design to the final stages of producing actual, usable products (Drain & Sanders, 2019). Assessment frequently takes place in workshops instead of actual environments, constraining its capacity to evaluate designs (Drain & Sanders, 2019). Robertson and Simonsen (2012a) assert that underestimating the integration of prototypes into daily practice overlooks an opportunity for collaborative design.

In response to these challenges, Co-operative Inquiry (CI) provides an alternative framework grounded in participatory action research. Developed by Heron and Reason in the 1970s, CI emphasises research "with" rather than "on" participants, framing all individuals as both researchers and subjects of study. This inclusivity is reinforced by four interrelated forms of knowing identified by Heron and Reason (1995):

1. Propositional Knowing: Theoretical knowledge acquired through formal learning and literature.
2. Practical Knowing: The ability to carry out actions based on propositional knowledge.
3. Experiential Knowing: Understanding gained through direct experience and interaction with the real world.

4. Presentational Knowing: The expression of knowledge through artistic or symbolic mediums, such as drawings, stories, or metaphors.

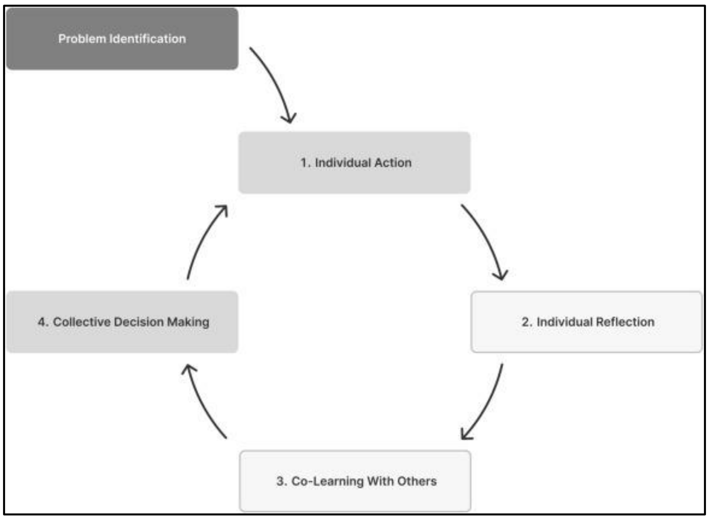

Figure 2.27 The Four Key steps in a Single Cycle of Cooperative Inquiry, adapted from Reason (1994); Reason and Heron (1995)

Figure 2.27 representee four steps in cooperative inquiry approach that compose of: (i) participant takes action individually into specific problem, (ii) reflects on that action, (iii) share experiences, and (iv) learn from other experiences and a collective knowledge begins to develop (Reason, 1994). The iterative movement between action and reflection enables designers and participants to achieve a deeper and more holistic understanding of the problem at hand. Within design research, CI supports collaborative exploration of user experiences and helps uncover latent needs that might not be explicitly articulated. By situating inquiry in real contexts, CI facilitates the identification of subtle interactions between users and artefacts, often leading to unexpected insights and innovation (Reason & Bradbury, 2001). Moreover, emerging perspectives expand CI beyond human actors, recognising the role of non-human entities, such as rivers or ecological systems, as potential co-researchers within a pan-psychic worldview (Reason, 1994). This orientation reflects the growing awareness of interdependencies between human and environmental systems in contemporary design practice. Overall, participatory design and co-operative inquiry both challenge traditional top-down models of design research by elevating the voices and experiences of participants. They illustrate the value of collaborative, reflective, and context-sensitive processes in generating knowledge and shaping outcomes that are not only functional but also socially and environmentally responsive. Figure 2.28 indicates four phases of co-operative inquiry and how it leads to transformational knowledge. In conclusion, CI provide powerful approach to human-centred design research, by actively involves participants in all stages of the research, CI facilitates the creation of deeper, contextual, and relevant knowledge about user experiences and product design. Its approach is useful in exploring user experiences, understanding unintended uses, and driving innovation in product design.

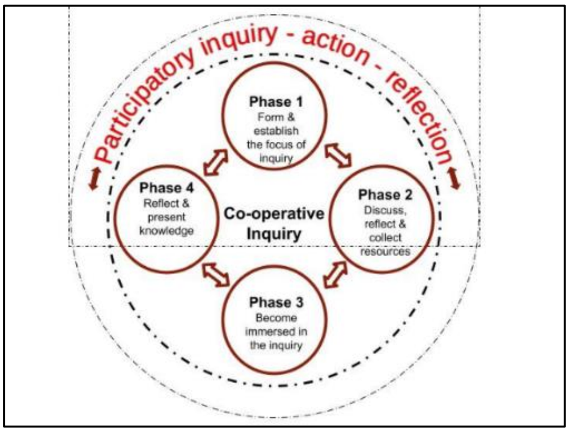

Figure 2.28 Graphic Representation of the Four Phases of Co-Operative Inquiry and how it leads to Transformational Knowledge (Reason, 1994; Reason & Heron, 1995; Short & Healy, 2017)

2.3.11 Summary of Section II

In summary for Section II, the exploration of design thinking demonstrates that it is not a singular or rigid construct, but rather a multifaceted and evolving paradigm that informs both theory and practice. As core, design thinking represents a human-centered and problem-oriented methodology, where creative reasoning and structured exploration converge to address uncertainty and complexity in design projects. This foundation is enriched by recognizing design dialogue from multiple perspectives, where interpretations drawn from psychology, education, engineering, and management reveal the broader adaptability of design thinking across disciplinary boundaries. The intellectual strength of design thinking lies in its reasoning processes. Deductive and inductive reasoning form part of the designer’s logical toolkit, yet abductive reasoning emerges as the most distinctive and powerful, enabling designers to propose innovative solutions by reframing problems and imagining possibilities not directly evident in existing knowledge. Such reasoning is reflected in the structured and unstructured approaches that designers employ. While structured approaches emphasize order, method, and formal evaluation, unstructured approaches encourage openness, iteration, and the suspension of judgment, both of which are necessary to nurture creative breakthroughs without stifling emerging ideas.

Equally central to this discourse is the nature of design expertise. As argued by Dorst (2011), the progression from Junior to expert demonstrates seven levels of design thinking, each shaped by its own approaches, tools, and skill sets. These levels indicate that design expertise is not merely a matter of accumulated knowledge, but a shift in orientation from problem-focused to solution-focused practice. This progression is accompanied by the cultivation of core design skills, including formulating, representing, moving, evaluating, and managing, which together form the backbone of design activities. These skills are inherently difficult to plan and manage, yet they illustrate the balance between creativity and structure that lies at the heart of design work. The reflective dimension further strengthens this understanding. Through reflective practice, designers learn by engaging in cycles of reflection-in-action and reflection-on-action, developing awareness of their own thinking and refining their processes over time. Methodological approaches also deepen the study of design thinking. Visual-based research, particularly using mediators as stimuli offers insight into how ideas are externalized and communicated. The popularity of the verbal protocol approach in providing access to real-time cognitive processes by capturing how designers articulate their reasoning while designing is very significant in design thinking research. Besides that, co-operative inquiry situates design thinking within a participatory context, emphasizing its collaborative and socially embedded nature will help unravel the problems being studied, especially research based on human behaviour. The view of these methodological perspectives provides researchers ‘weapons’ to reveal the subtleties of design thinking as both an individual and collective phenomenon.

Overall, the theoretical and methodological perspectives presented here position design thinking as a deliberate, professionalised, and reflective mode of reasoning, deeply embedded in practice and adaptable across domains. Its strength lies in its ability to integrate structured reasoning with creative openness, individual expertise with collaborative inquiry, and theoretical grounding with methodological application. As such, design thinking should not be reduced to a loose collection of tools or popularized exercises but recognized as a coherent intellectual tradition with profound implications for innovation, education, and cross-disciplinary problem solving. Within this study, the synthesis of these perspectives provides the necessary foundation for interpreting design thinking not only as a conceptual framework, but also as a transformative practice capable of shaping both disciplinary knowledge and real-world applications.

2.4 Section iii: Behavioural Science Study: The Phenomenon of Unintended Use of Product

The study of human behaviour towards products is considered an important topic in the fields of product design and interaction design today. In this research, the phenomenon of unintended use refers to the way users interact with a product beyond or different from the original designed function. This phenomenon has created a challenge for designers to understand why it is done, and how alternative uses may have implications (in positive or negative ways) for safety, product functionality, and user experience (Wakkary et al., 2015; Hassenzahl, 2010). Research on unintended use has opened for a deeper understanding of user behaviour and expanded the boundaries of conventional design to a wider level. The phenomenon of UHBE reflects the dynamic and creative nature of humans in using objects around them. Globally, users often adapt, modify, and customize products according to different personal needs and contexts, referring to a process called appropriation (Dix, 2007). An understanding of the patterns and factors that drive this phenomenon is believed to be able to help designers in producing conceptual product designs that are responsive, multiuse, and innovative. It may at the same time reduce the risk of functional failure or misuse of the product among users. In this section, several sub-sections will be presented and discussed for a more holistic understanding and develop a research framework that will support the three main components of the literature, answer research questions, and fill gaps in this research. The sub-sections included in this section are; (1) human interaction & behavioural design research, (2) user experience research & evolution, (3) everyday designing, (4) the phenomenon of unintended use of product, (5) the framework of everyday designing, (6) motivation towards unintended behaviour, (7) the attributes of unintended behaviour, (8) interpreted human behaviour & experience through a hermeneutic approach, and (9) Implicit needs of Users.

2.4.1 Human Interaction & Behaviour in Design Research

The concept of interaction design initially emerged from user interface and software integration studies in the early 1980s. However, recent research argues that limiting interaction design to software is a misinterpretation. Löwgren & Stolterman (2004) described interaction design as a form of "creative design" to differentiate it from an engineering-driven approach. In practice, interaction occurs in everyday routines, motivating people to adapt to and internalise their environment. The central aim of interaction design is to anticipate how individuals use products, how their experiences evolve, and how they engage in self-designing through these interactions (Figure 2.29). Figure 2.30 (refer next pages) show discipline surrounding interaction design. The concept of interaction design initially emerged from user interface and software integration studies in the early 1980s. However, recent research argues that limiting interaction design to software is a misinterpretation. Löwgren & Stolterman (2004) described interaction design as a form of "creative design" to differentiate it from an engineering-driven approach. In practice, interaction occurs in everyday routines, motivating people to adapt to and internalise their environment. The central aim of interaction design is to anticipate how individuals use products, how their experiences evolve, and how they engage in self-designing through these interactions (see figure 2.29).

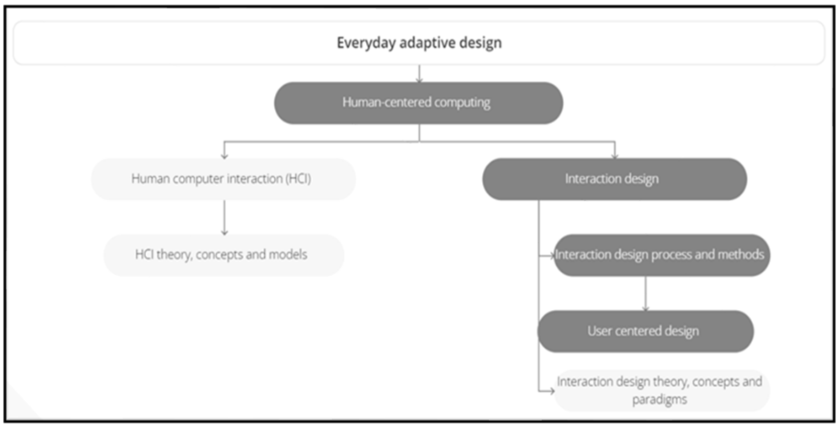

Figure 2.29 Interaction Design as a Form of "Creative Design"

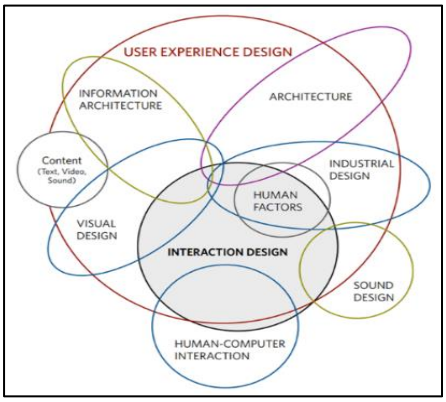

Figure 2.30 The Disciplines surrounding Interaction Design (Saffer, 2010)

The study of human interaction in mainstream products has become a major focus of user-centred design, which prioritises human factors or ergonomic aspects to meet the cognitive and physical needs of users (Norman, 1998; Stanton et al., 2005). This study focuses on how humans interact with objects around them intuitively and unconsciously, which shapes the evolution of design (Cross, 2006). In human-object interaction research, affordance theory is often referred to as a research framework according to the scope of the field, respectively. From an engineering perspective, Norman (1980) classified interaction into cybernetics and behavioural interaction. Cybernetics relates to servomechanisms, which are systems of motor control or homeostatic body functions. According to Norman, cybernetics involves feedback systems that depend on continuous interaction with the environment. Human beings constantly respond to their surroundings, whether people, objects, or environmental cues, through information processing that leads to behavioural responses. Yet, Norman highlighted the limitations of cognitive studies that neglect output and performance. Without output, there is no feedback, and without a holistic understanding of function, feedback cannot be fully explained.

More complex aspects of human interaction with objects and the environment are often overlooked, despite their importance for design practice. Building on this foundation, Norman (2002) introduced three levels of human interactivity: visceral, behavioural, and reflective (see Figure 2.31 on the next pages).

1. The visceral level relates to immediate emotional responses and protective mechanisms of the affective system, producing judgments of safety and value. In product design, it refers to initial impressions shaped by appearance and emotional.
2. The behavioural level concerns the control of human actions that are often

subconscious. For example, a person may unintentionally drive to a familiar destination due to ingrained motor responses. This level emphasises usability, effectiveness, and performance.

3. The reflective level represents the highest stage, where individuals rationally analyse meaning and value, influencing subsequent behaviour. Together, these three levels create a comprehensive product experience (Norman, 2004).

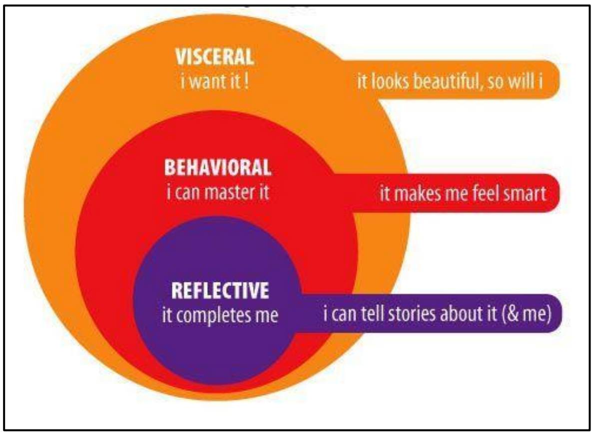

Figure 2.31 Norman’s Three Levels of Design

In product design, the visceral level reflects users’ initial impressions shaped by visual perception and emotional responses, while the behavioural level concerns subconscious skills and experiences during product use, and the reflective level involves rational evaluation before, during, and after interaction. Together, these levels form a holistic product experience. This study focuses on the behavioural level, where most interactions occur unconsciously and often result in unintended actions. Such behaviours highlight usability, effectiveness, and adaptability but also reveal challenges for designers in predicting functions. Unintended interactions expand knowledge of creative reuse, offering significant implications for future design practices.

Behavioural design focuses on understanding how people think and how these processes influence decision-making. It examines how habits are formed, spread from individuals to groups, and eventually shape broader social behaviours. Central to this concept is the “intention-action gap”, which occurs when people’s values or intentions do not align with their actual actions due to cognitive biases, limited attention, or environmental influence. This gap often results in unintended behaviours. Behavioural design therefore emphasises the need for designers to understand users’ cognitive processes and the impact of environmental factors. Since design is never neutral, products and contexts must be carefully crafted to guide decisions and behaviours in ways that are intentional, sustainable, and beneficial.

Affordance theory provides a framework for understanding human-object interaction (see Figure 2.32). Gibson (1977) defined affordances as action possibilities embedded in the environment, while Norman (1998) expanded the idea to perceived affordances, which are object characteristics that suggest appropriate actions. Building from Gibson, Gaver (1991) propose that "affordance, then, are properties of the world defined with respect to people's interaction with it". Affordances thus reduce confusion and error in product use. In line with this, Saffer (2010) categorised interaction design into three perspectives: (i) technology-centred, (ii) behaviourist, and (iii) social interaction design. The behaviourist perspective is most relevant to product design, focusing on how artefacts and environments communicate behaviour through functionality and feedback.

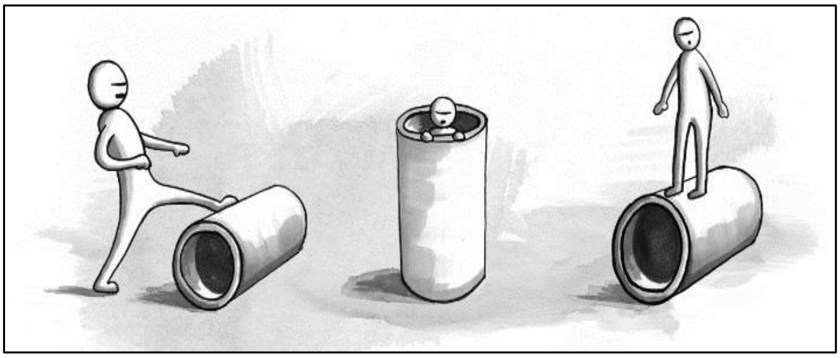

Figure 2.32 The Concept of Affordance

Classical design studies emphasised the significance of user interaction. Dreyfuss (1967) proposed five design principles: (i) utility and safety, (ii) appearance, (iii) ease of maintenance, (iv) low costs, and (v) communication, stressing the need for products that are safe, intuitive, and communicative through their form. Later, research introduced emotional dimensions in design, recognising how products shape feelings, motivations, and behaviours (Desmet & Hekkert, 2007). Suri (2005) further illustrated "thoughtless acts," or unintended behaviours, which influence interaction with products. Behavioural design highlights how people think, make decisions, and form habits, particularly the intention-action gap when intentions diverge from actual behaviours due to cognitive biases or environmental influence. Meanwhile, unintended interactions, such as reusing bottles or chairs for new purposes, exemplify creative appropriation and everyday designing (Hirschman, 1980; Wongkitrungrueng, 2018), where users act as co-designers by extending product life and purpose (Kim, 2021).

Design research has shown growing interest in user interaction and experience as central elements in product design (Forlizzi & Ford, 2000). The complexity of incorporating human interactivity and behaviour into product design lies in the need to consider not only the object but also human actions (Moggridge, 2007). Moggridge outlines six critical dimensions of this complexity: (1) anthropometrics requires designers to consider physical dimensions across stature, gender, age, and ethnicity: (2) physiology highlights the importance of understanding body functions, such as tactile feedback or repetitive stress, often requiring collaboration with physiologists: (3) cognitive psychology emphasizes understanding how the human mind works to address user needs beyond physical aspects; (4) sociology provides insights into user-object relationships within social contexts; (5) cultural anthropology stresses the influence of cultural practices on product interaction, such as differences in eating utensils; (6) ecology underscores the need to assess the interconnections between products, energy consumption, and broader socio-economic systems. Together, these dimensions reflect the interdisciplinary challenges designers face in integrating human interaction into product design.

Overall, the study of human interaction and behaviour emphasises that users do not merely consume products but actively reinterpret, adapt, and sometimes transform them. Theories of affordances, cognitive processing, emotional influence, and unintended use provide designers with valuable insights. These perspectives highlight the importance of designing products that are intuitive, adaptable, and responsive to both conscious and unconscious human behaviours (Norman, 1998; Gibson, 1979; Desmet & Hekkert, 2007; Suri, 2005; Alexander, 1964). In conclusion, the phenomenon of unintended interactions underscores the need to recognise users not merely as passive recipients of design but as active participants who reshape, reinterpret, and transform products through their behaviours. Understanding these dynamics allows designers to anticipate unintended human behaviour, integrate affordances more effectively, and create products that support both intended and emergent forms of use. This perspective enriches the discourse on human-product interaction by bridging design intentions with real-world practices, thereby offering valuable insights for sustainable and adaptive design approaches.

2.4.2 User Experience Research and Evolution

At the beginning of the introduction of User experience (UX) design, Hassenzahl (2010) stated that it was considered a strange phenomenon that was often criticized because of its vague and difficult to understand nature. However, the process of designing a product is not only focused on the designer but also formed through a combination of negotiations with several stakeholders including users. User experience design was created by a psychologist and cognitive designer, Don Norman since the 1990s. User experience (UX) means a deep focus on the user including the user's needs, values, abilities and limitations. User experience refers to any interaction a user has with a product or a service. According to Norman, "User experience encompasses all aspects of the end-user's interaction with the company, its services, and its products." User experience research entails understanding user behaviours, needs, and attitudes through various observation and feedback collection methods. Understanding the user experience building blocks helps designers in defining, designing, and evaluating user experience (Roto, 2006). Figure 2.33 illustrate the history of user experience research.

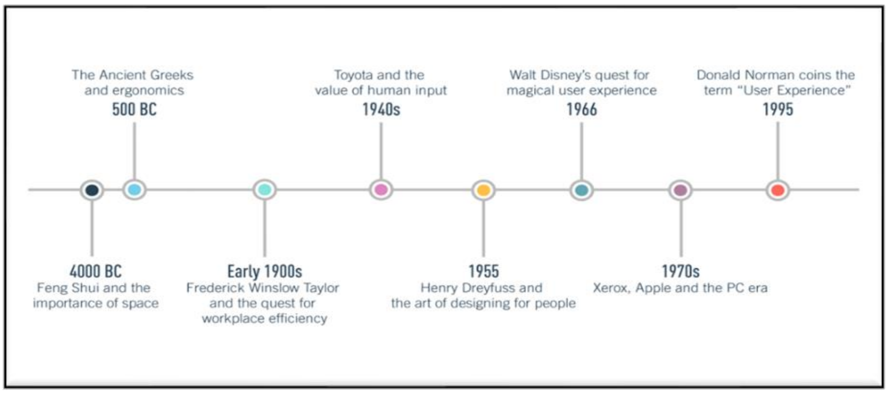

Figure 2.33 The History of UX Design

From different point of view, Forlizzi and Battarbee (2004) argue that user experience design is related to the creation of various meanings. Hassenzahl (2010) later developed that view as task- and work-related dominant responses 'usability' paradigm. However, they stated that ability eliminates usability problems by creating satisfaction, instead user experience about designing for pleasure in the first place, that usability is referred to as 'fun'. Early writing has linked individual experience at the moment experienced as a priority in usability. Below, some definitions of user experience that show some characteristics that affect the user experience that used as a reference in this research.

"All the aspects of how people use an interactive product: the way it feels in their hands, how well they understand how it works, how they feel about it while they' reusing it, how well it serves their purposes, and how well it fits into the entire context in which they are using it" (Alben 1996)

"Every aspect of the user's interaction with a product, service, or company that makeup the user's perceptions of the whole". (UPA 2006)

"The overall experience, in general or specifics, a user, customer, or audience member has with a product, service, or event" (Shedroff, online). Shedroff defines experience separately as "the sensation of interaction with a product, service, or event, through all of our senses, over time, and on both physical and cognitive levels". "A result of motivated action in a certain context." (Mäkelä & Fulton Suri 2001).

"A consequence of a user's internal state (predispositions, expectations, needs, motivation, mood, etc.), the characteristics of the designed system (e.g., complexity, purpose, usability, functionality, etc.) and the context (or the environment) within which the interaction occurs (e.g., organisational/social setting, meaningfulness of the activity, voluntariness of use, etc.)." (Hassenzahl & Tractinsky 2006).

In design research, over the last few years has been a growing interest and eagerness to design the user experience (Forlizzi & Ford, 2000). Previous research has discovered that user-product interactions take place in a context-of-use that is shaped by social, cultural, and organisational behaviour patterns (Forlizzi and Ford, 2000; Krippendorf, 2000; Hekkert and Van Dijk, 2011). Furthermore, through this contextual experience, people develop understanding (Norman, 1988). Previous research supported the hypothesis that different contexts of use influence different interactions, resulting in varying knowledge and understandings of a product's use. Likewise, Hekkert (2006) believed the function of a product shaping the user interaction experience by inspiring, enjoying, enriching, and strengthening a person's identity.

According to Andreasen, Hansen and Cash (2015) and Cross (20011), users as individual designers become part of the interactive design team to shape the design space and represented user's experience. In comparison to the main or utilitarian function of a design, users believe that the interaction experience with the product will influence purchasing power and reflect actual human behaviour.

Product designers can extend their point of view through an understanding of experience-centred notions to find the fit between technology and behavioural interactions. One of the other benefits of user experience research is that it helps designers understand how people live their lives so that designer can respond to their needs with informed design solutions. Good UX research involves using the right method at the right time during the development of a product. UX includes visual design, information architecture, interaction design, usability, user research and content strategy. Through consideration of UX as practices, designers can improve the quality of interaction and user perception of a design.

2.4.3 Everyday Designing Motivation

Everyday designing (ED) highlights how users reappropriate, reuse, and redesign products beyond their intended functions, emphasizing the role of product elements as triggers for creative reuse. Here are five factors that trigger everyday designing behaviour:

Product Elements as Triggers

Product elements play a crucial role in shaping user perception and reinterpretation. Form, colour, and material act as symbolic carriers that influence behaviour through cognitive and cultural contexts (Krippendorff, 2006; Crilly et al., 2008). Metaphors embedded in design further guide reinterpretation (Hekkert & Cila, 2015). Triggers for ED can be physical, such as form or material, or psychological, shaped by cultural and semantic associations (Norman, 1988).

Levels of Appropriation in Everyday Design

The degree of appropriation indicates user engagement in remaking products, represented in three levels: As-is, Remake, and Remanufacture. As-is involves repurposing without modification, Remake requires simple alterations, while Remanufacture demands advanced skills for significant transformation (Kim & Paulos, 2011; Kim et al., 2021). This continuum reflects how user knowledge, skill, and context shape creative involvement. While many repurpose with minimal change, others engage in deeper redesign, demonstrating how Everyday Design motivation ranges from pragmatic reuse to intentional creative transformation (Desjardins & Wakkary, 2014).

Physical Distance and Context

The spatial relationship between original and reappropriated products shapes ED categorized into close, middle, and far distances. Close reuse occurs in the same space, middle across adjacent spaces, and far involves significant relocation (Costantini et al., 2010). Proximity influences perception of utility and likelihood of reuse. Contextual and situational factors, including user characteristics, environment, and social norms, also mediate ED practices. Domestic settings particularly foster spontaneous adaptations, reflecting the ad hoc nature of ED (Desjardins & Wakkary, 2014).

Transformation of Function and Longevity of Use

A key dimension of ED is functional transformation, which includes function change, a completely new purpose and function addition, where the original use is retained but expanded. These can be temporary, alternating between old and new uses, or permanent, reflecting stable shifts. This framework reveals how product features inspire reinterpretation, balancing improvisation with innovation, and underscores ED's potential to uncover user practices often overlooked in conventional design approaches.

Design Affordance

The concept of affordance underpins ED by framing objects as opportunities for action shaped by user–environment interactions (Gibson, 1977). Norman (1988, 2013) distinguished between actual and perceived affordances, while Gaver (1991) categorized them as perceptible, hidden, or false, showing how interpretation shapes use. ED emerges when users perceive new affordances beyond designer intent. Affordances are dynamic, influenced by context and experience (Kannengiesser et al., 2015), enabling adaptive, creative practices where familiar products trigger innovative reappropriations.

Everyday design illustrates how users actively reinterpret and reappropriate products through creative engagement with their elements. Product characteristics such as form, material, and manipulability serve as motivational triggers, encouraging new uses and functions. These triggers can be physical, psychological, cultural, or logical, shaping the ways in which users perceive affordances. The levels of appropriation, ranging from As-is to remanufacture, reflect varying degrees of motivation and skill. Spatial proximity, contextual factors, and functional transformation further contribute to the likelihood and sustainability of ED practices. Affordance theory provides a conceptual framework for explaining these behaviours, emphasizing that objects are perceived as action possibilities shaped by environmental and cultural factors. Everyday design thus represents a form of user-driven innovation, revealing opportunities for designers to better understand and integrate reuse behaviours into product development. By recognising the motivational role of product elements and affordances, design research can support sustainable practices while fostering creativity in everyday life.

Affordances can turn into normalisation when they are accepted by a wider user group than a specific group or individual user (Kannengesser et al., 2015). Perceptual responses to objects shown by individual users to a larger group of users will become an example and follow until it is accepted as a habit emphasis lives. For example, the garage door has the "ability" to hang clothes and flowerpots. The concept of ability has similarities with the everyday term used by people, which is "usability" for objects when interacting. Figure 2.34 illustrates four categories of affordance as described by Norman: false affordance, perceptible affordance, correct rejection, and hidden affordance adapted from Gaver (1991). The model emphasizes the relationship between user perception and an object's actual function, which determines whether interaction occurs correctly, mistakenly, or remains entirely unnoticed.

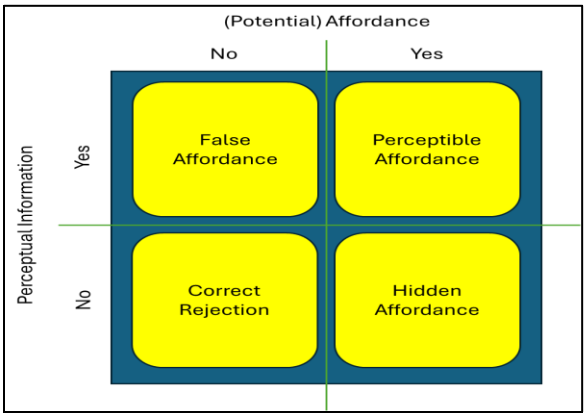

Figure 2.34 Perceive Affordance, adapted from Gaver, (1991)

2.4.4 The Phenomenon of Unintended Use of Product

Individuals interact and communicate with various product types for multiple purposes in daily life. Common examples include the creative use of empty bottles to separate egg yolks from whites, the application of Coca-Cola as a substitute for household cleaning detergents, and the transformation of wire hangers into disposable towel holders. These innovative practices are often discovered unintentionally and contribute to human convenience and meaning-making, rather than being the outcome of systematic trial-and-error studies. In this regard, non-designers often create novel functions through innovative product usage without deliberate intention (Hassan et al., 2022; 2024). Such examples illustrate the phenomenon of unintended use of products within everyday human activities (see Figure 2.35). On the left figure, a man is depicted using a drum barrel under his house to protect himself from flooding; in the middle figure, a woman is depicted using a chair in another way as a bucket for rubbish; and to the right figure, a person is depicted using a food tong to squeeze lemon juice. Unintended behaviour denotes (i) inadvertence as a purpose or goal without deliberate intention (ii) or an impromptu behaviour demonstrated without planning. As Dan (2015) stated "the state of mind that gives rise to creativity does not occur consciously and critically but occurs when the mind is unconscious, not evaluating, unintentional or spontaneous"

Figure 2.35 User's Unintended Use of Product

In design research, the unintended use of product has become an important subject of inquiry as scholars attempt to understand the dynamic relationship between designers' intentions and users' practices. Unintended use occurs when users engage with a product in ways that diverge from the purpose originally envisioned by its designer (Costantini et al., 2010). Rather than being perceived as misuse, unintended use is increasingly recognised as a creative and resourceful practice that reflects human adaptability and inventiveness. It demonstrates the interplay between design affordances, contextual influences, and user motivations. Gibson (1977) described affordances as action possibilities latent in the environment, while Norman (1988) introduced the notion of perceived affordances, referring to the object characteristics that suggest cues for interaction. In practical terms, product elements such as form, material, manipulability, and graphic features can provide signals that stimulate reinterpretation and alternative uses (Kim, 2020). These cues often result in novel functions that transcend the designer's original intentions. Empirical studies show that unintended uses frequently arise from pragmatic needs, situational constraints, or creative impulses. Desjardins and Wakkary (2013) found that household members often repurposed objects "as-is" to complete new tasks, such as using a jar as a vase or a chair as a step stool. Other research has identified levels of appropriation that vary from minimal modification (as-is) to small adjustments (remake) and more complex transformations (remanufacture). Each level reflects different degrees of skill, creativity, and contextual influence (Kim & Paulos, 2011; Kim et al., 2021; Dix, 2007). This indicates that unintended use is not a uniform behaviour but occurs across a spectrum shaped by user capabilities and environmental factors.

The roots of unintended use can be traced to earlier notions such as unselfconscious design. Alexander (1964) described unselfconscious culture as the tendency for people to create solutions that fit their needs without deliberate design knowledge, in contrast to the self-conscious process of professional design. In the context of unintended behaviour, Uleman and Bargh (1989), through their book Unintended Thought, introduced a branch of thought and action that can occur unintentionally, especially within complex social environments, where it can be influenced by both unconscious and conscious behaviour. Based on this concept, research has emerged across various design and product interaction disciplines that highlight the potential of unconscious behaviour within the design process (Kamil, 2017; Tang et al., 2021; Wakkary et al., 2015; Wu, 2024), discussing themes such as ergonomics, interaction, and innovation. Although there are numerous previous studies on unconscious behaviour in design research, discussions on the notion of unintended behaviour from a design perspective remain limited. The phenomenon of unintended use still receives limited attention, even though it reflects a critical gap between design intent and actual user behaviour (Friedman, 2000). This situation becomes even more significant when UHBE leads to a critical issues and social impacts. Through a critical review of literature published within the past seven years, it has become evident that there are few findings and limited discussions presented within a single coherent perspective that links the designers' design thinking towards UHBE comprehensively.

As mentioned in Chapter One, the term "unintended" referred to Uleman and Bargh (1989) research related to unintended cognition and automaticity in social psychology. "Unintended thoughts and behaviours often arise without conscious intention or awareness, driven by automatic cognitive processes." (Bargh, 1997). Bargh and Uleman's book "Unintended Thought" explores the activation and influence of thoughts, goals, and behaviours without conscious awareness or intention. While unconscious behaviour stems from internal cognitive processes beyond an individual's awareness, as introduced by Freud (1955), unintended behaviour, as discussed by Uleman and Bargh (1989), refers to actions that occur without prior intention, often triggered by contextual or situational factors. Similarly, Suri (2005) introduced the idea of "thoughtless acts," which highlight intuitive and spontaneous interactions with surrounding products. Brandes and Erlhoff (2006) also documented creative user practices through non-intentional design, reinforcing the significance of such behaviours.

More recently, Kim and Lee (2014) coined the term "everyday design" to describe users as proactive and creative agents who transform artefacts through repurposing. Everyday designing involves reinterpreting and creating new functions from existing products, positioning users as designers in their own right. In the process of creative use, individuals apply personal skills and techniques to transform the use and purpose of products according to contextual needs. Dix (2007) described this phenomenon as creative transformation of use, while Louridas (1999) used the term "bricolage" to represent the immediate invention of artefacts in everyday settings. These processes often occur unintentionally as a search for "goodness of fit," aligning closely with Alexander's unselfconscious process. Recognising the discrepancies between the intended design context and the actual user context, researchers have advocated for more bottom-up approaches in product development (Crilly et al., 2008). This aligns with the theory of "The Principle of Cognitive Interaction" by Norman (1980), which explores concepts such as 'The Design of Everyday Things' (Norman, 1988) and 'Affordance and Design' (Norman, 2008), related to the understanding of interaction and behavioural interactivity, and how these characteristics help identify both designer and user preferences through design research.

On the other hand, in psychology and consumer behaviour research, Midgley and Dowling (1978) defined UHBE as a form of user innovation, referring to product usage that deviates from the original design intent, which forms a “creative misuse” and unintentional user value. This consideration was later discussed more seriously through Hirschman’s Use Innovativeness Model, which refers to how users adopt new, unconventional, and creative ways of using products. He regarded UHBE as part of users’ innovative characteristics, reflected through five dimensions: creativity/curiosity, risk preferences, voluntary simplicity, creative reuse, and multiple-use potential. Based on this model, numerous researchers have explored the influencing factors of UHBE within the consumer context (Goldsmith and Foxall, 2003; Hoffman, Kopalle, and Novak, 2010; Pillai et al., 2022; Ridgway and Price, 1994; Wongkitrungrueng, 2018). In addition, perspectives from engineering (Hentschel, 2011) and cybersecurity (Bailey, 2017; Ronacher, 2015) have also discussed issues of unintended behaviour, providing positive contributions to their respective fields.

Scholars such as Ihde (2008) and Redström (2006) further argue that designers should pay attention to unintended uses and their relationship with user needs, as they represent authentic contexts where users assume the role of designers. Maestri and Wakkary (2011) have demonstrated how users engage in repair and transformation within household systems, broadening the understanding of user participation in design. In contemporary culture, characterised by demands for sustainability and transparency, the reuse and transformation of existing products rather than the purchase of new ones have become increasingly significant. Everyday design therefore embodies sustainability by enabling the extension of product lifecycles and the creative appropriation of resources. Consequently, the literature identifies various terms connected to the phenomenon of unintended use. These include unselfconscious design (Alexander, 1964), thoughtless acts (Suri, 2005), unexpected behaviour (Wakkary, 2016), designing for appropriation (Dix, 2007), unorthodox use (Hentschel, 2011), design by use (Brandes et al., 2009), and use innovativeness (Hirschman, 1980). These concepts collectively point to a design process that extends beyond professional practice, encompassing reuse, customisation, appropriation, and do-it-yourself practices. In this context, design activity is no longer confined to professional designers but emerges as a distributed process Involving both designers and users, reflecting creativity, adaptability, and innovation in everyday life.

On the other hand, in the context of design research, Valkenburg and Dorst (1998) have proposed a reflective practice mechanism (as introduced by Schon, 1983) that helps systematically analyze the way designers work and interpreted within research topic. However, Dorst (2011) in his discussion on design research studies and the application of design thinking (Cross 2011, 2023; Dalsgaard 2014; Dorst, 2011, Johansson-Sköldberg et al., 2013; Prochner, 2022) the discussion on creative thinking from the designer's perspective was found to be limited, since design research community has nearly ignored to oversimplifying design thinking, and held dear to its multiple perspectives or wider views, affirms that the situation has become quite problematic and challenging. Based on the statements, some considerations have been given to how UHBE in mainstream products can benefit designers at the early stages of design process. The discussion of designers' knowledge and reaction, encompassing the relevance and substantial contribution of the conceptual framework in the product ideation process, has been largely overlooked. Furthermore, the literature on the conceptual framework has been extensively examined, and it often involves mere terminological substitutions. However, the relevance of this framework for practicing designers, particularly regarding empirical evidence related to their design thinking, has received significantly less attention, thus creating a gap.

In conclusion, unintended use of product represents an important dimension of human product interaction that expands the boundaries of design practice. By acknowledging the creative potential embedded in these practices, designers can foster more resilient, adaptable, and user-centred design outcomes. This perspective challenges the conventional divide between designer intention and user action, situating unintended use as a fertile ground for innovation and sustainability. Recognising unintended use enables the integration of flexibility into product design, supporting user-driven creativity while encouraging resource conservation (Hekkert & Cila, 2015). As such, unintended use illustrates not only the adaptability of users but also the potential for designers to anticipate and embrace unexpected practices.

2.4.5 The Framework of Everyday Designing

The phenomenon of unintended use can be explained through several conceptual perspectives that illustrate how users engage with products beyond their intended purposes. One is unselfconscious interaction, referring to spontaneous or automatic actions performed without deliberate awareness, such as using a smartphone as a mirror. Design for appropriation, in contrast, considers how designers intentionally allow space for users to adapt, modify, or personalise products, as seen in digital platforms or video games. Non-intentional design captures situations where products are used in ways never envisioned by the designer, for example, a chair being used to block a door. Use innovativeness highlights creative ways users invent alternative functions that add value to products, such as repurposing plastic bottles as plant pots. Unorthodox use refers to actions that deviate from conventional expectations, often bordering on misuse yet demonstrating ingenuity, such as employing a screwdriver as a lever to open a paint can. These perspectives show that unintended use is not a singular category but a spectrum of user behaviours, ranging from unconscious habits to deliberate acts of creativity. For product design research, understanding these distinctions is crucial, as it reveals the complex interplay between designer intention and user appropriation in everyday contexts. The following section will examine each ED framework in detail to highlight the similarities and differences among them.

1. Non-Intentional Design (NID)

The term Non-Intentional Design (NID), introduced by Uta Brandes and Michael Erlhoff in the late 1990s, refers to the spontaneous redesign of everyday objects through user practices. Instead of creating new designs, NID emerges when users generate new meanings or functions through unplanned actions. In essence, NID reflects the transformation of norms into "ab-norms," describing unprofessional redesigns of professionally designed objects that occur in daily life. NID emphasises how functions and meanings are produced through use. Such actions are often triggered by immediate problems, motivated by convenience, or inspired by the pleasure of inventing new purposes. They may also arise from contextual goals, environmental changes, or reuse intentions. Conceptually, NID challenges traditional design norms by introducing vague yet intelligent transformations. Although it may compromise the efficiency of existing products, it often reduces costs and reveals alternative forms of value and innovation. Everyday examples illustrate this phenomenon clearly. A chair, originally designed for sitting, may be used as a ladder, a storage surface, or a towel rack. Similarly, mugs intended for beverages are frequently used as pen holders or containers. These reappropriations persist according to user purpose, showing how products are redefined through necessity and creativity. Even when labelled as "misuse," the outcomes often embody innovation and may hold commercial potential. Understanding NID is crucial for design research, as user adaptations are frequently personal and extend beyond what designers anticipate. This highlights the dynamic interplay between design intentions and user appropriation. For product design practice, acknowledging NID means recognising that unintended uses are not failures but opportunities. By integrating this perspective, designers can create products that better accommodate the complexities of daily life and leverage the hidden innovation found in unplanned practices.

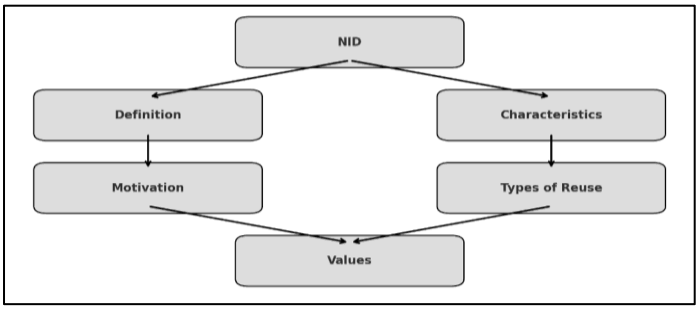

Figure 2.36 Framework of Non-Intentional Design, adapted from Brandes & Erlhoff (2006)

2. Design for Appropriates (DfA)

The term Non-Intentional Design (NID), introduced by Uta Brandes and Michael Erlhoff in the late 1990s, describes the spontaneous redesign of everyday objects by users. Rather than producing new designs, NID arises when users assign fresh meanings or functions through unplanned actions. It reflects the transformation of norms into "ab-norms," signifying unprofessional redesigns of professionally designed objects that occur in daily contexts. NID highlights how product functions and meanings emerge in use. Such actions are often triggered by immediate needs, shaped by convenience, or motivated by the enjoyment of creating new purposes. They may also result from contextual goals, environmental changes, or intentions of reuse. Conceptually, NID challenges conventional design principles by introducing ambiguous yet intelligent transformations. While these adaptations may reduce the efficiency of original products, they often lower costs and uncover alternative forms of value and innovation. Everyday practices illustrate this clearly. A chair, originally designed for sitting, may function as a ladder, storage platform, or towel rack. Likewise, mugs designed for beverages are frequently repurposed as pen holders or containers. These reappropriations persist according to user intentions, demonstrating how necessity and creativity redefine objects. Even when considered "misuse," such practices often embody innovation and hold potential for commercial application. Recognising NID is crucial for design research, as user-driven adaptations are highly personal and extend beyond what designers foresee. This underscores the dynamic interaction between design intentions and user appropriation. For product design practice, NID should not be seen as failure but as opportunity. By embracing this perspective, designers can anticipate diverse user behaviours, integrate flexibility into products, and find hidden innovation that arises from spontaneous practices in daily life.

3. Unselfconscious Interaction

From the perspective of the built environment, Alexander's notion of unselfconscious design is animated by the ongoing fixes and maintenance carried out by inhabitants in their surroundings (Wakkary et al., 2015). From a design standpoint, this idea was initially associated with primitive and traditional societies, where the design profession did not exist, and artefacts were typically produced by the users themselves. These practices, though tacit and unspoken, follow complex rules embedded in culture. As such, users acting as unselfconscious designers unknowingly bring about significant improvements and changes to artefacts in daily life. Importantly, these alterations often result in outcomes that fit well, despite being created without professional expertise (Kim & Lee, 2014).

Alexander (1964) contends that achieving a "good fit" is the primary aim of virtually every making culture, with "misfits" serving as obstacles that hinder functionality. Misfits are negative conditions that prevent harmony between form and context. Within the framework of unselfconscious design, Alexander argues that people inadvertently resolve misfits, thereby producing better fits. According to Wakkary et al. (2015), the direct response to misfits is a defining characteristic of unselfconscious design. When misfits are detected, users feel an immediate need to act, often employing materials and resources readily available in their environment for fixes, adjustments, or maintenance. These incremental engagements trigger subtle yet meaningful improvements in the relationships between products, environments, and users. Alexander described this dynamic as the simultaneous process of breakdown and correction, which naturally leads to a "goodness of fit." Knowledge of how to repair or adapt artefacts resides with the user, who is best positioned to identify what lacks fit and how it can be corrected to suit the environment.

This idea aligns with Suri's (2005) account of human cognitive behaviour. As intelligent beings, humans constantly interpret their surroundings, speculating on how objects might function and how they can be used. At the same time, humans develop a refined awareness of material properties, forms, and textures. According to Suri, such awareness is evident in daily actions, even when individuals are not consciously reflecting on design. Thus, unselfconscious design demonstrates how tacit cognitive processes guide human interaction with artefacts, resulting in adaptive solutions without deliberate planning. Central to Alexander's concept is the equilibrium between form and context. Every design problem, he argues, begins with the pursuit of fitness between these two entities: form represents the solution, while context defines the problem. Therefore, discussion of design must focus not solely on form, but on the ensemble that comprises both form and its contextual conditions. The achievement of a "good fit" lies in the successful integration of these elements.

Bargh and Morsella (2009) extend this argument through their theory of unconscious behavioural guidance (refer to Figure 2.37 on the next pages). They propose two stages: first, the automatic activation of behaviour by external stimuli; and second, the subsequent influence of these stimuli on perceptual, emotional, evaluative, and motivational systems. These processes, which occur unintentionally in everyday life, shape human behaviour by linking environmental triggers with responsive actions. Within design research, this perspective has been widely applied to understand the tacit, adaptive, and often invisible processes by which users engage with artefacts and environments (Wakkary, 2018; Kamil, 2017; Kim & Lee, 2014).

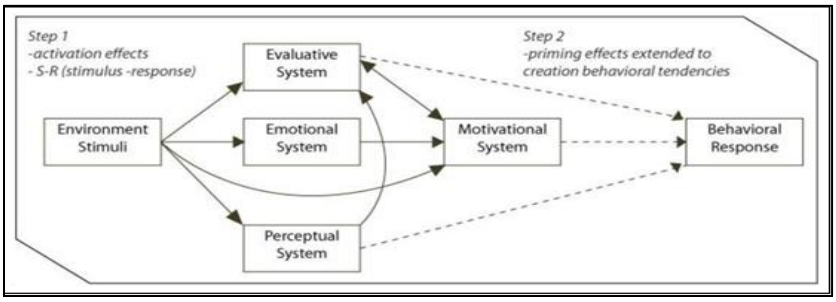

Figure 2.37 Unconscious Behaviour Guidance System, adapted from Bargh and Morsella (2009)

4. **Use Innovativeness**

Use Innovativeness refers to users' inclination to explore novel or unconventional ways of using a product beyond its intended functions. This concept distinguishes "novelty in usage" from "novelty in purchase," shifting the analytical focus from mere adoption to creativity in everyday product interaction. Theoretically, Hirschman proposed that innovativeness consists of three components: adoptive, vicarious, and use innovativeness (Figure 2.38). Adoptive innovativeness involves the actual adoption of new products, while vicarious innovativeness to gaining knowledge and information about products. Use innovativeness highlights applying already adopted products in novel ways to address new consumption. This dimension further divided into inherent and actualized use innovativeness. Inherent use innovativeness reflects consumers' receptivity, attraction, and creativity in using products differently, whereas actualized use innovativeness represents the realized application of such creative abilities in real product usage. Its theoretical roots trace back to Hirschman's (1980) early contributions on innovativeness, novelty seeking, and consumer creativity, which emphasized imagination and exploration as central to consumer engagement.

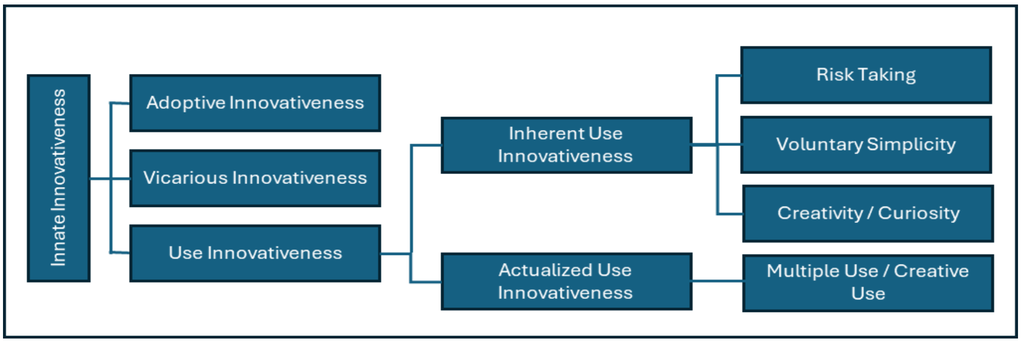

Figure 2.38 Use Innovativeness Model, adapted from Hirschman (1980)

The construct was further shaped by Price and Ridgway (1983, 1994), who formally defined and operationalized "use innovativeness" via validated scales and positioned the concept within a broader consumer behaviour framework. Price and Ridgway's (1994) model of use innovativeness outlines four key components defining exploratory usage behaviour. First, there is the exploratory tendency, reflecting the intrinsic drive to experiment with new configurations, functions, or contexts of use. Second, idea generation involves forming spontaneous hypotheses about alternative uses, subject to real-world testing. Third, the iterative trial process comprises experimentation, evaluation, and refinement cycles, distinguishing innovative use from routine behaviour. Fourth, outcome evaluation and reinforcement describe how beneficial novel usage strengthens future exploratory behaviour. These mechanisms unfold through daily product interactions, requiring cognitive flexibility, tolerance for ambiguity, and interpretative skill in recognizing affordances. In the context of design, this concept has less explored by design scholars as mentioned in the consumer and psychology research (Pillai et al., 2021; Wongkitrungreung, 2018).

In comparing the four frameworks, each provides a distinct perspective on unintended product use. NID highlights spontaneous actions that transform designed objects into new functions, positioning users as unintentional redesigns. DfA by contrast, emphasises deliberate improvisation, where adaptations arise to meet unforeseen needs shaped by cultural, technological, or environmental contexts. Unselfconscious Interaction, grounded in Alexander's notion of "goodness of fit," interprets user modifications as instinctive responses to misfits, producing equilibrium through tacit, iterative practices. Use Innovativeness shifts to consumer behaviour, focusing on exploratory tendencies, creativity, and cognitive processes driving novel applications. Collectively, these frameworks illustrate a continuum of unintended use: from unconscious adaptations (NID, Unselfconscious Interaction) to more deliberate and exploratory behaviours (DfA, Use Innovativeness). This comparative lens underscores users as spontaneous improvisers, tacit fixers, appropriators, and creative explorers, while positioning unintended use as a valuable dimension in design research.

2.4.6 Motivation towards Unintended Human Behaviour into Design Research

Use Innovativeness is conceptualised as a cyclical and context-sensitive process, reflecting how users explore and adapt products in novel ways. Price and Ridgway's (1983) validated scale, with items such as "I try new ways of using this product" and "I modify its usage", has been widely used in marketing research (Goldsmith & Hofacker, 1991). Later studies refined these measures, distinguishing use innovativeness from broader constructs like domain-specific innovativeness (Menold et al., 2014). Menold and colleagues identified four dimensions: (i) creativity and curiosity, (ii) voluntary simplicity, (iii) risk taking, and (iv) multiple use, streamlining earlier five-factor models by Hirschman and Price & Ridgway. While initially centred on physical products, the construct now extends to digital and service domains. For instance, live-streaming commerce demonstrates how affordances and community engagement inspire alternative product interactions, expanding evaluation methods and usage scenarios (Wongkitrungrueng, 2018). Such studies, while often focusing on trust or purchase intention, also illuminate how consumers invent usage strategies in dynamic contexts.

Clarifying the boundaries between use innovativeness and related constructs such as opinion leadership enables more precise modelling of outcomes like satisfaction, engagement, task performance, or meaning making. Importantly, distinguishing between instruction-bound users and those who creatively adapt products underscores the role of design, modularity, and affordances. At the micro level, use innovativeness links individual creativity in usage to macro-level consequences such as brand loyalty, diffusion of novel behaviours, and community formation.

Methodologically, mixed approaches are particularly valuable. Ethnographic studies, usage diaries, digital traces, and think-aloud protocols capture experimentation and cognitive processes, while quantitative testing with validated scales allows hypothesis-driven modelling. These approaches enable exploration of how design affordances influence performance, satisfaction, or long-term adoption.

The literature highlights three promising research avenues. First, refining cross-domain scales and verifying their validity across contexts such as IoT devices, household appliances, and mobile applications, including cross-cultural adaptation. Second, investigating how design features such as modularity, customisation, and flexibility stimulate exploratory behaviours and improve user experience. Third, examining community-driven diffusion, where social media, livestreams, and user-generated content facilitate the spread and normalisation of novel usage practices. Overall, use innovativeness offers a bridge between designer intentions and user perceptions, providing insights into unintended human–product interactions. By focusing on how users adapt products creatively, this model enriches design research and opens opportunities for more innovative and inclusive design practices.

Motivations behind unintended use are equally diverse. The use innovativeness model emerges from Hirschman's (1980) foundational insight into consumer creativity and was systematically operationalized by Price and Ridgway (1994) to describe product usage as an active cognitive-behavioural cycle. The model uniquely offering both conceptual rigor and measurement tools. Its expanding applicability across physical, digital, and social commerce environments underscores its relevance for contemporary consumer research. By integrating formal measurement and rich observation data, use innovativeness research contributes to understanding how design, technology, and community interactions coalesce to shape innovation at the moment of use. Most of these studies discuss how factors as individual, psychology, social and cultural, context of use and product element are identified in determining the level of motivation that affects the user's interaction with the product and how it correlates with factors of unintentional use of the product. Based on empirical and conceptual evidence portray through Hirschman model of use innovativeness in measuring how people use a product beyond its intended or routine functions, researcher sees the applicability of this model in research to investigate UHBE towards mainstream products.

2.4.7 Attributes of Unintended Human Behaviour

The "use innovativeness" model refers to a concept often used in marketing and innovation research to understand how users adopt and adapt to new products, services, or technologies. It measures the degree to which individuals are willing to try, adopt, and creatively use existing products in new ways in their daily lives. This concept is closely related to the diffusion of innovation theory, which explains how new ideas, products, or technologies spread through a population. However, one of the problematic features of research on human creative and innovativeness is the measurement of used behaviour (Hirschman 1980). According to Hirschman, research is needed to refine distinctions between types of innovative behaviour toward using the product within the product context in various ways and using the product outside the product context in unintended ways. Thus, Hirschman (1980) introduced the use innovativeness model encompassing two types of behaviour when users use existing products creatively: (I) Inherent Use Innovativeness (IUI), which refers to multiple uses of the product in its context (Multiple-Use) and (ii) Actualized Use Innovativeness (AUI), which refers to the use of the product outside its context in an unintentional way (Creative-Use).

Hirschman [1980] along with Ridgway and Price [1994] provide theoretical support for the use of innovativeness definition by emphasizing five (5) dimensional components in assessing the use of innovative behaviour, namely (i) Risk-taking, (ii) Voluntary Simplicity, (iii) Creativity / Curiosity, (iv) Multiple use and (v) Creative use.

These five dimensions result from the Model of use innovation as an exploration of product usage and behaviour, through the critical review of measuring of innovativeness, Menold et al. (2014) have proposed the use of psychometric instruments for the evaluation of innovativeness behaviour in general. They summarize Hirschman and Ridgway & Price dimensions into four (4) components in measuring user innovativeness attributes, actions, and cognitive as (i) creativity and curiosity, (ii) Voluntary simplicity, (iii) risk-taking and (iv) multiple use, this dimension is the focus of this paper to identify unintended attributes and patterns. The attributes represented by every dimension are extracted through a systematic literature review under the notion within the research area such as unexpected behaviour (Pillai et al., 2022; Brandes and Erlhoff, 2006), Designing for appropriation (Alan, 2007), Unorthodox use (Hentschel, 2008), non-international design, design by use (Brandes et al., 2009), and unselfconscious interaction (Wakkary et al., 2016) (see Table 2.6). The following are main components of the dimension along with representation of attributes used in the evaluation of UHBE study. Table 2.6 are representation of each component of UHBE.

Table 2.6
Attributes Representation for each Dimension of UHBE

Dimension	**Attributions**	UHBE **Notion**
Creativity / Curiosity	Creativeness	Andreason, 2011; Stolterman, 2001, Hirschman, 1980
	Innovativeness	Hirschman, 1980; Wongkitrungrueng,2018
	Trial and error	Edward Lee Thorndike, 1913; Andre Lord, 2021
	Spontaneous interaction	Andreason, 2011
	Belief	Andre Lord, 2021
	Perception	Norman,1988; Gaver,1991
	Attitude	Andre Lord, 2021
Voluntary Simplicity	Influence by others	Suri, 2005, Duane & Arnold, 1977
	Living style	Wongkitrungrueng,2018; Duane & Arnold, 1977
	Experience	Aurisicchio et al. 2011
	Social Sharing	Aurisicchio et al. 2011; Crilly,2005;
	Culturally based conventions	Crilly,2005; Duane & Arnold, 1977; Suri 2005
Risk-Taking	Unavailability of the actual product	Wongkitrungrueng, 2018; Aurisicchio et al. 2011
	Unexpected situation	Aurisicchio et al. 2011; Stolterman, 2001; Kim, 2021; Crilly, 2005; Wongkitrungrueng, 2018
	Save Cost	Hadi Harati et al, 2019; Wongkitrungrueng,2018
	Convenient	Pillai et al., 2021; Kim,2021
	Quick solution	Kim,2021; Hentschel · 2011
	Save Time	Hentschel · 2011; Kim, 2021
	Economic circumstances	Aurisicchio et al. 2011; Kim,2021
	Location	Wongkitrungrueng, 2018; Kim, 2021
Multiple-Use	Materials cues	Kim, 2021; Crilly, 2005; Hentschel · 2011
	Product performance	Aurisicchio et al. 2011; Kim, 2021
	Form cues	Crilly, 2005; Kim, 2021
	Object ability	Georgia Konzel, 2012
	Texture	Cordell 1997; Kim, 2021

	Size	Kim, 2021; Hentschel · 2011
	Usability	Norman,1988; Kamil, 2017
	Fit (for purpose)	Suri 2005; Kamil, 2017
	Symbolic communication	Shannon,19xx; Aurisicchio et al. 2011
	Manipulability	Kim, 2021, Wakkary, 2015
	Symbolic form of original product form	Norman, 1988; Crilly, 2005; Aurisicchio et al. 2011
	Representative original function	Norman, 1988; Wongkitrungrueng, 2018

1. Creativity and curiosity

Creativity refers to the ability to generate novel and valuable ideas, solutions, or expressions. It involves thinking outside the box, making connections between seemingly unrelated things, and coming up with original concepts. Creative individuals often knack for seeing possibilities where others may not and are willing to explore unconventional paths (Hirschman, 1980). Curiosity is the innate desire to learn, explore, and seek new information and experiences. It drives people to ask questions, investigate, and discover. According to Menold et al (2014), creativity and curiosity are defined as creating new products or disassembling products to view their inner workings that are indicative of cognitive style. For instance, some people using a pair of kitchen tongs, squeeze it to get the lemon juice. Through systematic review, humans perceive the interaction towards the object may be influenced by perception, belief, attitude, creativeness, innovativeness, spontaneity, and trial and error.

2. Voluntary simplicity

Voluntary simplicity often referred to as “moderation”, is a philosophy and lifestyle choice that involves less material possessions, consumption, and the complexity of the lifestyle as a whole in order to focus on what is considered more meaningful and fulfilling. In user research, Menold et al. (2014) defined voluntary simplicity as an individual preference for recovering previous products for full utilization, with cognitive effect as the motivational factor. However, voluntary simplicity is not limited to individual preference but is influenced by social, environmental, and political aspects. Humans desire to seek a solution within the current object set rather than in the marketplace (Hirschman, 1980). For instance, most people tend to manipulate a chair as a waste plastic holder by reversing the chair i.e., during Malay wedding ceremony. The characteristics may be influenced by living style, cultural context, ethical factors, ecological awareness, and social experiences.

3. Risk-taking

Risk-taking preferences refer to humans who lack a fear of trying new things with the objects surrounding them (Hirschman, 1980). Risk-taking is a common experience in everyday life that exists to understand problems and assess people's perceptions, and immediate response is essential to address social, technological, and environmental change and the side effects of social progress (Beck 1992, 2009). Risk-taking is the exploration and implementation of new and valuable ideas, encouraging the emergence of current, uncertain ideas, and stimulating the allocation of time, human, and financial resources. People tend to risk-taking because of individual comfort (Menold et al., 2014). For example, some people wear plastic bags to protect their heads when umbrellas are not in place during rainy days, even if there are risk. The attributes under the roof of risk-taking may influenced by affordability, unexpected situations, cost-savings, convenience, quick solutions, time-save, location, and economic factors.

4. Multiple use and Creative use

Multiple-use or creative use describes the tendency to explore diverse functions of an object, reflecting its potential for reuse (Hirschman, 1980). The principle assumes that utilising products in multiple ways generates greater value than restricting them to a single purpose. Menold et al. (2014) define multiple use as the relationship between an individual's perceived value of a product and its potential for varied applications, enabling people to solve emerging everyday problems more effectively. In user experience research, product elements often trigger reinterpretation for alternative purposes (Kim, 2020), while in design research, such elements are intentionally used to capture user attention (Crilly et al., 2008). Yet, interpretation remains subjective, as individuals interact differently with products. Norman (1988) highlights that symbolic communication between object and user directly shapes perceptions of affordances within an environment. Examples illustrate this adaptability, such as binder clips used not only for binding papers but also for organising cables or storing loose change. The multiple-use dimension is thus expressed through attributes that guide user actions, including material cues, performance, form, texture, size, usability, fit for purpose, manipulability, symbolic communication, and the representation of the product's original function. Table 2.7 indicates the attributes of UHBE dimension.

Table 2.7
The Characteristics of UHBE Attribution Component

Dimension component	Attribute
Creativity and curiosity	perception, belief, attitude, creativeness, innovativeness, spontaneity, and trial and error
Voluntary simplicity	living style, cultural context, ethical factors, ecological awareness, and social experiences
Risk-taking	affordability, unexpected situations, cost-savings, convenience, quick solutions, time-save, location, and economic factors
Multiple use and Creative use	material cues, product performance, form cues, object ability, texture, size, usability, fit for purpose, symbolic communication, manipulability, symbolic form of original object, and representation of original product function

2.4.8 Interpreted Human Behaviour and Experience Through Hermeneutic Approach

Martin Heidegger's concept of the hermeneutic circle (1927) emphasizes the interdependence between the whole and its parts, where meaning emerges from the interplay of lived experience and contextual reality. Building on this, Gadamer (1975) interprets hermeneutics as an anticipatory process of meaning-making, shaped by the horizon of understanding, prejudice, and dialogue as a model of interpretation. Within the design process, hermeneutic circle highlights how both designer's past experiences and the historical conditions of the artifact contribute to the constitution of meaning. This dynamic requires designers to acknowledge the influence of past biases, while simultaneously broadening their horizon of understanding, as depicted in Figure 2.39.

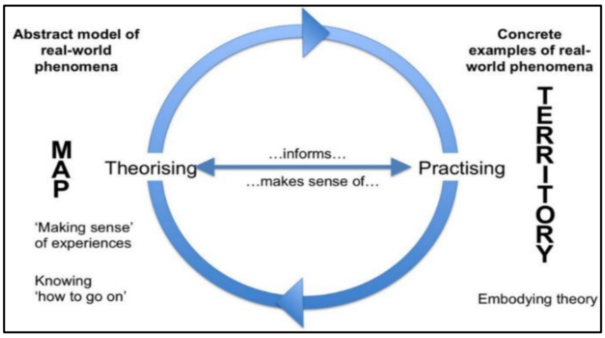

Figure 2.39 Hermeneutic Circles, the Future of the Design of Things to Come, adapted from Brinkley Warren (2010)

Designers, therefore, must cultivate hermeneutic skills that align creativity, technology, and human behavioural interaction with the user's lived experiences, rather than relying solely on personal intention. In this sense, the product becomes a medium of dialogue between designer and user, offering multiple perspectives on functional quality, performance, efficiency, and ergonomics. This is consistent with Crilly's (2005) interpretation of Monö's (1997) semantic functions, description, expression, exhortation, and identification, which frame how form and material communicate meaning. Monö's communication process model further illustrates how products transmit meaning to users through an optimal conversational exchange. This process allows designers to trace the origins of user memory, uncover layers of inspiration, and integrate challenging yet expansive ideas through the hermeneutic circle (Gadamer, 1975).

In this regard, design functions as a translation of user needs, situated within an interpretive cycle of designer–user interaction that resonates with Shannon and Weaver's model of communication (1949). For designers' interpretation, recognizing these deviations is crucial: unintended user behaviours provide insights into how memory, creativity, and contextual reinterpretations generate new layers of meaning. Through the hermeneutic circle, designers can thus reframe unintended behaviours not as failures of design, but as opportunities to expand understanding, inspire innovation, and realign product functionality with lived user experience. Figure 2.40 indicate how hermeneutic circle linking designers' intention to unintended UHBE.

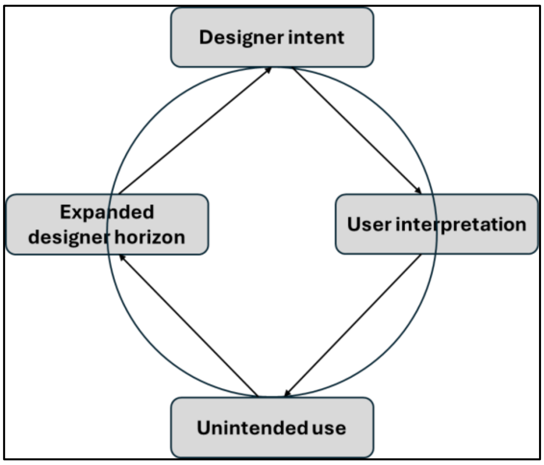

Figure 2.40 Hermeneutic Circle in Design: Linking Designer Intention to Unintended User Behaviour

2.4.9 Implicit Need of the Users

Implicit needs are the fundamental motives, desires, emotions, and frustrations that shape users' behaviour and decisions. They are not always apparent or plain, and at times, consumers may remain unaware of their existence. Implicit needs are crucial since they uncover the genuine value proposition of your product and highlight how it might be distinguished from competitors. In this study, the term implicit needs of users are used interchangeably with the notion of latent or unarticulated needs, referring to user requirements that are not explicitly expressed but can be inferred through unintended product use and behavioural adaptation. Implicit needs are more tacit and emerge through Unintended Human Behaviour (UHBE). Brandes and Erlhoff (2006), through the concept of Non-Intentional Design (NID), explained how users often generate new functions spontaneously. Dix (2007) further argued that appropriation represents a form of interaction in which users employ products in ways that deviate from the designer's original intent. Suri (2005) introduced the concept of thoughtless acts to describe automatic actions that reveal implicit needs. In addition, Kim and Paulos (2011) demonstrated how users engage in reuse, remake, and remanufacture, reflecting tacit creativity. Hirschman (1980) also emphasized use innovativeness as a form of user exploration that may not necessarily be anticipated by designers. In contrast, explicit needs encompass the core functional aspects of a product anticipated by designers. For instance, Norman (1988) emphasized that products should be designed in such a way that users can intuitively understand how to use them. Similarly, Dreyfuss (1967) highlighted safety, utility, and ease of maintenance as fundamental principles of user-oriented design. Furthermore, Moggridge (2007) as well as Desmet and Hekkert (2007) extended this concept by incorporating ergonomics and emotional experience as part of explicit needs.

2.5 Mitigation the core issue for conceptual framework

The development of this conceptual framework is synthesised from three main components in the literature review. First, the literature on product design provides a foundation for understanding the nature and challenges in product development, including the role of human factors, the evolution of design activities, and the significance of conceptual ideation. Within this context, the concept of product affordance plays a crucial role as it defines the potential interactions offered by a product. Affordance not only explains how the form and function of a product support the intended use envisioned by the designer, but also how it opens possibilities for alternative interpretations by users, which may lead to unintended uses. Second, the framework of design thinking strengthens the understanding of designers' reasoning processes, the approaches employed in addressing design challenges, and the levels of creativity and reflection embedded in design practice. This component highlights how design thinking acts as a bridge between complex user needs and more responsive, human-centred design strategies. Third, the review of UHBE in product use offers insights into user interaction, perception, and motivation towards unintended behaviours. The discussion on explicit and implicit needs, together with the phenomenon of misuse, reveals the gap between designer intent and user action. This element is essential in evaluating how product affordance, context of use, and user interpretation contribute to the phenomenon.

Thus, this study identified a gap in the previous studies regarding the motivation, context of uses, and potential towards phenomenon based on Hirschman's Use Innovativeness Model, which critically discussed the interaction attributes in consumer behaviour that recently attracted research interest in other disciplines, such as studies by Wongkitrungrueng (2018) and Pillai et al. (2022). However, the recent study on unintended interaction that links designers' design thinking remains underexplored, both theoretically and methodologically, particularly within design research and consumer behaviour research from a designer's perspective, as well as the value of the phenomenon for existing products. Thus, it reflects a gap in the fragmented integration of design research and consumer behaviour research. This study used triangulation strategies to bridge the gap and to offer a new perspective on an existing research problem.

Overall, the conceptual framework (see Figure 2.41) emphasises the dynamic relationship between designer intent, product affordance, user product interaction, context of use, and the phenomenon of unintended product use. It not only integrates theory and practice but also exposes the conceptual gap that exists, thereby contributing new insights into understanding the disjunction between designer interpretation and user perception.

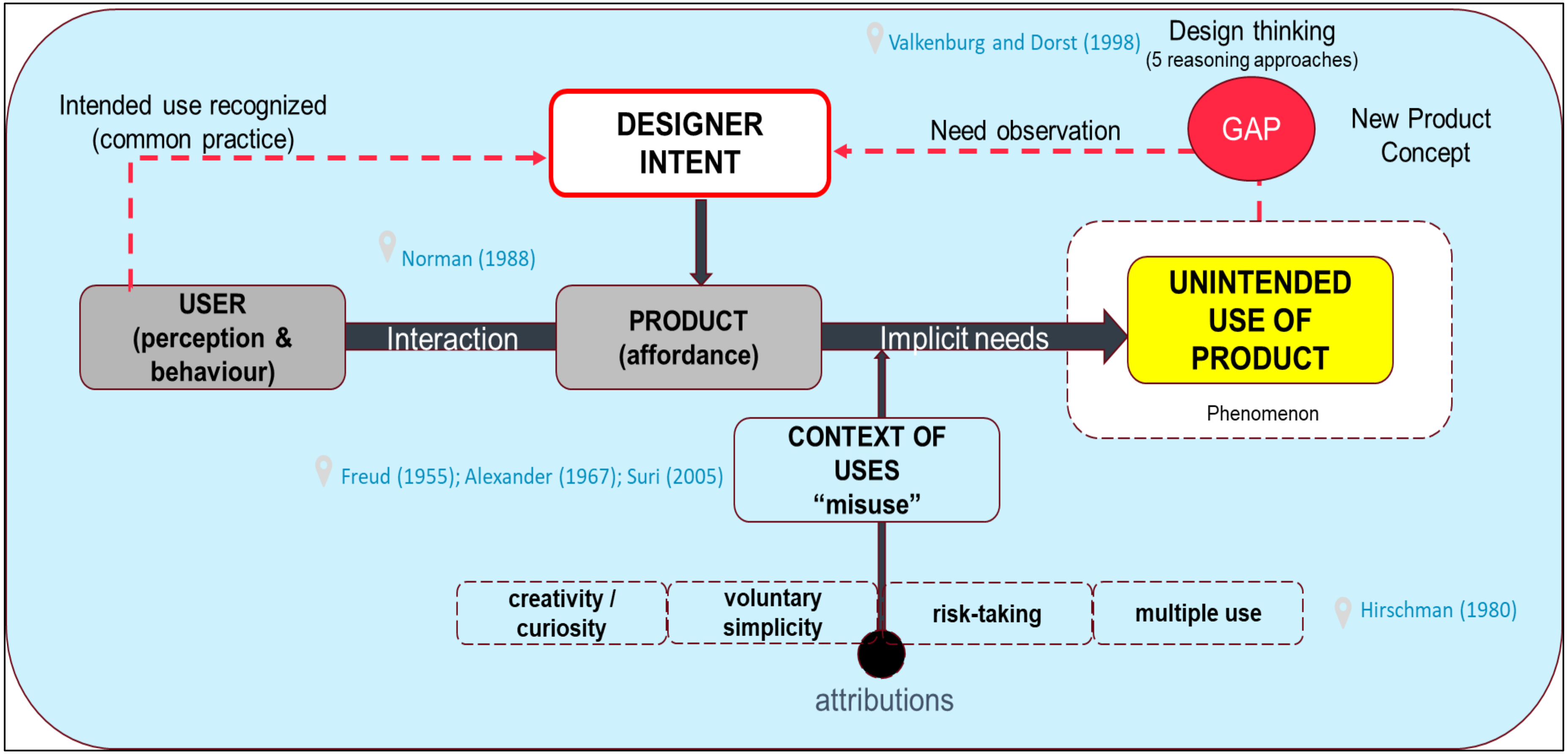

Figure 2.41 The Conceptual Framework of Designer Reasoning towards Unintended Interaction: The Integration of the Designer, User, and Product in Understanding the Phenomenon of Unintended Use of the Product

CHAPTER 3
RESEARCH METHODOLOGY

3.1 Introduction

This chapter outlines the methodological framework of the study, detailing the philosophical foundations, research design, data collection methods, and analysis strategies that are relevant to the research. In general, research methodology refers to the systematic approach used by researchers to conduct studies. It will also address ethical considerations and provide justification for the chosen approaches. The goal is to ensure that the research process is transparent, rigorous, and aligned with the objectives of the study. A well-defined research methodology provides the reliability, validity, and credibility of the research findings. Through the framework of Design Research Methodology (DRM), the component will include research paradigm, research design, research approaches, sampling and sample size that are developed within the context of the research work. Therefore, research is structured based on a particular research philosophy that defines what constitutes valid research and the appropriate methods to obtain knowledge. In this chapter, the researcher emphasises the importance of understanding the philosophical framework in evaluating and conducting strategic research.

3.2 Research Paradigm

In the world of science and philosophy, the research paradigm is a combination of thought patterns, concepts, theories, research methods and standards that are referred to and developed for a study. Kuhn (1962) explains that scientists began to define and use it to explain the whole conceptual framework of the research. According to Kamel Khaldi (2017), research paradigms determine the formulation of the problem chosen, associated research questions or hypotheses, the sampling procedure and the selection of the appropriate research tools and the way the data collection is analysed, followed by the discussion and interpretation. In other words, a research paradigm is a related system of thought and practice in defining the nature of the inquiry studied. Through examining the paradigm, humans are able to visualise the concept of understanding and solving a problem with an appropriate methodological approach to find out what lies behind meaning, variables and possibilities. Thus, this study is grounded in a research paradigm that shapes understanding of reality, guides the development of research questions, and influences the methodological choices made throughout the study. According to Crotty (1998) and Creswell (2009), the research paradigm theoretically helps scientists to initiate a study through a process of assumptions about how they will learn and what will be learned during their inquiry. Since this study is aimed at observing and investigating the designer's 'interpretation' towards social context, Kamil (2017) recommends a flexible research design to be relevant to the current situation through a clear theoretical research framework, a systematic and principled approach to unravelling the research questions and achieving the research objectives at various levels. Based on this argument, a research paradigm was specifically developed. Consequently, this study stands on the research paradigm that comprises three core components: ontology, epistemology, and methodology. Each of these elements plays a critical role in shaping the philosophical and practical orientation of the research. As proposed by Creswell (2009), the three different elements in philosophical research inquiry that help explain the research paradigm, ontology, epistemology and methodology. Table 3.1 and Figure 3.1 indicate the researcher's characteristic of 'pragmatic' paradigm use in this study.

Table 3.1
Researchers' 'Pragmatic' Paradigm

	Philosophical	Assumption
Ontology	According to Crotty (1998, p. 10), Ontological presumptions focus on what makes up reality, or simply what is, including object structures, attributes, events, processes, and relations in all domains of reality. In other words, ontology is concerned with the claims we state on what we believe to be true about how things are and work regarding our knowledge (Creswell, 1994; 2009).	The research adopts a constructivist ontological stance, recognizing that multiple social realities exist and are constructed through human interactions, conversations, and meaningful actions. Reality is explored by examining phenomenon and make sense of interpretation. These interpretations emerge from diverse human experiences, knowledge, and perspectives, and are captured through various forms of representation, including text, visuals, and videos.
Epistemology	According to Creswell (2009) epistemology is the studies of science on how we know of what we know (forms of knowledge). Epistemology concerned on how we understand the knowledge. Other point of views, epistemology concerned with the creation, acquisition, and communication of knowledge, or what it means to know. Epistemologies consist of asks the question, concerned with the nature of the relationship that exists between the would-be knower and what can be known.	The research adopts an interpretivist epistemology, where events are understood through subjective interpretation shaped by multiple contexts. Knowledge is constructed by those active in the research process through real-life experiences, natural settings, and interactive (talking, listening, writing). Its personal and interactive modes of data collection.

Methodology	Creswell (2009) defines methodology as the process of gathering data, describing, explaining, and predicting phenomena using specific methods or techniques. In other words, methodology refers to the processes for studying something or the science of discovering something. Thus, methodology is concerned with the why, what, where, when, and how of data collection and analysis. In general, the methods chosen are rooted in how the researchers perceive knowledge (ontology) and how knowledge is acquired (epistemology).	Process of data collected through multidimensional approach: (Mixed-method approaches) Users: interaction observation, video, survey Designers: verbal, interview, interaction, video, sketching and reflection session.

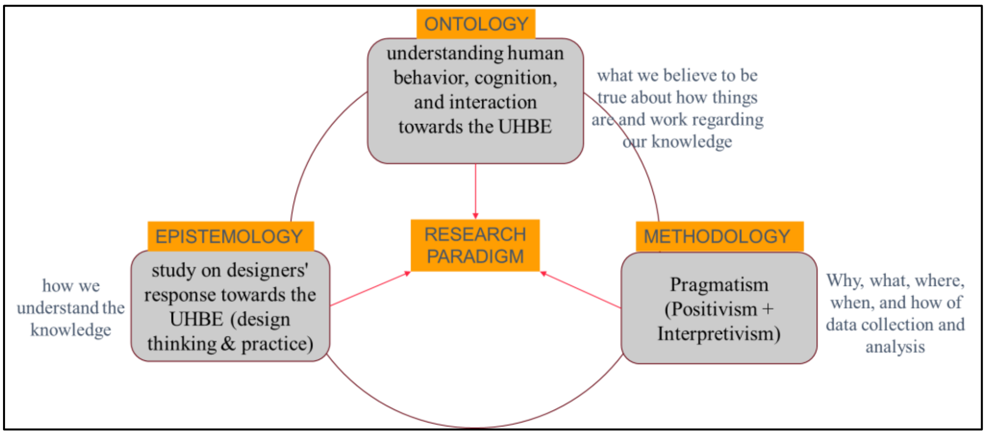

Figure 3.1 Research Paradigm

Therefore, to illustrate the philosophical and methodological aspects more visually, this research refers to the "research onion" by Saunders (2012), which helps explain the layers in planning research from the early process. This statement can be illustrated as in Figure 3.2 on the next pages.

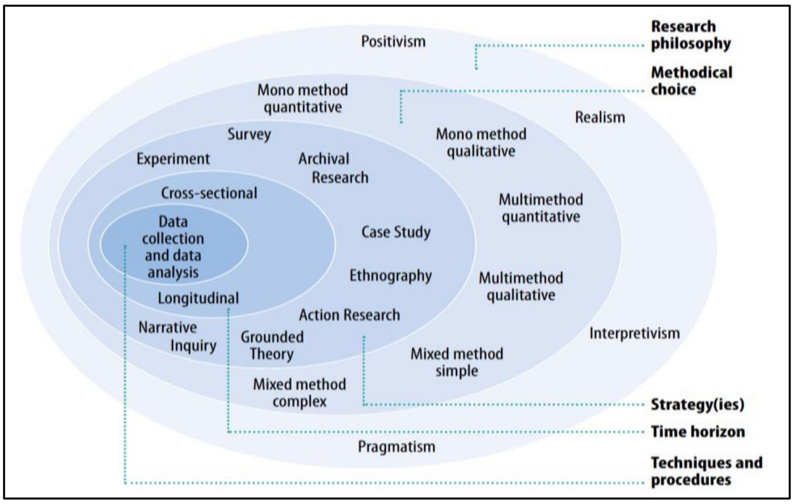

Figure 3.2 The Research Onion, adapted from Saunders et al. (2011)

Thomas Pelleth Yohannan (2010) examined ontological and epistemological perspectives via the lens of an individual's worldview. He elucidates that human perception of reality possesses relative significance and considerable effect. This worldview (his) referred to encompasses the implications of 'objectivism' and 'constructivism.' The researcher examined how the concept of worldview significantly influences various aspects of design and interaction. Consequently, an individual's perspective may vary based on the circumstances. This study emphasis both overviews and considers it as a developing consensus regarding the understanding of 'what is there?' What constitutes 'need' is particularly relevant when examining user behaviour and interaction in the context of product development from a designer's perspective. Creswell and Creswell (2018) compare qualitative, quantitative, and mixed methods approaches in determining the research process in designing research (refer Table 3.2).

Table 3.2
Comparison of Research Processes (Creswell and Creswell, 2018)

Quantitative Methods	**Mixed Methods**	**Qualitative Methods**
Pre-determined methods	Both predetermined and emerging	Emerging methods
Instrument-based questions	Both open-and closed-ended questions	Open-ended questions
Performance data, attitude data, observational data, and census data	Multiple forms of data drawing on all possibilities	Interview data, observation data, document data, and audiovisual data
Statistical analysis	Statistical and text analysis	Text and image analysis
Statistical Interpretation	Across databases interpretation	Themes, patterns, and interpretation

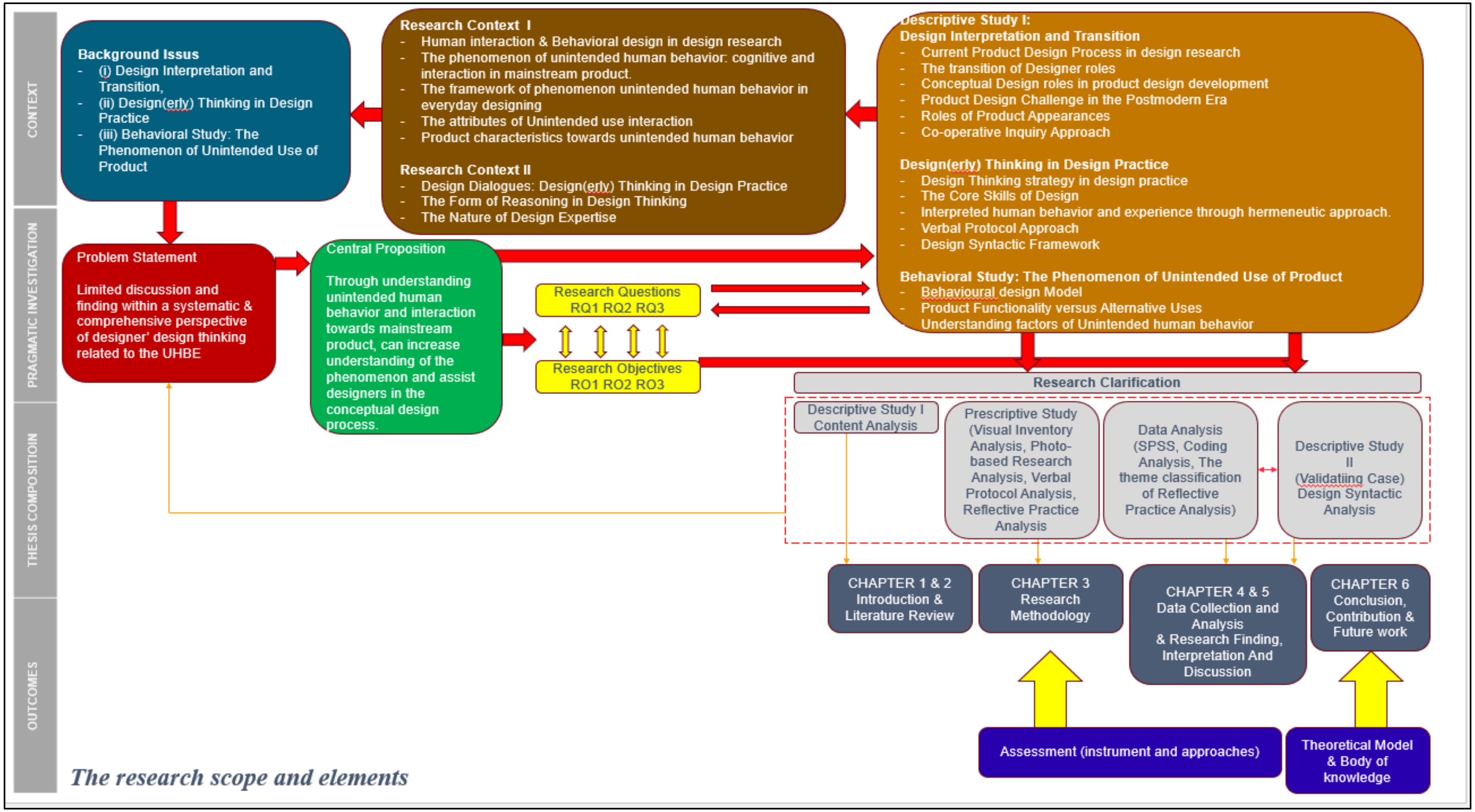

Figure 3.3 The Flowchart of Research Scope and Elements

Based on Creswell and Creswell's (2018) recommendation, this study is grounded on a pragmatic approach (mixed method) that refers to research integrating positivism (quantitative) and interpretivism (qualitative) methods in one study to produce a comprehensive explanation of research problems (refer to Figure 3.3). Leech and Onwuegbuzie (2009) agreed that mixed methods research is always considered when conducting research that relates to investigating human behaviours and phenomena. Many scholars applied mixed methods in design science research for broad and in-depth purposes of understanding and corroboration (Creswell and Clark, 2007; Johnson, et al., 2007). Consequently, pragmatic research is proposed within the scope of research as it driven by the nature of the research question and has many ways of interpreting and conducting research due to a diverse reality (Sanders and Stappers, 2008). Therefore, in this study the qualitative and quantitative approaches referred as;

1. Positivism – Use quantitative data, such as structured observation, close-ended questionnaire within researcher and participants (user and designer), inductive to deductive procedure to underlying variable factor and attributes of research subject that relies specifically on empirical scientific evidence.
2. Interpretivism – Use qualitative methods, such as semi-structured interviews, participant observation in the artificial mobile lab, and case studies that aim for 'emphatic and complex multiple understanding of the research subject, how individuals explain their behaviour and gaining in-depth insight into individual interpretation of meaning and motives.

Pragmatism incorporates aspects of both positivism and constructivism, it constitutes an independent worldview and is not bound to a singular philosophical system or reality (Creswell, 2009). Significant emphasis is placed on concentrating on a subject and employing pluralistic methodologies to gain knowledge regarding the issue. Researchers possess the autonomy to select methods, strategies, and processes for their investigations, focusing not on the dispute about reality as objective or subjective, but on how these choices best fulfil their goals and objectives. Creswell (2009). According to Liem and Bonnemaire (2015), they explained that philosophical worldviews are defined as "a basic set of beliefs that guide action" (Creswell, 2009; Lincoln and Guba (1985), which has an influence on the practice of design (see Figure 3.4 on the next pages). Based on the ontology and epistemology, the methodology for this research was determined and created based on Warell (2001), Crilly (2005) and

Liem and Bonnemaire (2015). The methodology of this research is delineated into four components: (1) Research context (Study background), (2) Research activities (Pragmatic investigation), (3) Research composition (thesis structure), and (4) Research Outcomes (refer to Table 3.3).

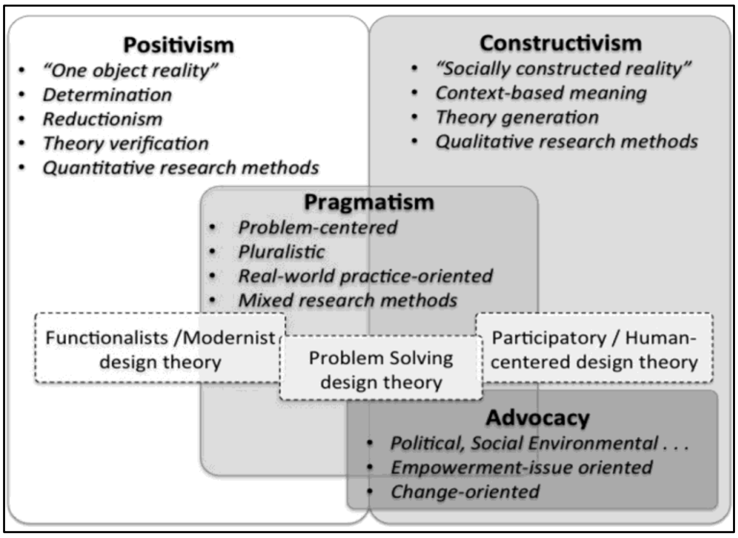

Figure 3.4 An Overview of presented Philosophical Worldviews and Design Theories, adapt by Liem and Bonnemaire (2015)

Table 3.3
Body of Research Framework

Domain	The Activities
Research context	Covers background of studies that find important issues and problems. Included basic principles of the study that elaborate on the theme, limitations and scope of knowledge studied.
Research Activity (Pragmatic Investigation)	Investigative activities carried out from the theoretical study phase to the empirical study. The investigative process in research is aimed at resolving doubts and establishing arguments that can support theory. The investigative process is developed through research questions and research objectives. This investigation contains an important element as a research structure capable of contributing to the discovery of the results that will be described in detail in data collection and analysis chapter.
Research Composition	In the thesis, the contents of research work are included. The descriptive body of work in this research work will be elaborated through thesis writing. Theoretically, a thesis composition contains a standard topic, template, and items that assist the researcher in detailing the research work. A detailed description of the research work will be discussed in detail throughout the whole chapter in this study.
Research outcomes	The end of this thesis will find the results of research work including evaluation of tools and methodologies, and the descriptive theoretical knowledge or model of study. These findings will be clearly discussed in discussion chapter.

3.3 Framing Inductive and Deductive Reasoning

Examining the comprehensive research framework (Abidin, 2012; Anwar, 2016; Kamil, 2017; Vermol, 2018), four (4) steps are employed in design research to transition from the abstract to the tangible design phase. Implementation is essential for assessing the structure and evolution of the design. The researcher initially incorporates the framework of inductive and deductive reasoning to enhance comprehension in the study and integrate essential information into experiments. The overarching significance of deductive and inductive reasoning in social research offers a scientific framework for designing research to evaluate the central propositions and phenomena. Figure 3.5 delineates the operational relationship between inductive and deductive thinking, commencing with the observation of the user's unintended behaviour in formulating generalisations regarding interaction information related to the perceived functionality of the product. Consequently, the understanding derived from the research examines the deductive approach to the designer's idea in relation to user interaction. It is a methodology that employs an observational approach to get certain findings. Inductive reasoning, by validating the phenomenon, yields a range of conclusions derived from empirical studies. This extends knowledge by examining protocols that shape human behaviour to elucidate why designs function as they do from the user's viewpoint, and how this understanding might impact the creativity and perspectives of designers during the design process. This chapter will initially analyse the discourse around the competency model research paradigm. All research is fundamentally organised around a series of philosophical assumptions that define what is considered acceptable study and the suitable methodologies for advancing the knowledge under investigation. To perform and assess strategic research projects, it is essential to understand the underlying 'assumptions.' This chapter examines the philosophical assumptions and methodological design choices that support this research investigation.

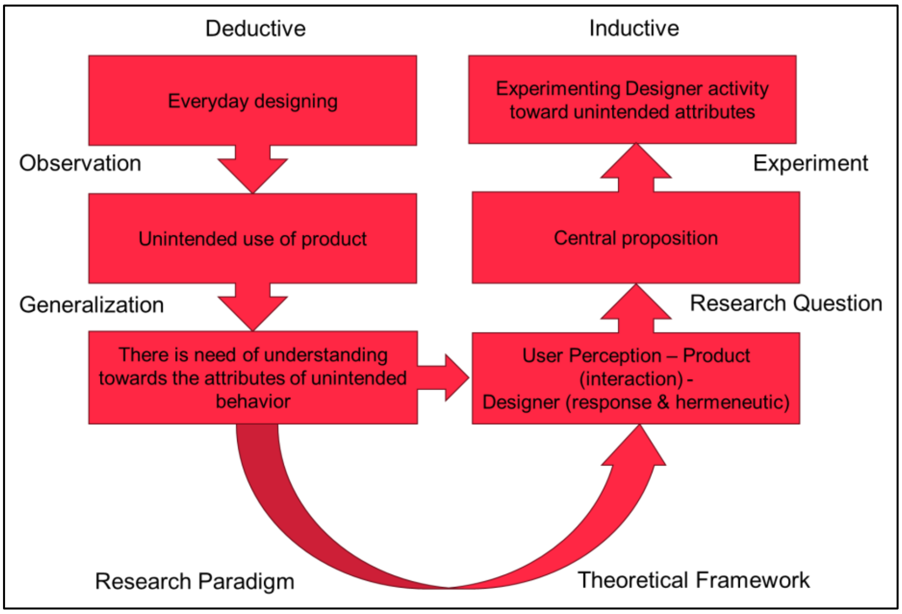

Figure 3.5 Researchers' Inductive and Deductive Reasoning in this study that rectifies directive Scope for the Research Design

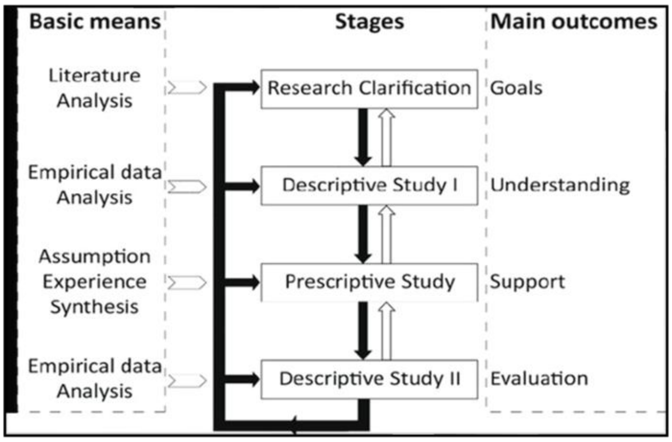

Figure 3.6 Design Research Methodology (DRM) Framework (Blessing and Chakrabarti, 2009)

3.4 The Design Research Methodology

Research can be defined as a "Systematic and logical study of an issue or problem or phenomenon through a scientific method" (Krishnaswamy and Satyaprasad, 2010). Different research methodologies are chosen to address research gaps and research questions; research methodology should enable data collection to answer the research questions (Cash, 2018). The different studies that lead to this thesis can be organized in a research framework which is based on the Design Research Methodology (DRM) proposed by Blessing and Chakrabarti (2009) (see Figure 3.6). The aim of this framework is to create an understanding of certain phenomena as well as to improve them. The DRM framework is composed of four iterative basic stages: (1) Research clarification, for identifying and clarifying the research problem; (2) Descriptive study I, through empirical studies the understanding of the research problem is increased; (3) Prescriptive study, where methods to address the research problem are developed and applied; and (4) Descriptive study II, where the impact of the proposed method is evaluated. DRM derives its knowledge from four sources: design research, design-related scientific research, cognitive psychology, and practical experience. In this study specifically, the framework was built using the following stages:

1. Research Clarification (RC): The Research Clarification phase represents the initial stage of the Design Research Methodology (DRM), aimed at systematically identifying and articulating the research problem. Blessing and Chakrabarti (2009) emphasise that effective research begins with a clear understanding of the issues to be addressed. During this phase, the researcher conducts a comprehensive literature review to identify knowledge gaps, relevant theories, and current developments in the field. This process also includes the formulation of the research objectives, key research questions, and the preliminary scope of the study. In other words, the process entails obtaining an overview of the existing understanding of the area of interest, which assists the researcher in planning the most appropriate research approach to solve problem.
2. Descriptive Study 1 (DS-1): Descriptive Study I is the second phase in DRM, aimed at gaining a clear understanding of the current situation related to the research problem. This phase focuses on observation, data collection, and initial analysis to capture real-world practices, needs, or issues within a specific context. As stated by Blessing and Chakrabarti (2009), DS-I helps identify factors influencing design performance and enables a deeper understanding of existing environments or systems. In the process of gathering sufficient evidence and understanding the current situation, which is not clearly determined in the existing literature, the theoretical studies will be expanded and critically examined during this stage. Methods used in this phase include interviews, surveys, and observations.
3. Prescriptive Study (PS): The Prescriptive Study is the third phase in DRM, focusing on developing proposed solutions based on insights gained from the

previous phase. During this stage, researchers propose models, frameworks, methods, or tools aimed at improving the design performance or addressing the issues identified in Descriptive Study I. As suggested by Blessing and Chakrabarti (2009), empirical studies will be carried out and analysed (in depth) to determine the most influential factors at this stage, as well as to answer three research questions. Activities in this phase may include conceptual design, simulations, or the development of new theoretical frameworks. PS serves as a bridge between current understanding and the intended intervention.

4. Descriptive Study 2 (DS-2): Descriptive Study II is the final phase of DRM and focuses on evaluating the effects and effectiveness of the proposed solution developed in the Prescriptive Study. The primary goal is to assess whether the proposed intervention results in meaningful improvements over the current situation or enhances design performance. In this study, the applicability and the usefulness of the UBD framework will be evaluated at this stage, whether the intervention can be proposed as a sustainable design solution method and increase the value of existing or new product concepts. The findings from this phase are used to verify whether the research objectives have been met and to refine the proposed solution if necessary.

3.5 Research Framework

From the methodology figure of DRM, (Blessing and Chakrabarti, 2009, p. 14-15) look into the scenario through the example as per given:

"Imagine a research project that starts with the aim of improving the way in which the early stages of the design process are executed, in particular the task clarification stage. The underlying assumptions of the researchers (partly based on their understanding of design and partly on beliefs) are the following: task clarification is a crucial activity; improving the quality of task clarification will improve the design process; this in turn will result in a better and thus more successful product. Furthermore, they consider the currently available design support ineffective. The researchers decide not to immediately concentrate on their initial idea, the development of a requirement management tool but to apply a systematic research

approach, following the DRM framework shown".

The flow chart of the study framework is depicted in Figure 3.7. The purpose of this framework is to incorporate all relevant variables prior to the implementation of the data collection method, allowing for the identification of additional determinants. The primary objective of this document is to function as a visual depiction of the many design tasks, significant milestones, and guiding principles, and to provide a preliminary outline of the study's progression over three years. Moreover, this framework elucidates the integration of theoretical and empirical investigations within the overarching structure.

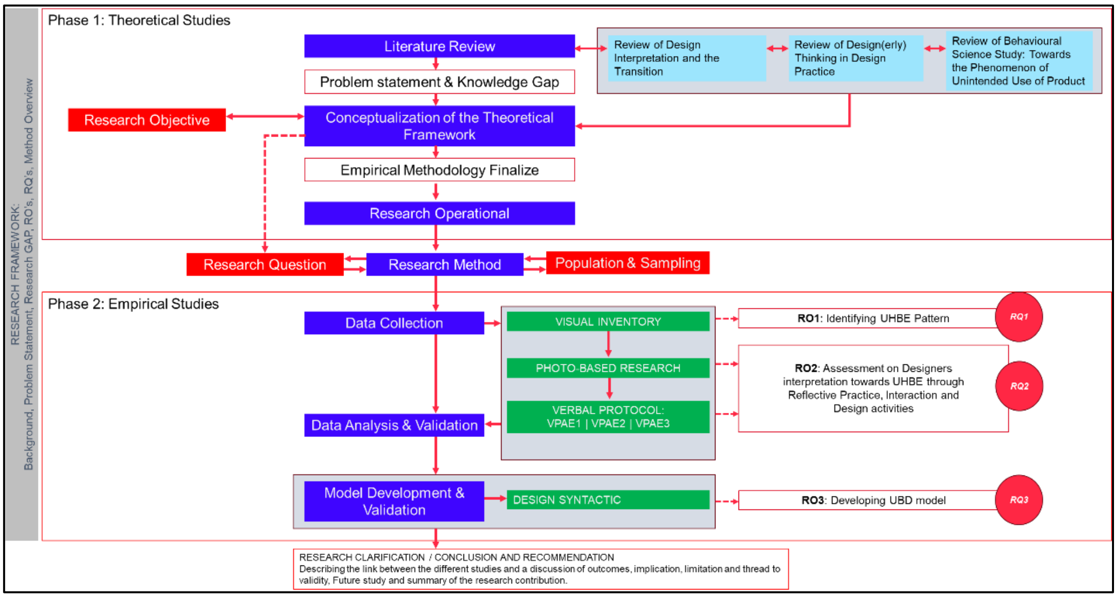

Figure 3.7 Research Flowchart of the Study

The research framework encompasses two phases of the study, the theoretical study and the empirical study, as depicted in the flowchart. The first phase of the research encompassed theoretical investigations. During this phase, the primary objective is to acquire knowledge and comprehend theories derived from prior research projects that contribute to the development of research proposals for this thesis. In this procedure, the utilisation of content analysis is employed to identify the foundational components of research, such as the most recent discoveries within a particular field of study, the methodologies used in prior studies, the identified gaps in research, and the current concerns pertaining to research theories. Consequently, the examination of research components in this study aims to establish the theoretical foundation. This involves identifying the framework of the theoretical structure, formulating research questions and objectives that align with the study's purpose, and devising an empirical design methodology to address the research inquiries. Theoretical examination conducted at this phase also facilitates the comparison of methodological techniques employed in prior research endeavours, with the aim of formulating an appropriate methodological approach for the present study.

On the second phase of the study, the empirical study was undertaken throughout the fifth to ninth semester of the academic program. In this phase, a series of tests was conducted in accordance with the stages outlined in the previous phase, building upon the findings obtained in phase 1. There are four stages of research activities during an empirical study, which consist of Visual Inventory study, Photo-based research study, Verbal protocol setting, and design syntax. An empirical study begins with an observation activity to gather data, which is then processed into the VIA approach. Visual inventory analysis focuses on users' perspectives (Collier and Collier's, 2001) using Leslie's informational layers concept (2012) to provide information regarding factors, motivation and attributes of UHBE. According to Chomoro-Koc (2011), the objective of the visual inventory analysis is to elicit the participants' perception regarding the researcher's subject research through a survey approach. In this study, the objective of conducting a survey is to evaluate the dependability of the data and solicit an evaluation from the participants. Moreover, the survey aims to reveal representative attributes of UHBE with regard to product usage towards mainstream products, as well as to address the first research question.

The second stage is Photo-based research, which focuses on evaluating designers' perspectives towards the UHBE phenomenon based on Pauwel's integrated framework of visual (2010) (where photos are selected derived from the VIA outcome). According to Mason (2005), the objective of the analysis is to ascertain the photos that exemplify a specific theoretical framework of unintended human behaviour towards mainstream products in everyday life. Through PBA, the results of the study will reveal the main properties of UHBE through visual analysis. These results can also establish a method for identifying UHBE interactions, thus answering the second research question. The survey study is very useful in obtaining the reliability of the photos, which will serve as valuable research material (specifically, visual elicitation stimuli) for the next stage of verbal protocol analysis (VPA) studies.

For the third stage, the VPA study was conducted to assess the designers' interpretation of the UHBE attribution and phenomenon. In this stage, there were three series of investigation episodes conducted focusing on: (i) Response to phenomenon through photo elicitation, (ii) Reflective thinking and interaction – moment inspiration, and (iii) Reflective practice – design sketches activity. In this experiment, four images were used as visual elicitation stimuli generated during the PBA study phase. During the VPA trial, participants were instructed to express their thoughts verbally. To illustrate, individuals could express and explain their cognitive process when generating conceptual product ideas (in the form of sketches) using their perceptions, analyses and reflections by referring to the photos provided. The findings from this third stage will also answer the second research question. A design syntax analysis (DSA) experiment was conducted at the final stage. The objective of this study was to validate the effectiveness of the UHBE design model framework, while validating the results of the various components based on the VPA, PBA and VIA studies. In other words, it assessed the potential of UHBE interaction towards mainstream products as a way for designers to produce new conceptual designs. This analysis was conducted using the design language framework, as proposed by Warell (2001). The experimental findings prompted an assessment of the relevance and effectiveness of the research conducted, supported by the results of the previous theoretical investigation in phase 1 and the comprehensive analysis of the VPA study. This experiment aimed to address the third research question.

3.6 Triangulation Strategy

In the process of obtaining comprehensive data that supports the depth of a study, the best strategy is to use a variety of approaches and sources of information. Triangulation in qualitative research refers to the use of multiple methods or data sources to increase a holistic understanding of the phenomenon being studied, which can produce new ways or discoveries of looking at the phenomenon. It can see the various strengths and focuses of sources, so that they complement each other (Creswell, 2009) (See Figure 3.8). Triangulation "gives a more detailed and balanced picture of the situation." Triangulation data seeks to establish a methodology for the objective analysis of qualitative data. Its purpose is to mitigate the deficiencies and biases that may arise from relying on any single method. Furthermore, triangulation, which encompasses both qualitative and quantitative data collection, enhances validity and introduces diverse perspectives into the research. Patton (2002) sees inconsistencies in triangulation as an opportunity to identify deeper meanings in the data obtained.

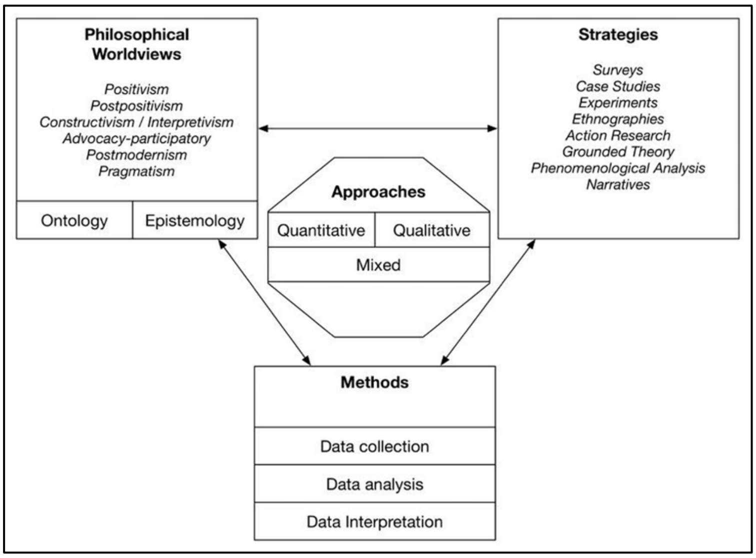

Figure 3.8 Triangulation Framework for Research Strategy, adapted from Creswell (2009)

According to Miles and Huberman (1994), triangulation in social science research refers to a process in which researchers attempt to confirm a finding by demonstrating that independent measurements do not contradict each other. Meanwhile, in human behaviour research, Cohen and Manion (2000) define triangulation as an "attempt to map out, or explain more fully, the richness and complexity of human behaviour by studying it from more than one standpoint." In the study of behavioural phenomena, for example, integrating user experience with designer knowledge to create an improvised design concept, the triangulation approach is an important aspect that can determine the consistency of data and analysis. The selection of the type of triangulation depends on the objectives of the study. In this research, multiple types of triangulations were used to confirm the findings. Based on the framework proposed by Miles and Huberman (1994), five forms of triangulation in qualitative research are distinguished:

1. Data source triangulation: Data collected from different individuals, at other times, or from different locations.
2. Methodological triangulation: Utilisation of various methods such as observation,

interviews, and document analysis.

3. Investigator triangulation: Involving multiple researchers to enhance the reliability of interpretation, akin to reliability measures in quantitative research.

4. Theoretical triangulation: Application of different theoretical perspectives to explain findings.

5. Data type triangulation: Combining both quantitative and qualitative data for analysis.

In this study, a triangulation approach was used in data collection, methodology and research analysis to investigate a research question, compare results, which helps to increase the accuracy and credibility of findings, as well as increase the certainty of study findings and reduce bias in research, as illustrated in Figure 3.9.

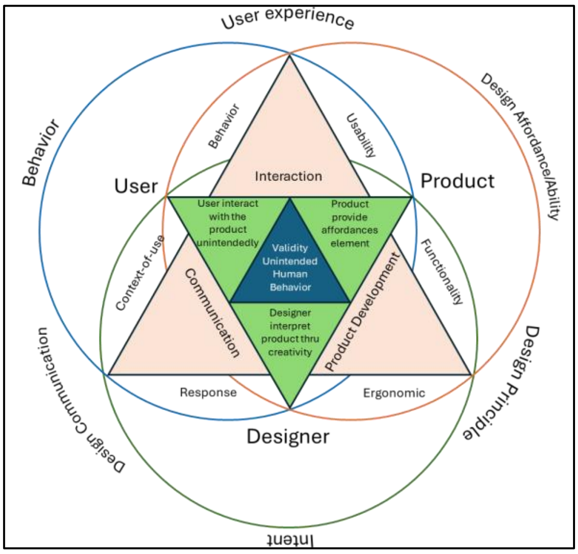

Figure 3.9 Researcher Triangulation Model in overviewing validating Concept in consecutive to area are involved, reproduce through the study Model of Farinha and Ferreira (2013)

3.7 Research Strategy and Instruments

This section provides an elucidation of the research methodology employed in the present study. The objective of this study is to conduct a comprehensive analysis and evaluation of the theoretical framework and methods used in the approach under consideration. Blessing and Chakrabarti (2009) assert that it is essential for researchers to provide a comprehensive explanation of their chosen research technique, including a justification for why this specific approach, method, and context were selected to solve the study problem, question, and hypothesis. It is imperative to provide comprehensive descriptions for each technique, regardless of whether it pertains to empirical research, supporting development, or assessment. In terms of sequential terminology, the description should have sufficient detail to enable the reader to ascertain the relevance of the findings to the present investigation. Saunders et al. (2012) identify seven distinct research strategies: experiment, survey, case study, action research, grounded theory, ethnography, and archive research, which depend on the nature of the study and the decision made by the researcher.

The strategy used in this study is set to descriptive research with the intention of exploring and obtaining research knowledge. The descriptive research approach is a research method that aims to explain the characteristics or phenomena of a population, situation, or subject being studied through data collection in a qualitative study. The descriptive research approach, also known as the systematic approach, is a research method that is summarised through several combinations of data collection methods such as questionnaires, observations, document studies, and so on. Descriptive research, which is considered conducive to providing a detailed picture of what is happening, offers a pragmatic way of collecting factual information and explaining the relationship between variables without manipulating it (Yin, 2018).

Creswell (2018) added that the descriptive approach aims "to explore and explain phenomena that are occurring in the current situation by providing a description of facts, characteristics, and patterns." This research is widely used in the social sciences and humanities to understand the behaviour, attitudes, or perceptions of individuals or groups towards a phenomenon (Babbie, 2020). In this thesis, the methodology used includes seven different descriptive research components, namely: (1) Visual Inventory Analysis, (2) Photo-based research analysis, (3) Survey study, (4) Verbal protocol analysis; (5) Reflective thinking and interaction, (6) Reflective practice analysis; and (7) Design syntactic analysis.

3.7.1 Visual Inventory Analysis

Visual analysis is an essential component of design research as it enables a deeper understanding of user behaviour, preferences, and needs (Lee, 2025; Hassan et al., 2023). The use of visual methodology, particularly through artefacts such as photographs, has long been recognised in qualitative research (Brown and Collins, 2021). Visuals serve as valuable data because they can represent past actions, provide documentary evidence, and reveal traces of practical reasoning. This method has been widely employed to study human experiences and perceptions through the systematic examination of visual and textual materials. Different techniques are commonly applied within visual analysis. Visual content analysis focuses on identifying and counting image elements, semiotic analysis interprets the meaning of signs and symbols, while visual discourse analysis explores how messages are communicated. Collier and Collier (1986) introduced the concept of visual or photograph inventory, in which everyday pictures from supported sources were analysed to understand human behaviour and personality. Research using visuals can be grouped into two general orientations. The first concerns visuals produced for specific purposes under controlled conditions, with a focus on their content. The second orientation examines the cognitive dimensions that emerge from the process of creating visual data. Van Leeuwen and Jewitt (2001) further outline two perspectives for studying images: one sees the image as a representation of who, where, and what of reality, while the other treats the image as evidence of how its creators have reconstructed reality. The first perspective views visuals as documentary data that can be examined through content analysis (Ball and Smith, 1992). Within this approach, visual materials may include advertisements, diagrams, maps, signs, and documentary photographs (Emmison and Smith, 2000). The second perspective focuses on how images reflect the reconstruction of reality, providing insights into the interpretative processes of their makers.

Visual data are understood as representations of past actions and simplified reductions of reality that require corroboration, often through testimonies, in order to address ambiguities in interpretation (Loizos, 2000). Psathas (1979), for instance, examined how practical reasoning is embedded in hand-drawn maps created by laypersons, showing how such sketches reflect both the individual's solution to the request "draw a map to our place" and their conceptual knowledge of the known world. These maps reveal personal experiences of location, highlighting how visual artefacts embody situated understanding. This aligns with Collier and Collier (2001), who argued that visual records are valuable for analysing human experience by uncovering both "pattern" and "meaning." According to Collier and Collier (2001), two distinct interpretative approaches can be applied when analysing visual records. The first focuses on examining the content of images as data, while the second interprets images as vehicles for eliciting information beyond what is visually present. Within this view, photographs taken from individual realities are appropriate sources, yet most studies have concentrated on analysing the processes of experience captured in the making of visuals, rather than verifying human experience embedded in conceptual representations.

Collier and Collier (1986) further advanced visual methods through the development of “cultural” and “photographic inventories” to systematically document social phenomena. Their inventory method, later introduced and exemplified in Contemporary Information Studies, demonstrated how structured visual data could be integrated into research designs. By carefully assessing visual records, researchers were able to incorporate visual methodologies into their studies with greater analytical impact. Between 1941 and 1959, John Collier served as a documentary photographer across diverse contexts, asserting that his photographic work sought to “mirror” the reality of situations, even when deliberately staged (Collier & Collier, 1986, p. 7). He referred to these extensive visual descriptions as “cultural inventories,” which were made possible through systematic “visual inventories” (p. 45). This approach emphasised that photographs are not neutral but reflect the lived realities of particular groups shaped by their specific locations, contexts, and cultural settings.

Based on Collier (1986), Brown and Collins (2021), Leslie et al., (2012) and Lee (2025), this study applied Visual Inventory Analysis (VIA) as the first approach to address the first research question effectively. The goal of using visual inventory as a methodology is to identify the factors and attributes of unintended use interaction from the users’ perspective. Additionally, the visuals were also used as a preparation sample of visual stimuli (research subject) for the next phase of research activity. Rationally, VIA studies will allow human memory and experience to suggest and determine the main attributes that influence human behaviour in using a product outside the original context of the product’s function, by referring to sample photos revealed in a questionnaire (survey). At this phase, a hundred photos representing UHBE were captured, and only 15 photos will be described in the VIA survey form. The photos were collected through (I) natural observation (researcher-generated) (Collier, 1967), (ii) voluntary images (participant-generated) (Clark, 1999), and (iii) social media (social media sharing) (see Banks, 2001). Detailed information regarding type of photograph, layout, information and data collection methods will be explained in Chapter Four.

3.7.2 Photo-Based Research Analysis

Photography has become an influential medium in society and culture, capturing human experiences, behaviours, and emotions in daily life. Since Collier (1957) introduced the concept of photo-elicitation to describe the use of photographs in interview-based research, photography has gained recognition as a valuable tool in qualitative inquiry. Within the social sciences, researchers increasingly adopt photographs not only to document lived realities but also to interpret the deeper meanings embedded in visual representations (Prosser, 1998; Copes & Davis, 2023). Photo-based research has been acknowledged as an important form of social symbolism, reflecting the interaction between individuals and their environments (Steen Jacobsen, 2007). Scholars emphasise that visuals function as both a mirror of social reality and a powerful force shaping cognition and social behaviour. Beyond simple documentation, photographs reveal cultural and emotional dimensions often absent from written accounts. This method is particularly valued in ethnography and visual anthropology, where photography provides reliability and interpretive depth (Pauwels, 2010). Furthermore, photographs often carry unexpected emotional resonance, provoking strong responses that enrich the understanding of human experience (Collier & Collier, 1986, p. 131). Thus, photography not only records but also interprets reality, establishing itself as an indispensable resource in qualitative social research.

Recent scholars have recognised photo-based research as a significant form of social inquiry. Rose (2016) argues that images are not just descriptive tools but cultural artefacts carrying social, technological, and symbolic meanings, highlighting the "agency of the image" within broader socio-cultural contexts and power relations. Similarly, Pink (2015) stresses the value of visual and sensory materials in accessing lived experiences and integrating them with ethnographic methods. Together, these perspectives show how visual methodologies offer critical insights into representation and visual culture. Photography has opened new horizons in qualitative research by offering multi-dimensional insights into participants' daily lives (Milasan, 2024; Copes & Davis, 2023). It extends beyond documentation, providing deeper perspectives that enrich traditional approaches. Kamil (2017) argues that photographic images are "active," functioning like speech acts, where audiences engage in interpreting meanings and responding to their implicit messages. Similarly, Burri (2012) introduces the concept of "visual rationality," positioning images as essential components in reasoning processes. This approach shifts knowledge construction from linguistic or textual foundations toward visual engagement, allowing phenomena to be understood through "seeing with images." Within mainstream research, Photo-Based Analysis (PBA) is widely recognised as a complementary method to text-based inquiry, offering interpretive depth and cultural insight. In this study, an integrated framework of visual research adapted from Pauwels (2010) is employed to ensure a comprehensive analysis of the phenomenon. This approach highlights the value of photography not merely as supportive evidence but as a critical methodological tool in qualitative exploration.

The Integrated Framework for Visual Research, developed by Luc Pauwels (2010) is a conceptual model that provides a comprehensive approach for using visual methods in social research. This framework emphasises the integration of visual data, both as a tool for data collection and as an analytical lens for understanding social and cultural phenomena. Pauwels' framework is structured around several key components:

1. The Origin and Nature of Visuals: This focuses on the type of visual material being used, whether produced by researchers (e.g., photographs, videos) or existing in cultural contexts (e.g., advertisements, art).
2. Research Focus and Design: It guides the research question, determining how visuals are used either as a subject of study or as a methodological tool.
3. Analysis and Interpretation: This involves interpreting the visual data within its cultural, social, or political context.
4. Output and Communication: It considers how visual research is presented to audiences, highlighting the importance of ethical considerations, especially in relation to representation and privacy.

Pauwels' (2010) framework has been widely adopted in diverse fields of social research, including visual ethnography, popular culture studies, media research, and investigations of social identity. Its value lies in providing researchers with a structured foundation to formulate more precise research questions, select appropriate methods of data collection, and conduct rigorous analysis of visual materials. In this study, Pauwels' framework is employed to assess designers' thinking in relation to User-

Human Behavioural Experience (UHBE). The framework facilitates the integration of visual and textual data, enabling designers to better understand and interpret how individuals interact with products and their surrounding environments through photographic sources.

Based on these perspectives, a holistic analysis that integrates text and visuals is valuable for researchers in obtaining comprehensive insights. The process begins with field notes and observations supported by photographs gathered during fieldwork. Visual analysis is then conducted by presenting photographic plates that illustrate theoretical points, accompanied by textual descriptions to support interpretation. In this approach, a theoretical concept is first developed, followed by the selection of photographic evidence that effectively demonstrates the concept. Thus, this study applies Photo-Based Analysis (PBA) to address the second research question. Rationally, the use of photographs as a methodological tool not only supports a deeper understanding but also provides access to empirical information that reveals hidden aspects of human interpretation and behaviour, often inaccessible through conventional approaches. In order to stimulate reasoning and interpretation, representative photographs of the use of UHBE from the VIA study are employed. These visuals serve as both data for evaluation from the designer's perspective and as stimuli for the subsequent phase, Verbal Protocol Analysis (VPA). The main components of the PBA study will be outlined in the survey section, while a more detailed account of data collection, findings, analysis, and interpretation within this research framework will be presented in Chapter Four.

3.7.3 Survey Research: Visual Inventory and Photo-based Research

Survey research is a procedure in both quantitative and qualitative research and is widely used to collect data from a group of people, allowing researchers to gain insights into the opinions, behaviours, characteristics, or experiences of participants. De Vaus (2013) defines survey research as a method of collecting standardised information from a specific group of individuals, usually by asking structured questions. In his book 'Surveys in Social Research' (De Vaus, 2013), he emphasises that surveys are designed to produce numerical data that can be statistically analysed to identify patterns, relationships, and trends in responses to answer the research questions. According to

Creswell (2014), survey research is a valuable strategy because it addresses a specific problem or issue, determines the perceptions of individuals or populations, and helps identify beliefs or attitudes through the analysis of a representative sample. The flexibility and efficiency in collecting large amounts of data, especially through online tools, make this approach popular among researchers. Generally, survey research designs are divided into two types of surveys: the first is the cross-sectional survey design, and the second is the longitudinal survey design. A cross-sectional study or cross-sectional time horizon is a type of observational research design in which data is collected from a population simultaneously. A longitudinal study involves the survey procedure of collecting data about the event in which data is gathered for the same subjects regarding the same variable repeatedly over an extended period of time.

Dillman et al. (2014) emphasised that the selection of survey designs should be appropriate according to the type of survey research. However, qualitative surveys are less structured than quantitative surveys and can be a useful way to understand consumer needs and preferences. In the development of survey research, De Vaus (2013) improved the aesthetic and graphic quality of surveys by using font sizes that are appropriate for respondents; rationally arranging items to avoid unintentional response bias and properly arranging items on each page can increase response rates to online surveys. Addressing these and other concerns in electronic surveys can reduce measurement error (i.e., deficiencies in validity or reliability) and increase response rates. Common characteristics of survey research as outlined by Dillman et al. (2014) are:

1. Respondents are selected through a probability sampling procedure
2. Systematic questionnaire or interview procedure
3. Sophisticated statistical techniques

Creswell (2014) suggests 6 early steps in survey research design, including (i) identifying the target population and sample, (ii) selecting survey instruments, (iii) exploring the relationships between variables, (iv) formulating research questions, (v) determining specific items to be included in the survey, and (vi) establishing procedures for data analysis and interpretation. This structure clearly shows that the survey research design procedure requires consideration of determining the participants, the variables, the appropriate instruments, and the type of analysis that will be used throughout the survey activity. Each survey design that is constructed must be either a pure experiment, quasi-experiment, pre-experiment, or single-subject design to ensure that it meets the specified characteristics.

In the study, the survey was conducted at the beginning of the empirical research and was divided into two different approaches based on the research objective. First, the survey was conducted on a group of users to assess the main attributes of UHBE through visual inventory analysis. Second, the survey was conducted on a group of designers to determine reliability and evaluate the designers' responses through photo-based research analysis. The findings from the second survey will be used as visual elicitation stimuli in the next stage of the Verbal Protocol Analysis (VPA) experiment.

Construction of Questionnaire

The structure of the survey in this study was built based on the research requirements for both approaches. It should be designed based on the purpose of the study so that the researcher can obtain the necessary data information. De Vaus (2013) emphasises the significance of a structured approach in survey research, highlights that effective survey design requires a careful and systematic process to ensure data quality and validity. Thus, He outlines several key stages in the survey process, which include: (i) Defining Research Objectives, (ii) Questionnaire Construction, (iii) Sampling and Data Collection, (iv) Questionnaire Layout and Design, (v) Pre-testing, (vi) Data Analysis, and (vii) Ethics in Survey Research (De Vaus, 2013). Based on those requirements, this research began to build a set of questionnaires for VIA and PBA research. The following are suggested steps to design a questionnaire based on Hair et al. (2016), as shown in Table 3.4.

Table 3.4
Steps to be Followed in the Design of a Questionnaire (Hair et al., 2016)

Step 1	Initial Considerations: - Clarify the nature of the research problem and objectives. - Develop research questions to meet research objectives. - Define target population and sampling frame (identify potential respondents). - Determine sampling approach, sample size and expected response rate. - Make a preliminary decision about the method of data collection.
Step 2	Clarification of Concepts: - Ensure the concept(s) can be clearly defined. - Select the variables/indicators to represent the concepts. - Determine the level of measurement.

Step 3	Determine Question Types, Format and Sequence: - Determine the types of questions to include and their order. - Check the wording and coding of questions. - Decide on the grouping of the questions and the overall length of the questionnaire. - Determine the structure and layout of the questionnaire.
Step 4	Pretest the Questionnaire: - Determine the nature of the pretest for the preliminary questionnaire. - Analyze initial data to identify limitations of the preliminary questionnaire. - Refine the questionnaire as needed. - Revisit some or all of the above steps, if necessary.
Step 5	Administer the Questionnaire: - Identify the "best practice" for administrating the type of questionnaire utilized. - Train and audit field workers, if required. - Ensure a process is in place to handle completed questionnaires. - Determine the deadline and follow-up methods.

The process of structuring the question is an important element in the construction of questionnaire design so that data is obtained accurately and effectively according to the planned strategy (De Vaus, 2013). This section will explain in detail the procedure for constructing questionnaire questions by focusing on the structure and components used in the design of the questionnaire. The main goal is to ensure that researchers obtain sufficient information based on the questions that are built (De Vaus, 2013). Each component that is developed is not only for designing effective questionnaires but also for critically evaluating survey methodologies. De Vaus systematic framework provides a strong foundation for conducting reliable and valid social research, particularly for online surveys like using Google Forms. He discusses the use of closed-ended and open-ended questions and provides detailed insights into the strengths, limitations, and appropriate use cases for each type of question.

De Vaus (2013) suggests employing closed-ended questions to get clear, quantifiable data and recommends performing statistical analysis. These are particularly effective when the range of possible answers is known and when conducting large-scale surveys. Closed-ended questions are those that provide respondents with a set of predefined answers to choose from. These questions are often multiple-choice, yes or no, or Likert scales. According to De Vaus, closed-ended questions are helpful for quantitative analysis because they produce data that is easier to code, analyse, and compare across respondents. He underlined the advantages of using closed-ended questions as;

1. Ease of Analysis: Closed-ended questions simplify data analysis since responses are standardised, making it easier to perform statistical analysis.
2. Reduced Ambiguity: By providing predefined answers, researchers can limit the

potential for respondents to misinterpret questions, thus improving the reliability of the data.

3. Efficient for Respondents: These questions are quicker and easier for respondents to answer, which can lead to higher response rates, especially in surveys with many participants.

To facilitate respondents' comprehension of the questionnaire and emphasize misunderstandings, the questionnaire uses simple words, eliminates ambiguity, and features an aesthetically pleasing format that facilitates ease of comprehension for the respondent. Additionally, respondents were afforded the option to select a sort of 'neutral'. This arises from the potential uncertainty of respondents regarding their answers to a particular topic (Pallant, 2010). However, for exploring new topics or gaining deeper insights, De Vaus (2013) recommends incorporating open-ended questions. Open-ended questions allow respondents to answer in their own words, providing richer and more detailed qualitative data. He emphasized that open-ended questions are valuable for exploratory research where the researcher seeks an in-depth understanding or when the range of possible answers is unknown. De Vaus underlined the advantages of using Open-ended questions in surveys.

1. Depth and Insight: These questions enable respondents to express their thoughts, feelings, and experiences in detail, which can lead to deeper insights that might be missed with closed-ended questions.
2. Flexibility: Open-ended questions are ideal for exploring new or complex issues where predefined answers might not be sufficient.

According to De Vaus, open-ended questions allow respondents to use terms in their own way, which may result in the collection of irrelevant data. Compared to closed questions, each response given is according to a standard and is limited to the suggested answers provided by the researcher based on the scope of the study. Although open-ended questions offer answers that are in-depth, insightful, and flexible, closed questions are needed for researchers to focus and collect more concise and representative answers. Both types of questions have (i) their respective strengths and weaknesses in data collection activities, (ii) have unintended effects on the researcher. For example, open-ended questions can elicit unexpected but valuable responses from respondents, while closed questions allow respondents to respond without any pressure.

Thus, this study employed a closed-ended question approach to provide quantifiable data. With the aim of assessing the reliability and opinions of respondents, the VIA study questionnaire design was built to analyse data from a user group. The findings from this survey will support the construction of the questionnaire design in the PBA study, which involves analysing data from a group of designer respondents. This questionnaire design includes the activity of responding to the content analysis of the image with related phenomena of UHBE through photo representation. The goal of the PBA study questionnaire design is to compare views between users and designers on the topic of the study, and how these similarities or differences are addressed to explore potential in future product design activities. In the questionnaire set of VIA study, the questionnaire components consist of four section namely: (1) Section A: Background information and demographic profile, (2) Section B: Understanding towards unintended use of product, (3) Section C: The Motivation of unintended behaviour, and (4) Section D: Overall Evaluation and Satisfaction (adapted from Leslie's informational layers concept, see Figure 3.10).

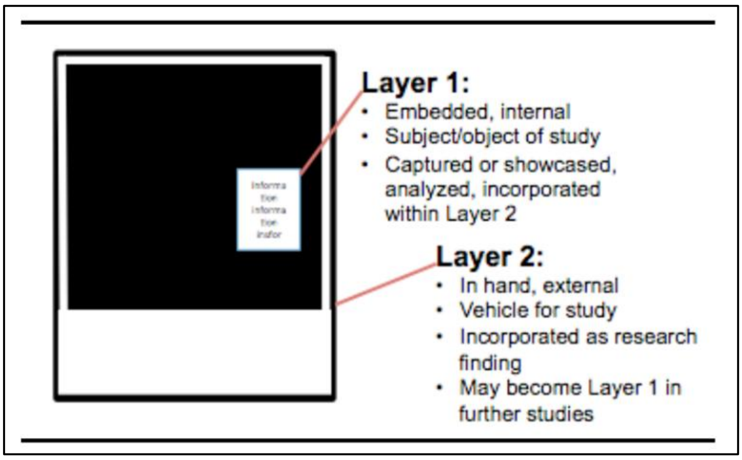

Figure 3.10 The Two "Information Layer" present for most information to Researchers who use Visual Data, adapted from Leslie (2012)

Meanwhile, the questionnaire set for the PBA study was implemented using Pauwels' theoretical framework of visual analysis. The integrated framework for visual social research introduced by Pauwel contains 9 specific criteria under 3 main components to analyse a visual. Figure 3.11 shows an integrated framework for visual social research based on Pauwel's framework used in photo-based research analysis. There are four sections of questions that will be developed through Pauwels' framework for the purpose of photo analysis. It includes (i) visual research reference, (ii) visual data resource, (iii) visual research focus and design, and (iv) Overall Analysis. To strengthen the collection of this data, several sub-criteria were designed to evaluate the response and interpretation by respondents based on specific criteria as suggested in the Pauwels Framework.

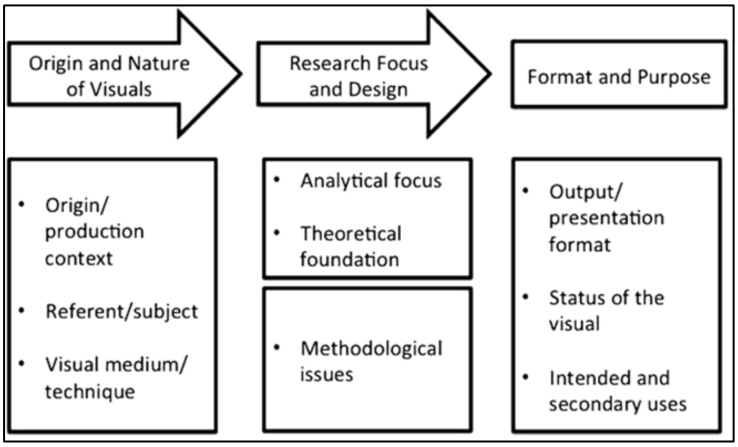

Figure 3.11 Integrated Framework of Visual Research adapted from Pauwel's Framework, (2010)

Both instruments in this study were tested for reliability using the Cronbach Alpha method. The analysis was conducted in accordance with Hair et al. recommendation. The construction of the questionnaire, the results and discussion of Cronbach's Alpha analysis will be reported in Chapter Four of this thesis. Both data collection methods (VIA and PBA) will help researchers obtain sufficient information to answer the first and second research questions through survey activities. By focusing on data from both types of survey questions, it will serve as data that can be quantified through frequency and systematic coding design to measure the reliability of stimuli and build grounded theory through photo analysis (VIA and PBA).

Likert Scale

A Likert scale was originally developed by Rensis Likert in 1932 and being popular tool used in surveys and questionnaires to measure people's attitudes, opinions, or perceptions (Likert. R, 1932). It is a way to quantify qualitative data, especially in the field of social sciences. A Likert scale is a type of rating scale used in psychological research to measure attitudes towards a statement or subject. The Likert scale comprises a sequence of statements pertaining to a specific issue, each crafted to assess the respondent’s degree of agreement or disagreement, typically use a 5-point or 7-point scale. A Likert scale is characterised as a set of items that encompasses the aggregate of positive and negative remarks regarding an attitude object, presented to a group of participants. Joseph and Rosemary (2003) assert that specific responses to items are aggregated, resulting in persons with a “strongly agree” disposition attaining the greatest scores, while those with a “strongly disagree” disposition receive the lowest scores, among others. Thus, in this study, a 5-point Likert scale was used, ranging from strongly disagree to agree strongly. This scale is used to ensure that respondents’ focused responses are completely attained. Consequently, the interpretation of the data source was converted into a descriptive style to assist the researcher in formulating pertinent hypotheses. According to Hair et al. (2016), the responses collected are considered ordinal data, which reflect an ordered relationship between categories, but the intervals between the categories are not necessarily equal. A well-designed Likert scale is symmetric, which equals positive and negative response options and balanced to reduce bias. Thus, Likert scale was utilised due to its low complexity for responders and rapid completion, as it transforms qualitative opinions into quantifiable data, facilitating statistical analysis and offering adaptability in measuring a broad issue.

3.7.4 Verbal Protocol Analysis Approach

Verbal Protocol Analysis (VPA) is a key research method in design studies as it reveals designers’ cognitive processes through verbalisation during design tasks. Shealy et al. (2023) describe it as a form of multi-tasking, drawing on the Multiple Source Theory (Basil, 2012), where designers simultaneously design and speak. VPA records participants’ thoughts either concurrently or retrospectively, which are then transcribed and analysed to identify thought patterns, strategies, and decision-making (Ericsson & Simon, 1993). This method has been foundational in exploring cognitive processes across cognitive psychology, cognitive science, and behaviour analysis. Newell and Simon (1972) defined VPA as identifying psychological processes in problem-solving, while Flower and Hayes (1980) described it as the ordered activities a subject engages in during a task. Despite concerns that verbalisation might disrupt natural cognition, Ericsson and Simon (1980) outlining three distinct levels of verbalisation:

Level 1: Overt utterance of covert articulation or oral encodings, with no intermediate processes.

Level 2: Explication of thought content, in which no new information is introduced, but the information is held in a compressed internal format. Such an utterance will cause the subject to take more time with the task but will not change the structure of the process.

Level 3: Utterance that requires the subject to explain thought processes. This involves not simply recording information in short-term memory but linking it to information in long-term memory.

Verbalisation while designing produces more than just a verbal description of design elements; it includes insight into the designer's thought processes (Shealy et al. 2023). Through their study on the behavioural science of the designing process, they found significant differences in the think-aloud approach compared to the control group, where it not only influences design cognition, but also affects neurocognition.

Cross (2001) identified five approaches for investigating design thinking, which include conducting designer interviews, undertaking observation and case studies, using research protocols, fostering reflection and interaction, and applying simulation experiments. Within these approaches, Verbal Protocol Analysis (VPA) is recognised as a valuable method in design research. It enables controlled observation and experimental examination of problem-solving behaviours, making it one of the most effective tools for exploring the cognitive processes of designers in complex tasks (Abidin, Christoforidou, & Liem, 2009). VPA is often regarded as the most appropriate method and sometimes the only available approach for uncovering the hidden cognitive mechanisms of designers.

Abidin, Christoforidou, and Liem (2009) emphasise that VPA requires participants to be trained to express their usually internalised thoughts. This method helps to examine how individuals engage with design artefacts, acknowledging that verbal expression and interaction are closely connected with language and its social use. Unlike traditional interviews that tend to record behaviour rather than cognitive processes, VPA allows participants to verbalise their actions in real time. However, the analysis depends on coders who must carefully interpret the transcripts to identify the cognitive processes behind the actions. In the field of design science, numerous scholars have extensively published studies focusing on the cognitive dimensions of design activities. Furthermore, design activities have been categorised as problem-solving activities based on the specific design phase, as outlined below: The three stages of the design process are as follows: (1) conceptual design, (2) embodiment design, and (3) detailed design. Each phase helps understand the issue, generates solutions, and leads to the critical evaluation and selection of the best one. Thus, the VPA protocol will reveal designers' problem-solving behaviours, constraints, and needs. The study examines creativity, information acquisition, memory retention, spontaneous engagement, and design aids like drawings.

Based on the constitution of Cross, (2006); Cross, Christiaans, and Dorst, (1996); Abidin, Christoforidou, and Liem, (2009); Liem, (2017); and Shealy, (2023), the rational applying VPA in this study because its ability to provide rich and detailed cognitive data, which cannot be obtained through visual observation alone. According to Abidin (2012), VPA allows researchers to understand the complex cognitive interactions in design, especially when designers generate and refine ideas. In the context of this study, VPA is used to study the phenomenon of unintended human behaviour and how designers respond to UHBE attributes when carrying out design activities. As stated in the problem statement, unintended use of the product may expose risks to users if they are not aware of how to handle the product outside its original function. The question is, how to approach designers towards the UHBE phenomenon and what is their response to the behaviour? Thus, the benefit of choosing a VPA in the study will provide a comprehensive design protocol in investigating UHBE attributions through a series of verbal protocol setting experiment to evaluate designer's response, interaction towards mediator set and reflection-in-action towards UHBE phenomenon during design activity.

3.7.4.1 VPA Setting Up

Before the VPA session is implemented, the researcher needs to ensure that the location, environment of the lab space, including sensitivity to noise from surrounding activities, is free. For technical preparation, based on studies by Anwar et al. (2015) and Abidin et al. (2008), the use of a closed-circuit television (CCTV) approach during the protocol session is practical. It includes a viewpoint arranged to record the entire experimental space in an artificial environment (a design similar to the work of a designer). Figure 3.12 shows the development of a capture strategy that allows quantitative data to be calculated with the entry of direct evidence data, as proposed by Anwar et al. (2015), through the in vitro design protocol analysis setup. In the study, they used an influence panel to function as a source of inspiration for ideas or input contributions that may influence the designer during the design activity. In addition, time management for the protocol session is also emphasised to control the series of experiments for each participant. This strategy offers a comfortable atmosphere for the designer while practising design activities.

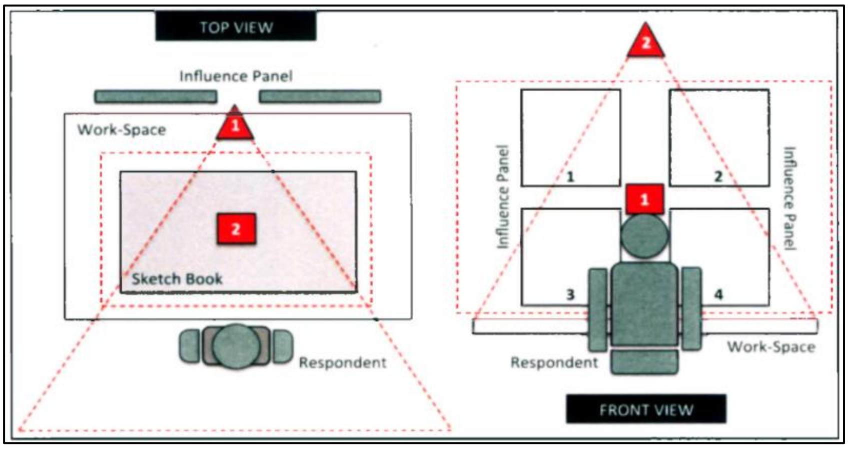

Figure 3.12 In-Vitro Design Protocol Setup (Anwar et al., 2016)

In this study, the VPA experimental design refers to the think-aloud protocol approach, where designers are asked to voice their thoughts while producing conceptual designs. This process is implemented through several sessions of recording activities using audio and video sources to ensure that all interactions, communication, and sketching activities are recorded for analysis. The data collection procedure begins with participants listening to a brief briefing about the course of the experiment and undergoing a brief training to familiarise themselves with the think-aloud technique (Abidin, Christoforidou & Liem, 2009). All activities are recorded using high-quality video and audio. In the meantime, ensuring the accuracy and reliability of data collection and analysis is an important component of every research project. Therefore, to ensure the validity and reliability used in the VPA study, this research work has adopted the three main components proposed by Creswell (2009) as follows:

1. Explaining in detail the main objectives of the study: Clear explanation of the study focus, including respondent details (category, age, experience) and logistical information (location, duration, and study period).
2. Data collection and analysis using triangulation: Internal validity and reliability were strengthened through triangulation by integrating six data sources: protocol transcripts,

video recordings, interaction images, retrospective notes, and coded matrix analysis.
3. Comprehensive report on data collection methods and analysis: A comprehensive report on data collection offers a precise and accurate picture of the data collection process, will be presented in Chapter Four.

Anwar et al. (2016) suggested managing time for the VPA activities for at least thirty minutes of design work, which aligns perfectly with the amount of information our short-term memory can hold. In design activities through VPA study, the time limit for designers to develop concepts in a short time procedure should be considered. Abidin (2011) suggested that the elements to be changed (identified as "selectivity"), rather than changing consistently, are used by designers during design activities, since it is a common practice of designers.

3.7.4.2 Interaction Protocol Analysis

Leem and Lee (2024) examined factors such as personal creativity modes, interactions, and design activities through verbal protocol analysis of interdisciplinary teams with backgrounds in arts and engineering. Interaction protocol analysis (IPA) was utilised in their studies to determine the interaction patterns among team members during the design thinking process. The IPA, proposed by Bales (1950), has been extensively employed to investigate and classify team interactions (Bell, 2001; Landsberger, 1955), particularly for examining the behaviours of small groups (Tuckman, 1965; Dowie et al., 2022).

Brown and Pehrson (2019) recently addressed the practicality of Bales' IPA method and proposed its effectiveness as a classification framework for analysing team interactions with a specific task. The interaction task is delineated through the IPA coding scheme as depicted in Figure 3.13.

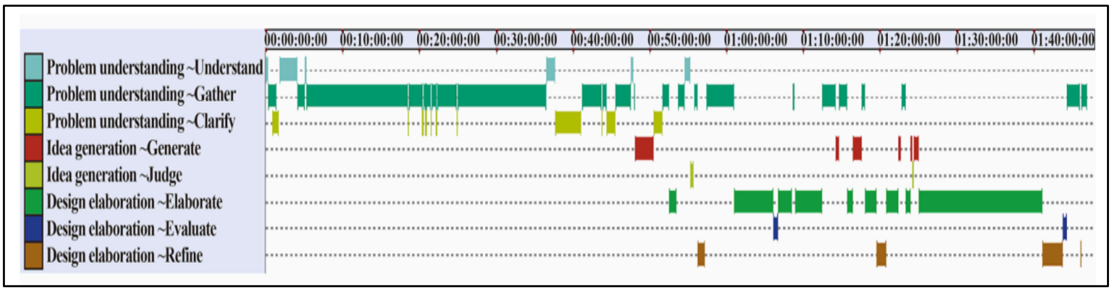

Figure 3.13 Interaction Protocol Analysis, adaptation from Leem and Lee (2024)

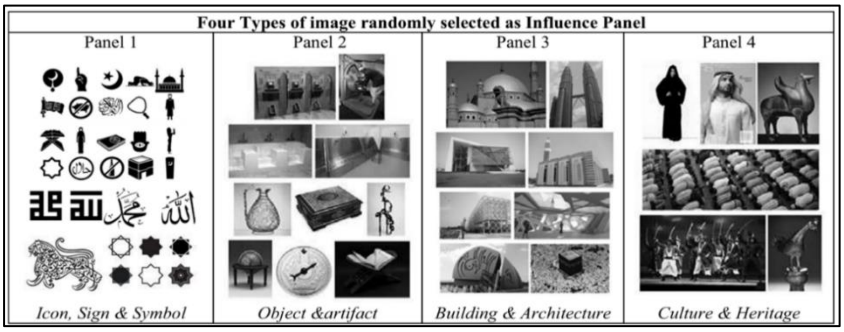

Figure 3.14 Influence Panel use to develop a concept in short time procedure (Anwar et al., 2016)

Creativity, in another sense, is a fascinating talent rooted in cognitive psychology, involving the analysis of inventive elements to understand, generate, or effectively manage their mechanisms. As noted in various literature sources (Archer, 1965; Mono, 1997; Muller, 2001; Cross, 2006; Fadel, 2009), the design process is inherently creative and thus garners similar attention. Articulating designers' thoughts during this process provides researchers with opportunities to uncover invaluable insights within the realm of "tacit knowledge" through interaction with the 'creative metaphor' (e.g images, object etc). In the study by Anwar et al. (2016), who utilised the In-Vitro Design Protocol (IVDP), notable ambiguities characterised by metaphorical thinking arise when developing forms that emerge during designers' sketch ideation. A similar finding is reported in Abidin's (2012) study, where he refers to this phenomenon as "consistency". This concept explains how designers assess metaphorical forms through their sketching tasks (Abidin, Christoforidou, and Liem, 2008). Through the mechanism, researchers are able to identify valuable insights to articulate designers' thoughts during this design activity. Thus, the use of panels can be a reference and influence designers in 'triggering' their ideas (Anwar et al. (2016). In addition, it aims to identify how designers interact with the panel and use these resources, in an explicit or implicit way. Figure 3.14 shows an example of the use of images as a source of metaphor in design activities.

Based on the constitution of Anwar (2016) and Leem and Lee (2024), this study applies the reflective thinking and interaction protocol to ascertain the interaction patterns using the influence panel, which is believed to reveal how designers frame the problem and integrate their thoughts in design strategies and decision-making regarding the UHBE phenomenon in the VPA episode. However, the explanation of how the analysis of designers' reflective thinking and interaction was conducted will be further presented in Chapter Four.

To conclude, the selection of the VPA study as an observational research approach in this research was guided by the recommendations of Cross (2006) and Abidin, Christoforidou and Liem (2009). The purpose of the study is to address the second research question, which examines designers' interpretations and reasoning regarding unintended product use and how such interactions may inspire idea generation during design activities. In this sense, the study focuses on investigating the cognitive processes designers employ in generating and refining conceptual ideas, with the broader aim of formulating a framework that fosters creativity in embedding UHBE attributes into mainstream product design. Within the research process, designers were tasked with developing conceptual ideas derived from the UHBE context of use through photo-based research while verbalising their thoughts and reflections. All interactions and communications throughout the creative process were systematically documented, including verbal explanations, reflective reasoning, and sketching activities within the natural context of design practice. Thus, VPA is essential in capturing, recording, and interpreting the richness of designers' reasoning as it unfolds in real time. The contribution of this study lies in advancing understanding of how designers perceive UHBE attributes in everyday product design and how mediated setups stimulate the generation of new product ideas. A detailed description of the methodology for conducting and analysing the VPA study will be presented in Chapter Four.

3.7.5 Reflective Practice Model

In this study, designers' interpretations and responses towards the interaction of unintended use of a product is important in design thinking and activity. Theoretically, the study was conducted to examine designers' activities in conceptual product ideation in relation to the integration of UHBE within mainstream product design. In other words, it is to analyse and understand how designers employ design activity as a strategic approach to generate conceptual ideas that embody UHBE attributions, as well as to answer the second research question. Consequently, the study adopts a practice-led research framework, also referred to as research through design (Zimmerman et al., 2007). As noted by Zimmerman, practice-led research involves using design practice as a form of inquiry to establish an evidence base that supports new insights or discoveries.

Practically, this entails designers undertaking design tasks that align with clearly defined research objectives, with the primary aim of generating and communicating novel knowledge and theories derived from their own design processes. As discussed in Chapter Two, design and designerly thinking are often viewed through the lens of reflective practice (Schön, 1983; Dorst, 2015), emphasizing the cognitive and experiential dimensions of design work. Reflective practice challenges both researchers and practitioners to re-evaluate the interplay between technical knowledge and creative artistry in the pursuit of professional excellence. It facilitates the dynamic relationship between creation and reflection-on-creation, enabling designers to refine their skills and enhance their practice-based activities continually. In this thesis, the reflective practice model is employed to reveal designers' cognitive processes and behavioural patterns during conceptual ideation focused on UHBE integration. A detailed explanation of how the reflective practice analysis was conducted will be presented in Chapter Four.

3.7.6 Design Syntactic Analysis:

Through detailed research and reference from literature sources as described in Chapter Two, the Syntactic Design Analysis (DSA) Model is used as a methodology in this research to improve the semantic understanding of products based on conceptual design by designers and address four main attributes related to the context of unintended use. The purpose of this analysis methodology is to achieve the third objective of the research, which is to "develop a model of unintended behaviour design that can enhance design thinking strategy during new product concepts". In other words, the third objectives aim to verify the applicability of the unintended-behaviour design model in generating novel ideas and design initiatives. Theoretically, this assessment is carried out with the aim of understanding the thought processes related to how designs are built and function using individual designer product concepts based on UHBE, thus validating the construction of the model framework. Rationally, the design syntactic analysis model has helped a lot in matters of in-depth understanding of design, starting from the aspects of classification, analysis, synthesis, and evaluation of visual product form in relation to technical considerations and functionality, including aesthetic aspects. In the field of design science research, this approach can be proven through research results and recommendations by the authors (Gumulya, Eiliana & Hartanto, 2022; Zhuopeng & Kamil, 2023; Kamil, 2017; Anwar, 2016; Abidin, 2014). According to Zhuopeng & Kamil (2023), a design syntactic approach helps designers to understand the form entity relations that reveal a consistent treatment of visual composition, design format, and syntactic function. In short, design syntax can be described as a basic framework that guides the creation of holistic visual product forms that integrate the technical aspects of industrial design and engineering design interactions. In this research, through individual designers' conceptual product concepts based on UHBE attribution during the VPA session, we carefully examined (i) identify and analyse the functional content of product concept, (ii) identify consistency of form entity and design being opportunistic, and (iii) analysing the format of product design concepts (Figure 3.15).

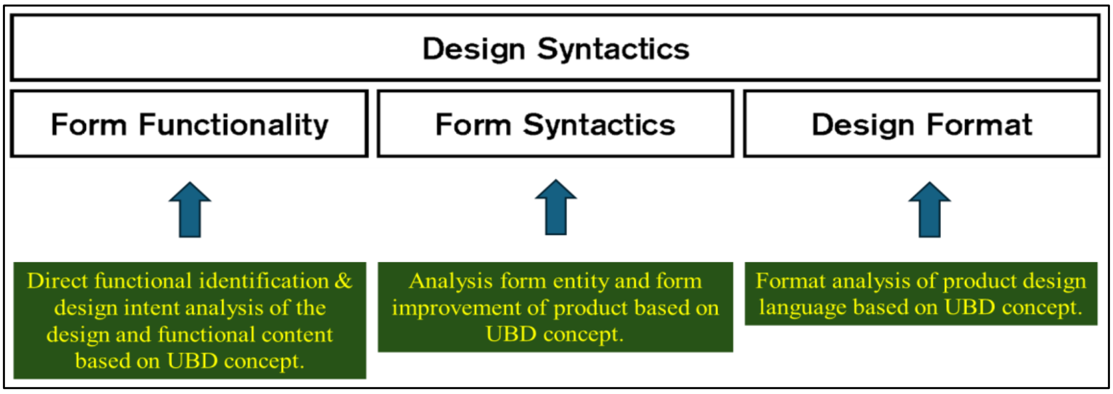

Figure 3.15 The Framework of Design Syntactic Analysis

In brief, DSA can be formulated as follows.

1. Form syntax describes how product form is organised, both at the broader organ level (e.g., the overall shape of a chair) and at the detailed material-physical level (e.g., stitching, edges, or texture of a material).
2. Form functionality addresses the idea that ever y visible surface in a product serves a function (whether structural, ergonomic, semantic, or aesthetic).
3. Design format relates to a broader design philosophy at the brand or company level, where the consistent use of form elements conveys a recognisable identity across different products (Warell & Nåbo, 2000).

3.8 Justification of Population and Sampling Profile

In research methodology, population identification and sampling are essential for producing valid, reliable, and meaningful findings. Properly defining the population ensures that the study targets the intended group or phenomenon, while sampling allows researchers to systematically select a subset of individuals, events, or objects from the larger population for analysis (Creswell, 2009). As Deming (1950) emphasized, sampling involves "the science and art of controlling and measuring the reliability of useful statistical information through the theory of probability" (p. 2). A well-defined population and carefully selected sample enable researchers to make credible inferences and establish the relevance of their findings (Garg, 2016). Since studying an entire population is often impractical due to time, resource, and feasibility constraints, representative samples are relied upon. Sampling methods are generally categorized as probability or non-probability sampling. Probability sampling techniques, such as simple random, stratified, and cluster sampling, provide each member of the population a known and equal chance of selection, enhancing the generalizability of findings. Non-probability methods, including convenience, purposive, and snowball sampling, do not guarantee equal chances and are typically used in exploratory studies or when access to specific expertise is needed. Selecting an appropriate sampling technique is critical to ensuring the validity, reliability, and applicability of results, depending on the research objectives, population characteristics, and practical considerations (Etikan, Musa, & Alkassim, 2016). A carefully chosen sampling strategy ensures that the sample reflects the diversity and key characteristics of the population, supporting credible and meaningful conclusions. However, every sampling method has inherent advantages and limitations that may affect the quality and validity of the study. In this research, the sampling process and procedures were adapted from Taherdoost (2016), as shown in Figure 3.16. Detailed discussion on data collection from the sample will be presented in Chapter Four.

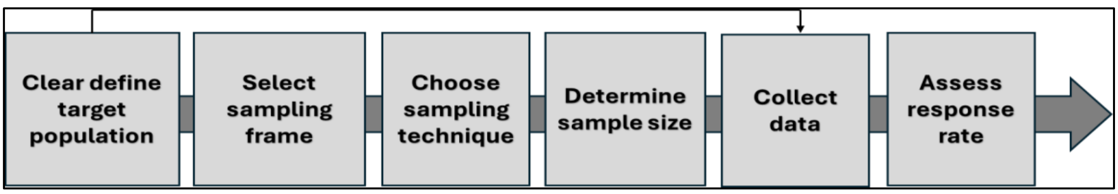

Figure 3.16 Sampling Process Steps, adapted from Taherdoost, H. (2016)

Identifying Target of the Population

In research, identifying the population refers to the process of defining a group of individuals or elements to be studied for the purpose of collecting relevant data that can be generalised through sample statistics. The characteristics of the target population, including relevance, accessibility, and representativeness, are essential in clearly outlining the scope of the study, increasing the reliability, validity, and transferability of findings. Alvi (2016) emphasised that population categories are often heterogeneous and can be subdivided into distinct groups that may not represent one another adequately. Therefore, population determination must be precise and systematic, particularly in qualitative and design research (Creswell, 2014). In this study, the target population is divided into two main groups: (1) users and (2) designers. Each group is selected based on its relevance to the phenomenon of UHBE towards mainstream product, to generate knowledge through multiple perspectives that are meaningful to the study. From user population who have direct experience towards UHBE, while designer who have a professional knowledge in industrial design (from the same background of product design).

The first target population comprises users in Malaysia with direct experiences of mainstream products that lead to unintended behaviours. This group was selected to provide foundational insights into how such behaviours occur and are perceived in real-life contexts. Participants were purposefully sampled based on clear characteristics of unintended behaviour, including product misuse or spontaneous actions, aligning with Creswell's (2014) principle of selecting participants who can meaningfully inform the research problem. The second population group consists of designers, including professional designers, product design students, design lecturers, and industrial modellers with extensive knowledge of the design process. This group was chosen to explore designers' perspectives on UHBE, particularly how they interpret and respond to user behaviours. Rooted in the theoretical orientation of design activity (Andreasen, 1998), this study employs an in-depth observational methodology, as emphasized by Cross (2006) and Yin (2018), to examine how designers engage with complex user behaviours, generate design ideas, and integrate external influences in decision-making.

Crilly et al. (2005) and De Vaus (2002) emphasise the importance of involving designers as research participants to bridge design intent and user experience. Engaging expert designers poses challenges, including time constraints and limited availability

(Cash et al., 2012). To address this, the study adopted broader inclusion criteria, involving a mixed group of design participants, as suggested by Dorst and Dijkhuis (1995), ensuring flexible representation of the design community. Guided by Jiang and Yen's (2009) categorisation of design capability, the sampling strategy includes designers with varying expertise to capture diverse insights into the design process responding to UHBE. The determination of both user and designer populations considers contextual relevance, participant involvement, inclusion and exclusion criteria, and alignment with the research objectives (Patton, 2002; Cross, 2006; Creswell, 2014; Merriam, 2015; Yin, 2018). As Golzar et al. (2022) highlight, clear population definition and sampling strategies enhance sample representativeness and generalizability of findings.

The Identification of the Sampling Frame

A sampling frame is a list or database from which a sample is drawn, representing the accessible elements of the population. It should be comprehensive and accurate to ensure the sample reflects the target population (Taherdoost, 2016; De Vaus, 2002). Selecting an appropriate sampling frame depends on the nature of the population under study (Creswell, 2014). For the user population, capturing UHBE is challenging due to its spontaneous nature and issues related to demographics, anonymity, and privacy. To ensure diversity and balanced representation, probability sampling was applied, specifically stratified random sampling. Respondents were categorised by demographic traits such as age, gender, race, and residency, with random selection within each stratum to reduce selection bias. For the designer population, challenges include restricted access to design organisations and irregular working hours, complicating appointment scheduling (Benoit et al., 2005). Given these constraints, non-probability sampling methods are suitable. Techniques such as convenience, purposive, snowball, and quota sampling are commonly used to reach "hidden" populations (Creswell, 2014). Thus, the study employs a dual approach: probability sampling for users to ensure representativeness and non-probability sampling for designers to accommodate access and scheduling constraints. This combination provides a practical and contextually relevant sampling framework, supporting the collection of diverse and meaningful data while addressing the unique challenges of both target populations.

Selection of the Sampling Scheme Method

This study employed a combination of probability and non-probability sampling to address two distinct target populations: users and designers, generating relevant data from both groups. This mixed approach aligns with Creswell and Plano Clark's (2018) recommendation for integrating multiple sampling strategies in mixed methods research. For users, stratified random sampling ensured balanced representation and allowed generalisation of findings to the broader population (Taherdoost, 2016). For designers, purposive sampling targeted those with relevant expertise, while snowball sampling enabled participants to refer other qualified designers, addressing challenges within niche expert communities (Etikan et al., 2016). The overall sampling scheme was selected based on suitability and practicality to access the target populations. Accordingly, random sampling was applied for user surveys, while the designer group employed purposive-snowball sampling across survey studies, VPA, and DSA, ensuring diverse and meaningful insights from both populations.

Sample sizes rationalization and parameter

Determining sample size in qualitative research is challenging due to the lack of fixed standards. Guest et al. (2006) identify seven sources providing guidance on appropriate sample sizes, as summarised in Table 3.5. In design research, Oppenheim (1992) notes that sample accuracy depends on the number of sub-groups considered, a view supported by Patton (2002), who emphasises that sample size is influenced by factors such as research purpose, use, credibility, and participant availability. For survey research, Sekaran (2003) cites Roscoe (1975), recommending sample sizes between 30 and 500 for most studies. These sample sizes are applied across surveys, interviews, and experimental procedures to ensure sufficient data for analysis and research findings.

Table 3.5
Sample Sizing according to Guest et al. (2006, p.61)

Research Paradigm	**Author**	**Samples / Respondents / Subjects / Participants / etc.**
Ethnography and ethnoscience	Morse, 1994: p.225	30 – 50
Ethnoscience	Bernard, 2000: p.178	30 – 60
Grounded theory -methodology	Creswell, 1998: p.64	20 – 30
Grounded theory	Morse, 1994: p.225	30 – 50
Phenomenology	Creswell, 1998: p.64	5 – 25
Phenomenology	Morse, 1994: p.225	At least 6 – above
All qualitative research (methodology)	Bertaux, 1981: p.35 – adapted from Guest et al., 2006	At least 15 – above

In qualitative research, sample sizes are often small. Charmaz (2006, p.84) notes that qualitative studies typically involve no more than 50 participants. Green and Thorogood (2009, p.120) further explain that, in interview studies, little new information emerges after about 20 interviews, indicating data can reach saturation. In this study, which involves two target populations and employs both quantitative (survey) and qualitative (VPA and DSA) approaches, the sample size was determined according to research needs. Following Oppenheim's suggestion and supported by design science researchers (Vermol, 2018; Kamil, 2017; Anwar, 2016; Abidin, 2012; Yin, 2003; Patton, 2002), a sample size of 30 is set for both the survey and VPA studies to ensure adequate data collection. For the survey, at least 30 participants are required to provide meaningful quantitative and qualitative data. The number of participants was determine based on pandemic constraint and the difficulty meet senior and expert designer, as mentioned in limitation of the study. Support by the previous study by other researcher in the same field (Vermol, 2018; Kamil, 2017; Anwar, 2016; Abidin, 2012), 30 participants is enough to provide a meaningful qualitative inquiry data. In this methodology. An industrial designer from the same background (product design) are classified into four different groups based on their career development (see Table 3.6) (see Abidin, 2012). Similarly, the VPA investigation will include 30 respondents for qualitative analysis. The number of designers (up to five at least) varying in experience use as a participant (Lloyd, Lawson & Scott, 1996). Additionally, the DSA session will involve 8 respondents to allow detailed observation and interaction, ensuring a comprehensive understanding of the research phenomenon across both target populations.

Table 3.6
Different Level of Career Development

No	**Level Expertise**	**Definition**
1	Junior	Industrial design student with design experience (1–5 years)
2	Intermediate	Work experience + knowledge in the industries & academic (6–9 years)
3	Senior	Work experience + knowledge in the industries & academic (10–19 years)
4	Expert	Work experience + knowledge in the ventures (> 20 years)

3.9 Research Ethics

MacDonald and Walton (1994) suggest that research disciplines involving human participants frequently give rise to ethical concerns pertaining to potential harm. Based on the guideline created as a result of the National Research Act of 1974, the report was written for the Protection of Human Subjects of Biomedical and Behavioural Research and published by The Belmont Report, which presents a comprehensive examination of seven ethical principles and guidelines addressing ethical issues arising from the conduct of research with human subjects. These principles follow Table 3.7.

Table 3.7
The Ethical Principles

Respect for persons – autonomy:	Research subjects must consent voluntarily and have their rights, dignity, and individuality safeguarded. An autonomous person can plan and execute goals. Respecting autonomy means considering others' opinions and not intervening unless it's harmful. When research participants lack autonomy, respect for humans requires protection. Self-determination rises throughout life, but disease, mental infirmity, or excessive limits can take it away.
Beneficence and non-maleficence:	Good research should outweigh risk. Increase research benefit and reduce participant and researcher damage. Precautions should decrease all dangers and injuries. Positive risk/benefit analysis must weigh risks and benefits. While 'risk' means damages. Psychological, physical, legal, societal, and economic rewards and hazards exist. Finding rewards may involve risk.
Justice:	Research should be equal between social groups. Equal treatment is a research justice ideal. Another example of respect for people. When selecting volunteers and weighing the pros and downsides of their research, researchers must consider the societal impact.
Informed consent:	Participants and study personnel must receive information candidly without coercion or reward for informed consent. The material should include the study method, goals, risks, rewards, alternative techniques, and a statement allowing participants to ask questions and withdraw at any time. Communication style and context are as crucial as content for understanding. Researchers must assess participant understanding.
Confidentiality and data protection:	Participants and study personnel must receive information candidly without coercion or reward for informed consent. Please follow study participant and group anonymity, confidentiality, and personal data standards. Researchers will determine whether to collect personal data, including participant interviews, during project design. Informed consent requires participant confidentiality. Participants can agree to data use many ways.
Integrity:	Research should be planned, reviewed, and executed with honesty, quality, and transparency. Faking data, documentation, or participant consent; falsifying data, imagery, or consents; plagiarizing others' ideas, intellectual property, or work (written or otherwise) without acknowledgement or permission; and misrepresenting data, such as suppressing rel.
Conflict interest	Make research independence and bias clear. A conflict of interest may compromise a researcher's independence from the institution or sponsor. Because the research may benefit them or a loved one. This gain may be pecuniary or involve commitments to others that affect studies. Possible fake conflict of interest. Researchers must disclose conflicts of interest.

This study highlights the significance of respecting and protecting the autonomy of participants, particularly when examining social structures and creating strong relationships with participants. The methodology employed in this study necessitates the use of video and audio recordings to capture participants' activities. To prevent any form of bias, it is imperative for researchers to treat all individuals equitably.

Consequently, obtaining ethics approval is unavoidable and must be obtained prior to commencing the inquiry. Therefore, the researcher has presented the written statements of participants' informed consent. Align with the UiTM requirement, all research related to human subjects must be approved by the Research Ethics Committee (REC) with reference number REC/12/2021 (MR/1074) before proceeding to the data collection process.

3.10 Validation

The validation of research has always been rooted in scientific inquiry (Pedersen, 1999) as discussed in the validation of the design approach. When qualitative researchers speak about research validity, it referred to plausible, credible, trustworthy and therefore defensible (Johnson, 1997) (refer to Table 3.8). To establish confidence in the usefulness and demand of the research, Pedersen et al. (2000) introduce the 'validation square,' which, provided it undergoes qualitative (theoretical and empirical) and quantitative (validation and performance) assessment, generally aligns with suitable validating research outcomes. The validation model (Figure 3.17) is categorised into Structural Validation and Performance Validation. Structural Validation guarantees that the methodology is logically coherent, and its elements are internally consistent (qualitative). Performance Validation ascertains the method's efficacy and utility for its designated purpose. It is quantitative and emphasises practical application.

Structural Validation is regarded as a qualitative procedure that signifies:

(1) accepting the individual constructs constituting the method.

(2) accepting the internal consistency of the way the constructs are put together in the method.

(3) accepting the appropriateness of the example problems that will be used to verify the performance of the method.

Performance Validation is considered a quantitative process that implies:

(1) accepting that the outcome of the method is helpful with respect to the initial purpose for some chosen example problem(s).

(2) accepting that the achieved usefulness is linked to applying the method.

(3) accepting that the usefulness of the method is beyond the case studies.

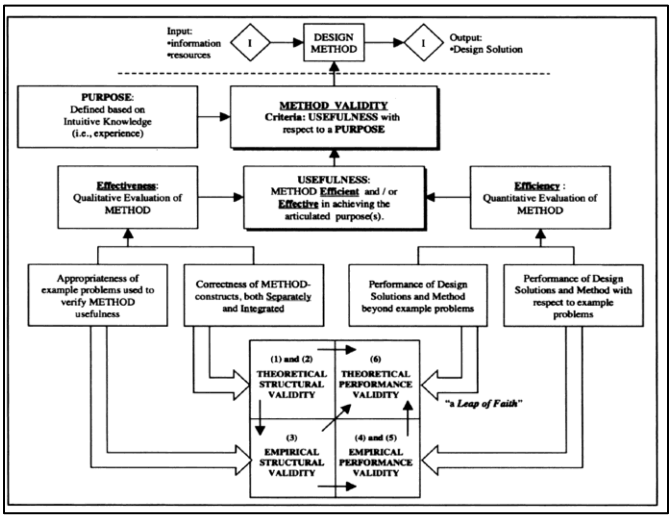

Figure 3.17 Design Method Validation: A Process of Building Confidence in Usefulness from Pedersen et al. (2000)

Both design and science concur that meticulous examination of the approaches employed to formulate their claims, whether semantic or factual, can validate their legitimacy (Krippendorff, 2006). The researcher adopts the designer's approach after analysing user feedback via the verbal protocol methodology to transcend subjectivism and uncover objective reality. This appropriateness allows the researcher to analyse the designer's intuitive insights, or "leap-thinking," shaped by experiential involvement and user feedback. The importance of engaging in ostensibly unattainable design research endeavours is rooted in the notion that the intersection of two disparate bodies of knowledge, mediated by a shared facilitator, promotes critical examination, hence substantiating further research investigations (Cash, 2018). In conclusion, the following list outlines the four types of validity evidence proposed by Cash (2012) required for this research:

1. Content validity: "That is based on the design activity that functions to build the design structure of the wash basin" in a controlled experiment.
2. Demonstration validity: "That is based on an existing artefact (conventional wash basin) that will be done and how."
3. Experimental validity: "That is based on the designers as they answer such questions that they can recognize the prototype for what it is capable of, and how much it has been tampered with during the design process."
4. Construct validity: "That is based on the level of syntactic line scores acting statistically as we would expect a measure of evidence of knowledge."

"*The mind is naturally created, the body shapes the intellect, and because most thinking is unconscious, the mind cannot know by self-reflection alone. An empirical study is necessary." ...* (Lakoff and Johnson, 1999, p. 5). Descriptions bordered below represent the researcher's selection in performing qualitative validity to the data.

Table 3.8
Practical References in promoting The Strategy in Qualitative Research Validity, inspired by the Study of Johnson, B. R. (1997)

Strategy	Description
Researcher as "Detective"	A metaphor characterizing the qualitative researcher as he or she searches for evidence about causes and effects. The researcher develops an understanding of the data through careful consideration of potential causes and effects and by systematically eliminating "rival" explanations or hypotheses until the final "case" is made "beyond a reasonable doubt." The "detective" can utilize any of the strategies listed here.
Extended fieldwork	When possible, qualitative researchers should collect data in the field over an extended period.
Low inference descriptors	The use of description phrased very close to the participants' accounts and researchers' field notes. Verbatims (i.e., direct quotations) are a commonly used type of low inference descriptors.
Triangulation	"Cross-checking" information and conclusions through the use of multiple procedures or sources. When the different procedures or sources are in agreement you have "corroboration."
Data triangulation	The use of multiple data sources to help understand a phenomenon.
Methods triangulation	The use of multiple research methods to study a phenomenon.
Investigator triangulation	The use of multiple investigators (i.e., multiple researchers) in collecting and interpreting the data.
Theory triangulation	The use of multiple theories and perspectives to help interpret and explain the data.
Participant feedback	The feedback and discussion of the researcher's interpretations and conclusions with the actual participants and other members of the participant community for verification and insight.
Peer review	Discussion of the researcher's interpretations and conclusions with other people. This includes discussion with a "disinterested peer" (e.g., with another researcher not directly involved). This peer should be sceptical and play the "devil's advocate," challenging the researcher to provide solid evidence for any interpretations or conclusions. Discussion with peers who are familiar with the research can also help provide useful challenges and insights.
Negative case sampling	Locating and examining cases that disconfirm the researcher's expectations and tentative explanation.
Reflexivity	This involves self-awareness and "critical self-reflection" by the researcher on his or her potential biases and predispositions as these may affect the research process and conclusions.

3.11 Summary of Research Methodology

This section explains the rationale behind method selection, its suitability to the research context, and how it contributes to the overall methodological framework established from the literature review. The chapter provides an understanding of the principles of research, including research design, paradigms, activities, structure, scientific approach, and sampling procedures. Establishing these elements clarifies how research methods are structured and implemented. In studies investigating human behaviour, Reason (1994) recommends a co-operative inquiry approach that integrates action, reflection, theory, and practice. In design research, human behaviour is a key factor influencing design outcomes (Warell, 2009). Hassen and Andreasen (2002) propose three components in design theory: design process, design objects, and influencing factors, to explain how design research generates knowledge, particularly regarding human behaviour and interaction. Empirical research is essential for addressing behavioural questions in design (Warell, 2001; Cross, 2006).

This study adopts the Design Research Methodology (DRM) by Blessing and Chakrabarti (2009), grounded in a constructivist ontology, interpretivist epistemology, and pragmatic methodology. Adapted from Warell (2001), Crilly (2005), and Liem and Bonnemaire (2015), the pragmatic approach combines quantitative and qualitative methods to investigate designers' perceptions of UHBE in mainstream products. The research paradigm is structured into four components: (1) Research context (background study), (2) Research activities (Pragmatic investigation), (3) Research composition (thesis structure), and (4) Research Outcomes. The research activities include the overall journey, theoretical and empirical studies, contributions through working papers, and researcher development, as illustrated in Figure 3.18. The study is conducted in two phases: theoretical studies (Research Clarification and Descriptive Study-I) and empirical studies (Prescriptive Study and Descriptive Study-II). The first phase establishes the study background, determines the study area, and refines the problem statement to ensure it is realistic, academic, and practical. A comprehensive literature review identifies knowledge gaps, relevant theories, and current developments, informing research objectives, key questions, and preliminary scope. Theoretical analysis also identifies reference models suitable for guiding methodology, data collection, and analysis, while clarifying factors influencing the research context.

The second phase (empirical study) builds on theoretical insights. Data collection and analysis aim to support the theoretical basis and investigate human factors not documented in existing literature. A quantitative approach is used in the early stage to support the qualitative approach, allowing transparent and ethical data collection. Combining quantitative and qualitative methods provides a comprehensive understanding, particularly when initial findings are unexpected. Triangulation is applied to generate new questions, reflect on participant responses, and validate findings. Four research strategies are employed: Visual Inventory Analysis (VIA), Photo-Based Analysis (PBA), Verbal Protocol Analysis (VPA), and Design Syntactic Analysis (DSA). Triangulation enhances validity and reliability, while reflective practice examines how designers integrate UHBE into new concept designs. Instruments include questionnaires, photo-stimuli, interviews, and experimental protocols. The sampling strategy involves 70 respondents for VIA using random sampling, 30 for PBA and VPA using purposive snowball sampling, and 8 for DSA using purposive snowball sampling. Research validation follows Pedersen's model, incorporating structural (qualitative) and performance (quantitative) validation. Designer feedback and verbal protocol analysis explore intuitive design thinking. Cash (2012) outlines four validity types—content, demonstration, experimental, and construct to support credible design outcomes. Applying both structural and performance validation ensures methodological coherence and practical effectiveness, while triangulation and reflective practice strengthen the reliability of insights.

Overall, the methodological framework demonstrates careful integration of theoretical and empirical approaches. The DRM approach, combining mixed methods, triangulation, and reflective practices, ensures comprehensive data collection, analysis, and validation. By engaging designers and users as participants, the study captures diverse perspectives on UHBE, informing both practical design strategies and theoretical development. The approach provides robust and credible research outcomes while addressing challenges such as sampling, data saturation, and access to expert participants. The research emphasizes the importance of design research in generating knowledge that enhances product development effectiveness (Warell, 2001). A schematic representation of the study summarises achievements, establishes methodological rules, and provides an overview of the research trajectory over a projected six-year period. The methodology integrates literature review, empirical investigation, sampling strategies, data collection, validation, and reflective analysis into a cohesive framework that supports the study's objectives (refer to Figure 3.18 on the next pages). In conclusion, this chapter provides a comprehensive overview of the methodological architecture used in this research. It explains the selection and justification of methods, research paradigms, sampling strategies, and data collection techniques. The combination of quantitative and qualitative approaches, triangulation, and reflective practices ensures robust and credible results, supporting both theoretical and practical contributions to design research. The structured approach enables the exploration of UHBE, facilitating insights into designer perceptions, user behaviour, and their interplay in mainstream product contexts. By following this rigorous methodology, the research aims to generate new knowledge that inform future design practices, contribute to academic literature, and support effective product development.

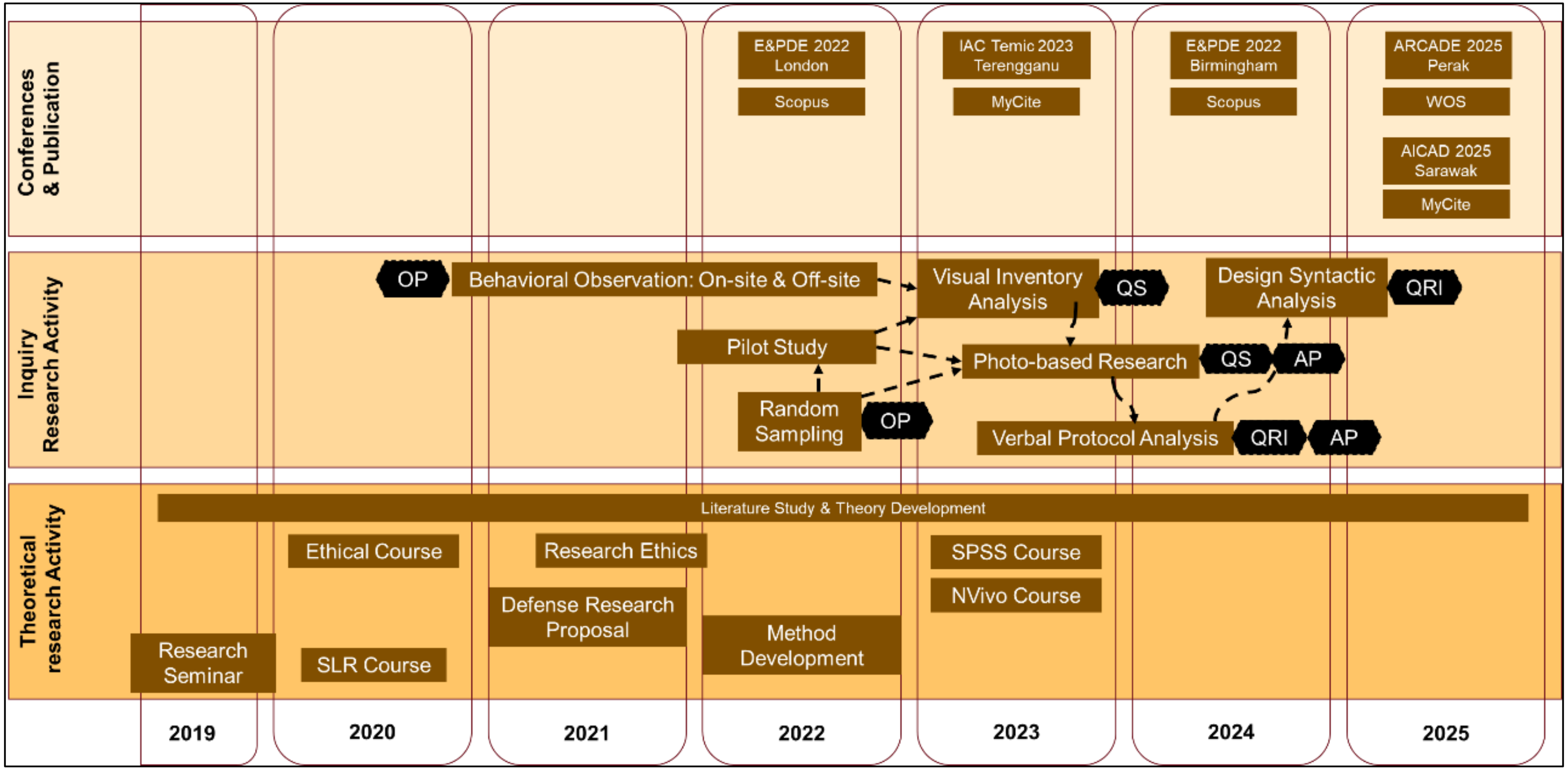

Figure 3.18 The Simplified Schematic Representation of Research Activities carried out during research work consist of Theoretical Studies, Empirical Studies, and Publications. Explanation of the abbreviations: OP = Observing Participation, AP = Active Participation, QRI = Qualitative Research Interview, and QS = Questionnaire Study

CHAPTER 4
DATA COLLECTION, ANALYSIS PROCEDURE, RESEARCH FINDINGS, AND DISCUSSIONS

4.1 The Data Collection

Data collection involves systematically gathering and analysing accurate data from various sources to address research problems and evaluate outcomes. The previous chapter outlined the general approach to investigating designers' behaviour in relation to user perception and design activities, aiming to obtain significant data for the research questions. This chapter specifies the sample and setup requirements for laboratory investigations while detailing the procedures of the core empirical methodology. According to Clemente et al., (2016), effective data collection relies on research instruments possessing five key characteristics: (i) brief and effective, (ii) systematically sequential, (iii) researcher-and sample-friendly, (iv) efficient, and (v) valid and reliable. These characteristics ensure that the data gathered is holistic and dependable.

This research follows a design science approach with two phases: theoretical and empirical studies. The theoretical phase, discussed in Chapter Two, identifies key attributes through a systematic literature review, which inform the construction of questionnaire items. The empirical phase focuses on data collection procedures, employing surveys and experiments to observe and measure real-world phenomena. Observation setups and verbal protocol procedures are recommended as effective methods for capturing designer cognition and behaviour during design development. In this study, the empirical methodology combines surveys and experimental techniques to capture both quantitative and qualitative data. Figure 4.1 (refer on next pages) illustrates the empirical research flowchart, outlining the steps involved in data collection, analysis, and interpretation. By integrating structured observation, surveys, and experimental setups, the study ensures a comprehensive and rigorous approach to capturing designers' cognitive processes and interactions with user-related phenomena, providing reliable and meaningful insights for addressing the research objectives.

Based on Figure 4.1, the data collection process in this study comprises four experimental phases: (1) visual inventory study, (2) photo-based research study, (3) verbal protocol study, and (4) design syntactic study. Phase 1 is designed to address the first research question and achieve the first research objective; phases 2 and 3 address the second research question and achieve the second research objective, while phase 4 addresses the third research question and achieves the third research objective.

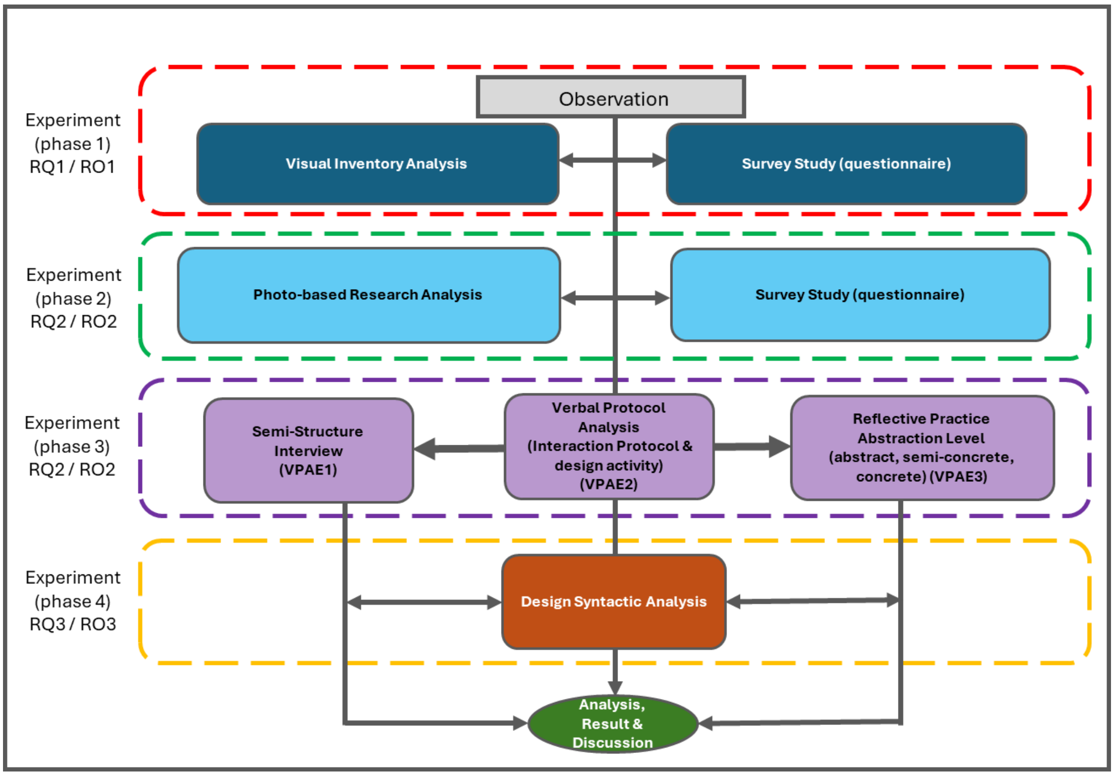

Figure 4.1 The Flowchart of Empirical Studies consists of Four Phases of Experimentation

The experiments are conducted continuously in alignment with the research workflow, where the findings from each phase influence the subsequent experimental phase. The comprehensive empirical data collection and analysis process is outlined in the subtopics, while the research conclusions are drawn from the combined results of all experimental phases. In other words, the overall data collection process of this study is illustrated in Figure 4.2 (on the next pages). Each data collection activity and analysis procedure will be explained in the following subsections.

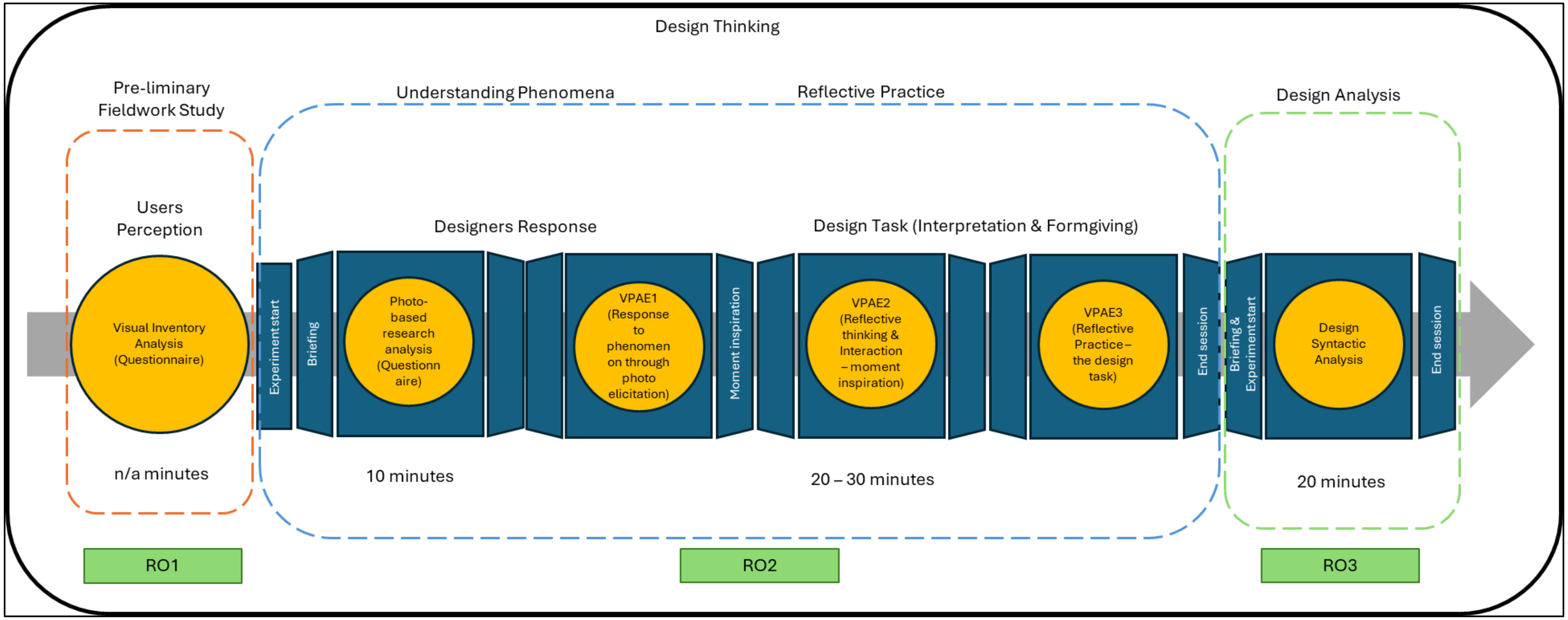

Figure 4.2 Fragmentation Stages of Data Collection Activities in the Study

4.2 Pilot Study

As discussed in Chapter Three, this study employs both quantitative and qualitative methodologies to address three research questions. Consequently, conducting a pilot study for both approaches is essential to test research instruments and tools before the main study, identifying potential issues that could affect the quality and validity of results (Anwar, 2016). Assessing the efficiency of instruments helps determine which processes should be included or modified. Given that the study involves multiple controlled processes such as data processing, verbal protocol, sketching, and design analysis obtaining participant feedback during the pilot study is critical. The pilot allows testing of research objectives, question consistency, distribution methods, protocol settings, data recording, and storage systems in the early stages. A small-scale pilot was conducted to: (i) assess feasibility, (ii) identify design issues, (iii) detect sampling problems, (iv) evaluate time and cost requirements, (v) gain experience, (vi) verify instrument functionality, and (vii) improve efficiency. Specifically, the pilot tested the questionnaire set for VIA and empirical studies, including PBA and VPA experiments, ensuring alignment of methodology with data collection procedures. It also evaluated location suitability and time allocation for participants. Any disruptions identified during the pilot allowed adjustments to instruments and data collection methods. Since human participants are involved, it was crucial to prepare them adequately to provide required data, as unforeseen issues during data collection could potentially impact the research process and outcomes.

For the quantitative research, the pilot study was conducted through the VIA study by selecting participants from fellow students to answer all the questions in the developed questionnaire. Since the study targets 100 participants to answer the first research question, the pilot study involved 10 participants, which is 10% of the total respondents required for the main study. Beyond assessing the suitability of the questions, this pilot study also tested the reliability of all questionnaire items (56 questions) using SPSS version 28, focusing on the Cronbach's Alpha value. The pilot study successfully met its investigative objectives. The results demonstrated that the questions were suitable and able to collect the intended data, while the reliability analysis indicated excellent internal consistency ($\alpha = 0.9$) according to Hair et al. (2016). Figure 4.3 illustrates the reliability of the 50 questionnaire items (excluding 6 demographic items) for the 10 participants involved in the VIA pilot study.

Case Processing Summary

		N	%
Cases	Valid	10	100.0
	Excluded[a]	0	.0
	Total	10	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
.983	.983	50

Summary Item Statistics

	Mean	Minimum	Maximum	Range	Maximum / Minimum	Variance	N of Items
Item Means	3.808	3.000	4.300	1.300	1.433	.083	50
Item Variances	.980	.400	1.656	1.256	4.139	.077	50
Inter-Item Covariances	.532	-.600	1.344	1.944	-2.241	.100	50
Inter-Item Correlations	.535	-.714	1.000	1.714	-1.400	.082	50

Summary Item Statistics

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Inter-Item Covariances	.532	-.600	1.344	1.944	-2.241	.100	50
Inter-Item Correlations	.535	-.714	1.000	1.714	-1.400	.082	50

Figure 4.3 The Reliability of Questionnaire Set in Pilot Study

For the qualitative study, a pilot study was conducted using VPA experiments (VPAE1, VPAE2, and VPAE3), which included three core activities: response to phenomena (semi-structured interviews), reflective thinking and interaction (mediator observation), and design tasks (creating new product concepts). Although the experiments were structured, potential inconsistencies across sessions required careful consideration. A pilot study was conducted to test the design protocol and data collection procedures, supported by video recording. Participants for the pilot were selected from senior designers to ensure balanced knowledge and experience across the four levels of designer expertise involved in the main study. This setup prevented visual obstructions and allowed clear recording of three critical angles: designer interactions, sketch profiles, and the overall experimental workspace. Figure 4.4 illustrates the three recording channels that captured these viewpoints with the necessary clarity, ensuring reliable and comprehensive data collection for the main qualitative study. As a result, the pilot study helped identify patterns of design activity to inform and guide the actual experimental episodes and successfully met the objectives of the empirical investigation. It verified the appropriateness of the questions, their ability to elicit the required data, and the optimal placement of designers and recording cameras.

Figure 4.4 Pilot Study conducted through Three Episodes of VPA

4.3 Visual Inventory Analysis: Identifying UHBE Attributes and Behavioural Study

In this study, an observational study was conducted to explore the issues and assist the researcher in gathering evidence to support the concept before conducting an in-depth investigation. The strategy focused on observing human behaviour both on-site and off-site, as well as skimming UHBE attributes (theoretical study) that are aligned with the primary research. The activities aimed to collect photographic data and identify key interaction characteristics that contribute to UHBE. This was carried out to answer the first research question: “What are the attributes of users’ unintended interaction with the mainstream products that reflect the phenomenon of unintended use of the product?” In other words, this study seeks a clearer understanding of the factors influencing UHBE toward mainstream products. Figure 4.5 presents the schematic stages of the VIA study, beginning with the collection of photographs that illustrate UHBE characteristics in users’ daily lives. Meanwhile, the UHBE attributes extracted from a systematic literature review of previous studies related to UHBE were used as items in the questionnaire set. This ensures that all attributes representing UHBE are clearly categorized for the purpose of this research.

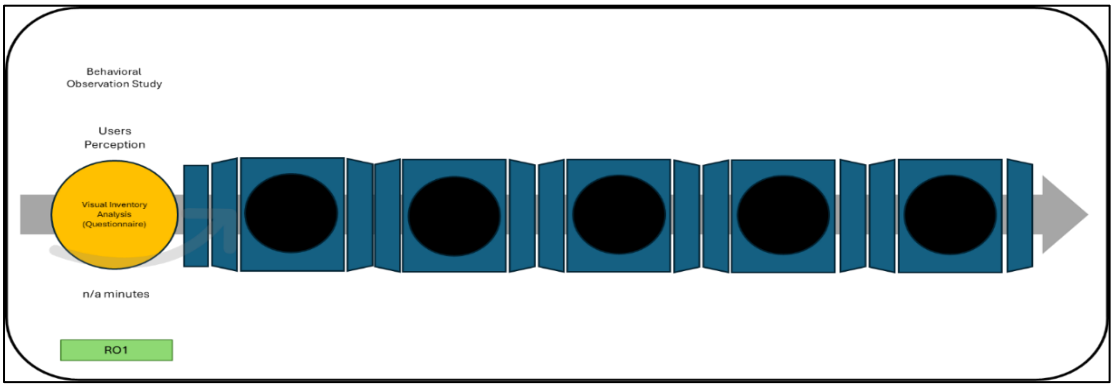


Figure 4.5 Fragmentation of Preliminary Fieldwork Study Stage

4.3.1 Visual Data Collection

Traditional user feedback approaches, such as text surveys, are no longer appropriate in collecting information on user reactions, especially to investigate factors that influence a human behaviour change, consciously or unconsciously (Wakkary et al., 2015). Text survey questions alone may not be able to capture the entire reaction of individuals, in this case, UHBE, which requires mental processes and spontaneous feedback. Thus, this study employed a visual-based approach, as it allows researchers to investigate user perceptions of their experiences and their responses to the phenomena through photo-elicitation of social contexts related to UHBE. Collier (1967) asserts that researchers who conduct studies can make use of images to elicit cultural context and information. Likewise, with the phenomenon of unintended use of products, user interaction can be evaluated and analysed through photo capture. To deeply understand human behaviour and personality, information gathered directly from the scene is essential for assessment (Collier & Collier, 1986).

As explained in Chapter Three, VIA refers to the visual analysis process of UHBE, encompassing ordinary events from human daily activities, including family, work, and community life that occur or are captured spontaneously (Liebenberg, 2009). A previous study by Kim (2021) classified the characteristics of unintended product use into two categories: (i) functions that are temporarily or permanently changed, and (ii) functions that are temporarily or permanently added. However, this study focuses explicitly on collecting or capturing photos of people who add product functions, either temporarily or permanently, in unintended ways. This means that the survey excludes contexts involving do-it-yourself (DIY) product use, modifications to the original form or physical features of the product, and combined usage (involving more than two products) that requires technical manipulation, as mentioned in the scope of the study.

As stated in Section 3.5.1, VIA photographic data were collected from three sources: (i) natural observation (researcher-generated) (see Collier, 1967), (ii) voluntary images (participant-generated) (Clark, 1999; Samuels, 2004), and (iii) social media (social media sharing) (see Banks, 2001, pp. 87, 99). Through direct and indirect observations across these three sources, more than 100 photographs were successfully collected, illustrating the exploitation of existing product functions (temporary or permanent) by individuals in various situations, which may unintentionally evoke different perceptions among viewers (including both positive and negative behaviours).

Figure 4.6 presents sample photographs collected from the three sources mentioned. For the collection of researcher-generated photographs, natural observations were conducted randomly across various locations and situations. The locations included areas around Penang, Perak, Selangor, and Kuala Lumpur, covering shopping malls, night markets, social activity spaces, and more. This was carried out to observe the relationship between human experiences and the objects surrounding them in daily life. However, there were mobility constraints during the natural observation period, as Malaysia was under the Movement Control Order (MCO), which limited movement for data collection purposes.

Therefore, the photo data collection strategy was expanded to the second source via social media platforms such as Facebook, blogs, and others to obtain a broader range of images. Interestingly, more ‘spontaneous’ and ‘logical’ images were found on social media platforms (live videos or photo postings) such as Facebook, TikTok, Instagram, and X. This source proved to be the most effective platform for finding images depicting UHBE phenomena among users. The final source was voluntary images, where participants shared photos showing unintended product use after answering survey questions. Through all three sources, the researcher captured UHBE moments as case evidence. These three data collection activities were carried out between 1 September 2019 and 20 February 2021 to obtain photographs that accurately represent UHBE characteristics.

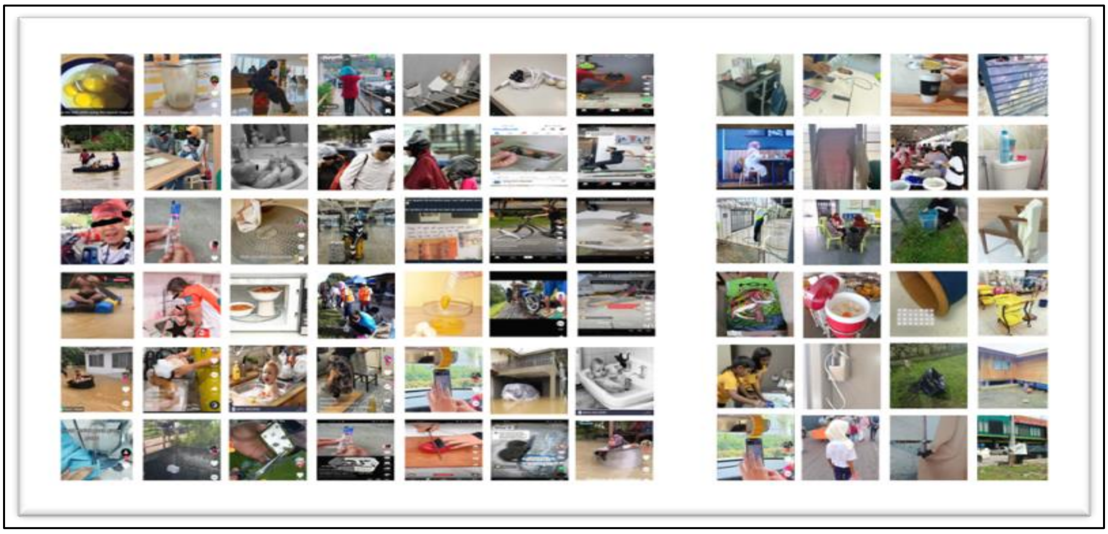


Figure 4.6 The Data Collection of Unintended Use of a product through Observation

All collected photographs were reviewed and evaluated (by fellow PhD researchers in the same faculty) based on the following criteria: (i) exploitation of existing product functions (temporary or permanent), (ii) involvement of different individuals, and (iii) demonstration of 'spontaneous' interactions. Out of 100 photographs collected in the initial stage, 15 final images were selected to represent the photo elicitation used in the developed questionnaire set. The photos included in the survey were accompanied by descriptions depicting UHBE situations and interactions (see Leslie's information layer), as illustrated in Figure 4.7. To maintain ethical standards in this research, all photos containing identifiable individuals were blurred or censored for distribution and publication purposes.

Figure 4.7 Selection of Fifteen Representative Photos used in VIA Survey of Unintended Human Behaviour in Mainstream Products

To gather responses from the people regarding the UHBE phenomenon, a questionnaire set was developed comprising four main components (see Table 4.1). The questions were designed as closed-ended questions requiring respondents to provide a rating for each item. A 5-point Likert scale was used, ranging from 1 to 5 (strongly disagree, disagree, moderate, agree, and strongly agree). Each question item was reviewed and approved by the Research Ethics Committee (REC) of UiTM (REC/12/2021 (MR/1074)). The questionnaire was prepared in two languages to assist respondents in answering the questions. The main components of the questionnaire distribution for the VIA study are presented as follows.

Table 4.1
Questionnaire Item Distribution

Section	Information	Question
A	Demography Profile	6
B	Understanding on UHBE	6
C	The Motivation of unintended behaviours:	
	(C1) Personal characteristics	6
	(C2) Dimension 1: Creativity / Curiosity	7
	Dimension 2: Voluntary Simplicity	5
	Dimension 3: Risk-Taking	8
	Dimension 4: Multiple-Use	12
D	Respondent's perception	6
Total item		**56**

Based on the table above, the questionnaire comprises four main components: (A) demographic profile, (B) understanding of UHBE, (C) motivation for UHBE, and (D) overall user perception. All questions were designed in a simple format using a rating scale. Section A consists of six basic demographic questions: location, age, educational background, occupation, and gender, which may influence understanding of UHBE. Section B contains six questions aimed at identifying the people's level of understanding and experience related to the topic being studied. Section C includes 38 questions focusing on factors, causes, and motivations that may influence UHBE. At the beginning of this section, Section C1 comprises six questions on basic personal characteristics. In comparison, Section C2 (32 questions) is divided into four dimensions of UHBE, whereas each dimension is represented by attributes that serve as keywords derived from literature findings related to UHBE research in order to help the researcher determine the primary representative characteristics for each dimension.

As stated in Chapter Three, the questionnaire was developed using Hirschman's Models of Use Innovativeness (1980), which later simplified into four dimensions by Menold et al. (2014). The total number of attributes across all four dimensions is 32 items, as discussed in Chapter Two (refer to Table 2.6). Lastly, Section D includes six questions focusing on respondents' perceptions and interpretations to validate (short-term and long-term) impacts of UHBE on society. In total, the questionnaire consists of 56 items that each respondent must answer. Most scholars in anthropology and ethnography employ visual-based research analysis as a reliable research methodology (Chomoro-Koc et al., 2011). Therefore, VIA is utilised to explore, synthesise, and analyse captured images both descriptively and objectively. The design of the questionnaire will be explained in the following section (see 4.2.3). The VIA study aims to obtain representative photos of UHBE identified by users, which will be used as stimuli in perception evaluation and visual elicitation for the PBA and VPA research.

4.3.2 Survey Conducting

In the VIA study, a survey was conducted using a random sampling approach to obtain user perceptions of UHBE and identify the attributes that influence it. The evaluation outcomes from the distributed questionnaire also help to determine the reliability of the selected photographs as photo-elicitation for the next phase of the research (PBA experiment). A total of 100 questionnaires were distributed using a dual approach (online and face-to-face) to a random selection of users. Table 4.2 presents details of the respondents involved in this study.

Table 4.2
Estimation of Respondent Involvement in the VIA Survey Study

Respondent Category	Gender		Total
	Women > 20 years	Men > 20 years	
User participant	50	50	100
		Total	100

Although respondents were randomly selected, participants were shortlisted through initial observation activities conducted during the UHBE photo collection process, as mentioned in Section 4.2.1. Generally, random observations targeted individuals who exhibited UHBE characteristics, whether in public settings or through shared content on social media (videos or photos). For participants recruited via face-to-face interaction, only those willing to complete the survey were provided with the questionnaire set via Google Forms at the survey location. Meanwhile, online participants were contacted through direct messaging on the social media platforms where they were initially observed. Upon receiving their consent, the Google Form survey link was sent to the respondents to answer all the questions provided. All responses and information submitted were kept confidential and used solely for the purposes of this research.

4.3.3 VIA and PBA Survey Analysis: Alpha Cronbach

For both surveys of VIA and PBA study (including pilot study), direct and indirect statistical data analysis was generated using the most popular method among social science researchers, namely the Statistical Package for the Social Sciences (SPSS), as well as obtaining reliability and validity of the data. To identify data that could potentially be extracted based on a structured and systematic process, this analysis used SPSS version 28 for Windows. In questionnaires, validity and reliability are two fundamental elements in evaluating a measurement instrument. Validity is concerned with the extent to which an instrument measures what it is intended to measure, while reliability is concerned with the ability of an instrument to measure consistently. Tavakol and Dennick (2011, p.53) asserted that "It should be noted that the reliability of an instrument is closely associated with its validity. An instrument cannot be valid unless it is reliable." When survey data emphasizes a scale to quantify the values, it is essential to verify the scale's reliability (Cronbach, 1951; Hair et al., 2016). Cronbach's alpha (Cronbach 1951), a metric for assessing internal consistency, is the most prevalent and commonly used dependability indicator. Reliability coefficients, including Cronbach's alpha, are generally computed using a Pearson covariance matrix, as is standard in statistical software like SPSS. This study employed Cronbach's alpha to evaluate the reliability of the VIA and PBA questionnaires. Cronbach's alpha is the predominant metric for assessing internal consistency and reliability. Calculating alpha has become common practice in social sciences research when multiple-item measures of a concept or construction are employed. This is because it is easier to use than other estimates, as it only requires one test administration. It is regarded as an indicator of scale reliability, with correlation efficiency when the range is between 0 and 1. Regarding reliability, an alpha value below 0.6 is deemed unacceptable, but an alpha value beyond 0.6 indicates an acceptable result (Hair et al, 2003). Hair et al. (2016) presents a simple step-by-step guideline for checking reliability, whereas the Cronbach alpha value is illustrated in Table 4.3.

1. See the "Case Processing Summary". It shows the number of observations
2. Reliability Statistics. It contains the amount of reliability and the number of items.
3. Item Statistics. It shows descriptive statistic for each and overall items.
4. Item-Total Statistics. It contains information of item if deleted both the scale mean and variance, corrected item-total correlation, and reliability (Alpha Cronbach if item deleted)
5. Scale Statistics. Shows the descriptive statistics for the scale

Table 4.3
The Value of the Reliability Analysis can be interpreted based on the strength using Rule of Thumb adapted from Hair et al (2016)

Cronbach's Alpha Value	Interpretation
0.9	Excellent internal consistency
0.8 to < 0.9	Strong internal consistency
0.7 to < 0.8	Acceptable internal consistency
0.6 to < 0.7	Moderate internal consistency
< 0.6	Poor / Unacceptable internal consistency

The first process of data analysis was carried out by determining the type of data analysis required to interpret the output data. Second, for the direct analysis of the questionnaire, the frequency distribution test was tested descriptively to summaries and illustrate how this test showed the number of frequencies of each value in the dataset, which helped the researcher understand the pattern and distribution of the data. Third, the data analysed were translated into a table to guide the researcher in explaining the output descriptively. Cronbach's Alpha indicates the reliability of multiple-item scales. It is a reliability coefficient that signifies the degree of interrelatedness among the elements in the set regarding internal consistency. Cronbach's alpha is frequently employed in research studies when numerous Likert scales are aggregated to form a composite score or summed scale. Reliability is commonly used synonymously with stability and internal consistency (Creswell, 2010). In preparing a survey design, item components are separated by question group to ensure that each score value tested by Cronbach's Alpha will form a reliable and consistent scale. The research design consists of several components to facilitate the understanding of the research for the participants.

4.3.4 Designing Visual Inventory Analysis Questionnaire

As mentioned in Chapter Three, the VIA survey was conducted using a questionnaire developed based on the research requirements to identify the factors influencing UHBE. Figure 4.9 shows a sample of the questionnaire designed to collect data aimed at achieving the first research objective and addressing the first research question. As previously explained, Section A focuses on demographic questions. The questionnaire also includes a brief introduction outlining the purpose of the survey, helping participants gain an initial understanding of the questions presented. Researchers' contact information is also provided if the participants require further clarification. In the questionnaire set of VIA study, the questionnaire set consists of 4 components namely: (1) Section A: Background information and demographic profile, (2) Section B: Understanding towards unintended use of product, (3) Section C: The Motivation of unintended behaviour, and (4) Section D: Overall Evaluation and Satisfaction (adapted from Leslie's informational layers concept, see Section 3.5.3). The instruments in this study were tested for reliability using the Cronbach's Alpha method. The analysis was conducted in accordance with Hair et al. recommendation. The results and discussion of Cronbach's Alpha analysis will be reported as well in this chapter.

Section A consists of 6 questions based on the demographic profile of the participant as follows: (1) Gender of respondents; (2) Age of respondents; (3) Race of respondents; (4) Occupation of respondents; (5) Education level of respondents; (6) Location of respondents. In the section B question, the respondent provides a detailed visual representation of the UHBE context of use. As mentioned in Chapter Three, the layout of the VIA questionnaire set is based on the two "information layers" of visual data, adapted from Leslie (2012). The respondent will refer to the photos to answer all questions in Section B and Section C. Table 4.4 describes detailed information on fifteen photos representing the UHBE-based recommendations by the expert, as mentioned earlier. Sample of questionnaire attached as in appendix 1.

Table 4.4
15 Representations of UHBE for Visual Inventory Analysis

Visual	Context of use	Source
	**Context 1:** use a hair clip to fix the earphone wire. -Product: hair clip -function: a clasp for holding hair in place.	Social media observation
	**Context 2:** Use food tongs to squeeze the lemon -Product: food tongs -function: a kitchen utensil that are used to move, rotate, and turn food. They can also be used to serve food, such as salad or spaghetti.	Natural Observation Location: Selangor
	**Context 3**: bathing the baby in the wash basin -Product: wash basin -function: a fixed bathroom sink that is attached to a water supply and drainage system, designed for hand and face washing.	Respondent sharing Facebook

	**Context 4**: flip the stool as a waste container -Product: stool -function: to offer seated individual’s body and arms, however certain chairs are intended for ‘perching’ rather than sitting.	Respondent sharing Facebook
	**Context 5**: the cup serves as an elevated tool to heat the food in microwave -Product: ceramic cup -function: mainly used for drinking, cups can also be used to store solids for pouring.	Social media observation
	**Context 6**: Residents wearing plastic bags on head walk in rain -Product: plastic bag -function: utilized for the containment and transportation of commodities like foodstuffs. This is a prevalent type of packing.	Social media observation
	**Context 7:** bag hanging on the back of the chair -Product: chair back -function: the portion of a chair that supports the back of a sitter.	Social media observation
	**Context 8:** winding the wire with the bottle -Product: bottle -function: to contain liquids such water, soft beverages, motor oil, cooking oil, pharmaceuticals, shampoo, or milk.	Natural observation Location: Perak
	**Context 9:** put the spoon on the cup -Product: cup -function: mainly used for drinking, cups can also be used to store solids for pouring.	Social media observation
	**Context 10:** the knob of the food thermos serves as a hanger -Product: knob handle -function: A lid handle used to hold during open or close the lid.	Social media observation
	**Context 11:** Separating egg yolk with a Water Bottle -Product: bottle -function: to contain liquids such water, soft beverages, motor oil, culinary oil, pharmaceuticals, shampoo, or milk.	Social media observation
	**Context 12:** sitting on some luggage -Product: luggage -function: Luggage is used to transport belongings while traveling.	Social media observation

	**Context 13:** air mattresses as transport to move goods during floods -Product: air mattress -function: to support your body and keep your spine aligned while you sleep	Social media observation
	**Context 14:** pot as a host for breeding fish and eggs -Product: clay pot -function: clay pot used for growing plants in.	Social media observation
	**Context 15:** fence serve as hanging clothes -Product: fence -function: a barrier, railing, or other upright structure, enclosing a designated area to restrict or manage entrance or egress.	Natural observation Location: Pulau Pinang

In Section B, there are six questions that respondents are required to answer by referring to the photo representation provided. The six questions are as follows:

1. *Do you have any experience with the scenario described above?*
2. *Does the behaviour of using the product outside of its original function occur among users?*
3. *Have you, your family, or your friends ever experienced a situation in which a product was used outside of its original function, as illustrated above?*
4. *Human behaviour that extends a product beyond its intended purpose can influence others.*
5. *Using a product outside of its original function involves risks.*
6. *Using a product beyond its original function means fulfilling a specific purpose.*

Next, Section C is divided into two segments, namely Section C1 and Section C2, to identify the key factors that influence why users create unintended use of products. Section C1 consists of six questions covering: (1) Age, (2) Personal Experience, (3) Personal Income, (4) Technical Skill, (5) Knowledge, and (6) Lifestyle. This section requires respondents to determine the fundamental factors contributing to UHBE in relation to mainstream products during everyday interactions. The next section, Section C2, represents the core part of the research for the first research Objective, which involves evaluating the attributes of UHBE in mainstream products. Section C2 consists of four dimensions: (1) Creativity/Curiosity, (2) Voluntary Simplicity, (3) Risk-Taking, and (4) Multiple Use (see Figure 4.8). In this section, a total of 32 attributes across the four main dimensions are evaluated by respondents, as outlined in Section 2.3.10. All attributes within each dimension were derived from a systematic review of literature related to concepts such as unexpected behaviour, designing for appropriation, unorthodox use, non-intentional design, design-by-use, and unselfconscious interaction (Hassan et al., 2022). The following presents the main components of the dimensions along with the attribute representations of unintended behaviour used in this study.

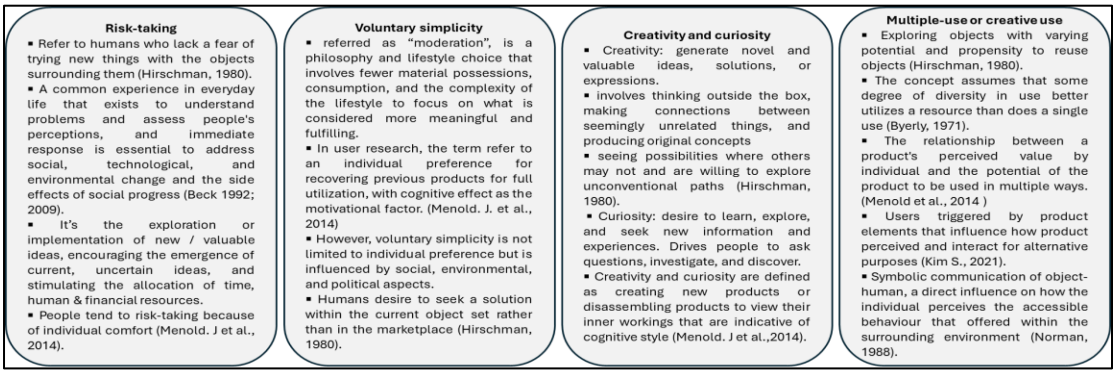


Figure 4.8 4-Dimension of UHBE Attributes

Meanwhile, Section D requires respondents to provide their perceptions of the overall evaluation conducted in the survey. A total of six questions is presented for respondents to answer. The six questions in Section D are as follows:

1. *Objects and situations affect the likelihood of changes in human behaviour?*
2. *"Unintentional" behaviour occurs when the user is facing a specific problem?*
3. *Unintentional behaviour helps you complete a goal or task in certain situation?*
4. *When discovering new functionality that benefits users, they tend to repeat it?*
5. *When the behaviour is frequently repeated, it can become a habit in human life?*
6. *"Unintentional" behaviour, when habitual, can be considered an intentional act?*

To select a representative example of "unintended interaction with products" for the think-aloud and design experiments, respondents voted for five of fifteen UHBE situations they observed or experienced. The selected situations were used in the subsequent Photo-Based Research analysis. All survey responses were automatically stored in an online Google Drive database and later compiled in a big data repository for analysis. Detailed findings from this selection and analysis process will be presented in next section.

4.3.5 The Result: Identifying Unintended Attributes from Users Perception through Visual Inventory Analysis

The VIA study involves survey research which conducted towards users as active respondents to assess the perception of UHBE phenomena. The aim of VIA study to address Research Question 1.

RQ1: *What are the attributes of users' unintended interaction with the mainstream products that reflect the phenomenon of unintended use of the product?*

This section will be presenting result from the survey conducted and discuss the findings in three segments: (1) descriptive analysis of visual inventory; (2) frequency distribution analysis of respondents; and (3) Cronbach's Alpha analysis. As stated in the Chapter One, the RO1 was designed to obtain data from VIA study: to identify the attributes of unintended use of product interactions that emerge from users' everyday experiences through behavioural observation. In other words, the main purpose of VIA is to find attributes or factors or characteristic that influence UHBE towards mainstream product in users' everyday life. In addition, the VIA also conducted to find 'one' representation of unintended interaction based on 15 photos provided in the questionnaire set, to be used (later) as a 'material' for photo elicitation stimuli in Photo-based research and VPA studies, as well as to obtain the reliability of the photo selected. During the observation phase, over 100 photographs representing 'unintended interaction' were captured, received, selected, and documented through natural observation, social media sharing, and voluntary by participants. All photos depict human exploitation of mainstream products that are interacted unintentionally, which create new uses or experiences based on specific context, problem facing users encountered in everyday life. In this chapter, the presentation leads to a discussion of how photos are documented and analysed. Figure 4.9 illustrates the fifteen photos that were selected and used as visual inventory that were used for the survey purpose.

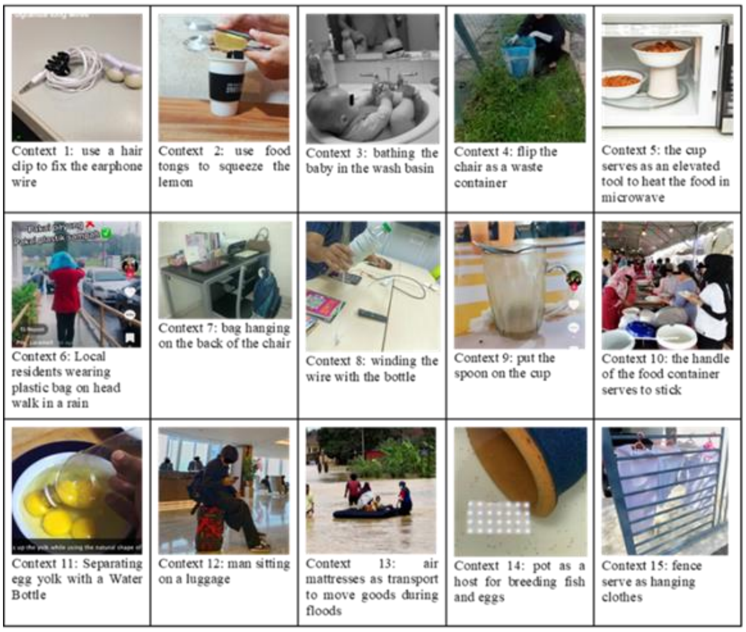


Figure 4.9 Fifteen Photos Representing UHBE used in the Survey through the VIA Study

Based on the survey conducted on 24 December 2022 – 14 June 2023, 73 respondents completed and returned the questionnaire out of 100 distributions through online platform and on-site (face-to-face) approaches. However, 3 data files were removed owing to outliers. As outlined, the evaluation score for the questionnaire design in the survey study was derived from four components: Section A: Background information and demographic profile, Section B: Understanding towards unintended use of product, Section C: The Motivation of unintended behaviour, and Section D: Overall Evaluation and Satisfaction. A total number of questions across the four components was 56, distributed as follows: Section A (6 questions), Section B (6 questions), Section C (38 questions), and Section D (6 questions). All the data will be analysed using descriptive frequency through SPSS version 28.

Respondents Frequency distribution analysis

Section A: Demographic Profile will present descriptive frequency analysis based on specific demographic information. Section B and C will present three sets of findings including (1) descriptive analysis of visual inventory analysis; (2) frequency distribution analysis of respondents; and (3) Cronbach's Alpha analysis. Meanwhile, Section B and C questions were evaluated using a 5-point Likert scale, ranging from 1:

"strongly disagree" to 5: "strongly agree." A Cronbach's Alpha analysis was performed to evaluate the reliability of the scale created by the total of the forty-four (44) items contributing to the evaluation score. Table 4.5 shows the reliability scale values for all 44 question items obtained from question on Section B and C which is the main body of the questionnaire set to answer RQ1. The following is a detailed explanation of the results of the survey conducted for seven months (24 December 2022 until 14 June 2023) and explained according to each section separately. The case processing summary reveals that the valid N (sample size) and the overall number of cases amount to 70. Nonetheless, the absent instance is non-existent. The results reveal that there are no excluded samples, signifying the absence of missing values in any reported cases. Furthermore, the reliability statistics for Sections B and C indicate that both sections contain forty-four items, which corresponds to the number of items in the assessment score of the questionnaire design. Consequently, it may be affirmed that the quantity of goods in Sections B and C is accurate. The Cronbach's Alpha reliability coefficient for Sections B and C is strong internal consistency at 0.826, according to Hair et al., (2016) value of the reliability.

Table 4.5
Reliability Score of Item Section B and C (44 Item Question)

Case Processing Summary	Valid		Excluded [a]		Total	
	N	Percent	N	Percent	N	Percent
	70	100	0	0	70	100

Reliability Statistics	Alpha	Cronbach's Alpha Based on Standardized Items	N of Item
	.826	.834	44

Section A: Demography Profile

This study uses descriptive frequency analysis to examine the frequency distribution of survey responses. This chapter indicates that 70 individuals participated as respondents in the survey study. The respondents' descriptive analysis has been examined based on six elements as follows: (1) Gender of respondents; (2) Age of respondents; (3) Race of respondents; (4) Occupation of respondents; (5) Education level of respondents; (6) Location of respondents. The element was includes into the survey to support the descriptive analysis if require.

Table 4.6
The Frequency Distribution of Respondents

Demography Profile		Frequency (f)	Valid Percent (%)
Gender	Male	32	45.7
	Female	38	54.3
Age	20-29 years	35	50.0
	30-39 years	17	24.3
	40-49 years	13	18.6
	50 > years	5	7.1
Race	Malay	57	81.4
	Chinese	8	11.4
	Indian	3	4.3
	Others	2	2.9
Occupational	Unemployed	8	11.4
	Student	16	22.9
	Employed	46	65.7
Educational	Certificate	9	12.9
	Diploma	25	35.7
	Degree	32	45.7
	Master / High Level	4	5.7
Location	City Area	52	74.3
	Rural Area	18	25.7

Table 4.6 presents the demographic profiles of the respondent in VIA study. From the overall population (n=70) based on gender, there are 38 female respondents with a percentage of 54.3%, compared to 32 male (45.7%). The second item assesses the ages of the respondent; there are four categories of ages consisting of 20-29 years (35 respondents), 30-39 years (17 respondents), 40-49 years (13 respondents) and 50 years above (5 respondents). The decision of limited to 20 years and above to ensure that the user participants understand the questionnaire provided, as mentioned in Chapter One. The third item were assessed on respondents' races, consist of 57 Malay, Chinese 8, Indian 3, and others only 2 respondents involving in this survey. The fourth item is the occupational status of the respondents. There are 8 unemployed, 16 students and 46 employed respondents involved in the survey. The fifth item assessed is respondents' educational level, consisting of 9 Certificates, 25 Diploma, 32 Degree and only 4 Master or high-level education holders. The last item is the location of the respondents. The highest respondents are in the city area consists of 52 respondents with 74.3% of all respondents, followed by 18 rural areas respondents (25.7%).

Statistical analysis of Section B: Understanding towards unintended use of product

Section B focuses on factors (attributes) that perceived influenced UHBE towards mainstream products among users. As explained in section 3.3.1, the final fifteen photos showing the context of use of unintended behaviour obtained during the observation activity were used in this questionnaire. There are 6 question to answer by the respondents. Using the visual inventory approach, each respondent will be answers all the 6 questions based on the fifteen photos provided. Based on the visual analysis, respondents are allowed to tick the five most photos depicted unintended use of mainstream product, based on their experiences, family or friends or even seen through social media. Figure 4.10 is the results show the percentage scale of fifteen contexts of use unintendedly as rated by the respondents.

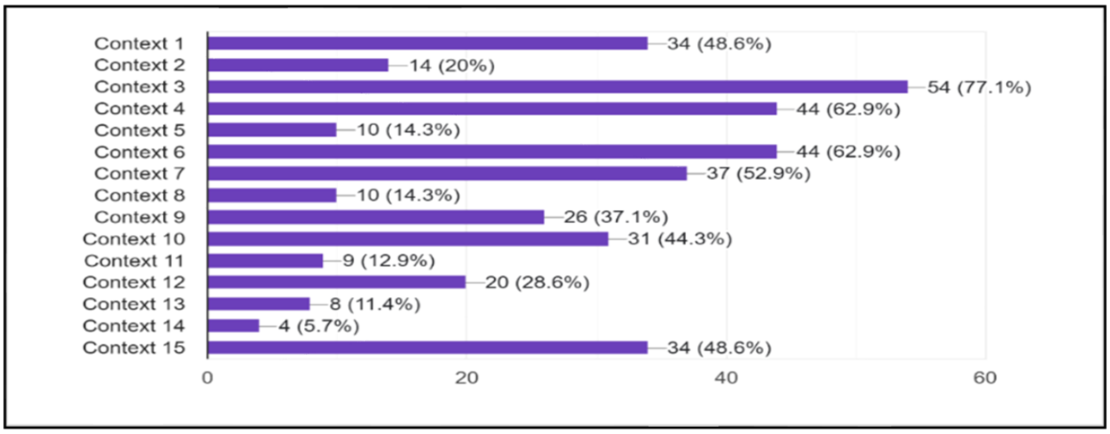


Figure 4.10 The Result of Most Experiencing UHBE Interaction by User's Respondent

Based on Figure 4.10, the visual representation of UHBE received the highest votes from the respondents' will be used as a photo elicitation for the next empirical study through PBA research and VPA. 77.1% or 54 respondents votes a visual depicted 'a person bathing baby in the wash basin', which representing the most context of use unintendedly compared to others visual as in the questionnaire. Figure 4.11 illustrates the most five visuals representing UHBE towards mainstream product which voted by 70 respondents.

				
bathing baby in the wash basin	**flip the chair as a waste container**	**residents wearing plastic bag on head walk in a rain**	**bag hanging on the back of the chair**	**fence serve as hanging clothes**
77.1%	**62.9%**	**62.9%**	**52.9**	**48.6**

Figure 4.11 Visual Rating based on Users' Response represented UHBE

As mentioned earlier, there are 6 questions in Section B to be answer by the respondents based on their perceptions and experiences towards unintended use of product. Through SPSS, the Cronbach's Alpha analysis is used to evaluate the reliability score consist of six questions. The result of the analysis will be critically elaborated and discussed based on Hair et al. (2016) procedures. The following are the result of the questionnaire for section B.

Case Processing Summary	**Valid**		**Excluded a**		**Total**	
	N	Percent	N	Percent	N	Percent
	70	100	0	0	70	100

Reliability Statictics	**Alpha**	**Cronbach's Alpha Based on Standardized Items**	**N of Item**
	0.826	0.834	6

Item Statistics		**Q 1**	**Q 2**	**Q 3**	**Q 4**	**Q 5**	**Q 6**
	Mean	4.29	4.27	4.11	4.19	3.30	4.19
	Std. Deviation	0.801	0.635	0.826	0.666	0.787	0.644
	N	70	70	70	70	70	70

Summary Item Statistics		**Mean**	**Min**	**Max**	**Range**	**Max/Min**	**Variance**	**N of Items**
	Items Mean	4.057	3.300	4.286	0.986	1.299	0.142	6

Item-Total Statistics		**Q 1**	**Q 2**	**Q 3**	**Q 4**	**Q 5**	**Q 6**
	Scale Mean if Item Delated	20.06	20.07	20.23	20.16	21.04	20.16
	Scale Variance if Item Deleted	6.345	7.661	6.672	7.12	8.94	7.613
	Corrected Item-Total Correlation	0.818	0.632	0.687	0.766	0.155	0.636
	Squared Multiple Correlation	0.723	0.549	0.594	0.636	0.06	0.503
	Cronbach's Alpha if Item Deleted	0.745	0.793	0.778	0.765	0.889	0.792

Scale Statistics	**Mean**	**Variance**	**Std. Variance**	**N of Items**
	24.34	10.287	3.207	6

Figure 4.12 Reliability Score of Question in Section B

The reliability analysis for the six items in Section B (see Figure 4.12), involving 70 respondents with a 100% response rate, revealed no missing data, allowing the analysis to proceed without adjustment. The Cronbach's Alpha value of 0.826 indicates strong internal consistency (Hair et al., 2016), confirming that all items measure the same construct consistently. Five out of six items recorded Corrected Item-Total Correlation values above the 0.3 threshold, with Item 5 (0.155) slightly lower but retained due to the high overall reliability. The Alpha if Item Deleted values (0.745–0.889) were all within the range of the overall α, indicating that removing any item would not enhance reliability. Although Item 5 (0.889) had the highest Alpha if Item Deleted value, all items were consistent and met strong psychometric standards. Overall, the instrument demonstrated high internal consistency, no missing data issues, and strong relevance of all items, validating its suitability for further analysis. The next section will elaborate descriptively in detail according to the six items of the questionnaire results in Section B.

	Strongly Disagree / Disagree %	Moderate %	Agree / Strongly Agree %
Do you have any experience with the scenario described above?	1.4	10.0	88.6
Does the behaviour of using the product outside of its original function occur among users?	0.0	10.0	90.0
Have your family or your friends ever experienced a situation in which a product was used outside of its original function, as in the illustration above?	1.4	21.4	77.1
Human behaviour that extends a product beyond its intended purpose can influence others.	0.0	11.4	88.5
Using a product outside of the original function has risks.	22.8	47.1	30.0
Using the product beyond its original function means fulfilling a specific purpose.	0.0	12.9	87.1

Figure 4.13 The Result of Descriptive Analysis in Section B1

The six questions asked to respondents in Section B focused on the issue of unintended behaviour phenomena, regarding to the users' experience, interaction, and behaviour using products outside the original function (unintended way). To interpret the data results, the total score obtained was evaluated statistically numerically through frequency distribution to facilitate the interpretation of users' understanding of the phenomenon. Therefore, descriptive analysis was conducted to discuss in detail the analysis.

Based on Figure 4.13, the findings from Question 1 found that 88.6% or 62 respondents agreed and strongly agreed that they had used the product outside its original context, as shown in the visual inventory. However, there are 7 respondents who were unsure about UHBE while only one Malay male respondent stated he had no experience regarding the UHBE. Its reflecting the phenomenon are significance topic to study within design research. For Question 2, the questions revolved around their knowledge and awareness of the phenomenon, finding that the assessment score was strongly positive with 90.0% (63 respondents) of the respondents agreeing or strongly agreeing that UHBE occurs within the society. However, only 7 (10%) respondents answered they unaware about the UHBE phenomenon. Meanwhile, question 3 showed differences perception on the assessments given by respondents regarding question on others factor may influencing UHBE. Out of 70 respondents, 77.1% or 54 respondents agreed that people closest to them was the one who shared experiences or information related to UHBE as depicted to the visual. Meanwhile, 16 (22.8%) respondents were unsure about the matter. The fact show there may be other factor may influence people to act unintendedly in everyday experience.

For Question 4, most of the respondents (88.5%) agreed that UHBE can influence other people through sharing information or experiences to others. it shows that question 3 and are significance based on users' perception. Next to Question 5, the question asked regarding 'risks affect if people used the product not in ordinary way as it is. Based on the question, there was a difference of perception within respondents. A total of 30% of respondents agreed or strongly agreed that UHBE has risks when individual use the product unintendedly. While 47.1% or 33 respondents were unsure about the risks and 16 respondents (22.8%) stated that they did not agree that UHBE can pose risks to users when using a product unintendedly. It shows that some respondents have experienced with the context with no harm or risk during the interaction. Question 6, the last question for Section B, shows that 87.1% of respondents agree that UHBE is experienced by users to meet their daily needs. The result show that the phenomenon aligns with most scholar (around the world) stated on their research finding, that people use a product unintendedly to fulfil the everyday activities and tasks. Based on Figure 4.14, it clearly shows that respondents clearly understand the UHBE phenomenon. Nevertheless, they unaware that the unintended actions may risk due to the uses of product in other way from designers' intent.

Statistical analysis of Section C: Unintended Interaction Attributes

In Section C of the questionnaire, there are two sub-sections (Section C1 and C2) of questions developed to determine what the main attribution of unintended behaviour are based on users' perception, according to respondents' evaluations. As mentioned in ealier, set of assessment questions divided into 4 dimensions based on the Hirschman Model of use innovativeness. In this study, Section C will answer the first Research Question (RQ1) *What are the attributes of users' unintended interaction with the mainstream products that reflect the phenomenon of unintended use of the product??* However, Section C1 were an assessment of general factors (the personal characteristics of individuals) that may influence UHBE, before proceeding to the main focus of the study. There are six personal characteristics that may influence of UHBE towards mainstream product: (1) Age, (2) personal experience, (3) Income, (4) Technical Skill, (5) Knowledge, and (6) Lifestyle. In other words, Section C1 also to see the patterns of motivation towards UHBE context of use. Figure 4.14 presenting the result of Section C1 based on SPSS analysis.

Case Processing Summary	Valid		Excluded [a]		Total	
	N	Percent	N	Percent	N	Percent
	70	100	0	0	70	100

Reliability Statictics	Alpha	Cronbach's Alpha Based on Standardized Items	N of Item
	0.813	0.816	6

Item Statistics		Age	Personal Experience	Income	Technical Skill	Knowledge	Lifestyle
	Mean	3.06	3.80	3.14	3.24	3.86	3.33
	Std. Deviation	0.961	0.809	0.889	0.859	0.687	0.775
	N	70	70	70	70	70	70

Summary Item Statistics		Mean	Min	Max	Range	Max/Min	Variance	N of Items
	Items Mean	3.405	3.057	3.857	0.8	1.262	0.116	6

Scale Statistics	Mean	Variance	Std. Variance	N of Items
	20.43	12.973	3.602	6

Item-Total Statistics		Age	Personal Experience	Income	Technical Skill	Knowledge	Lifestyle
	Scale Mean if Item Delated	17.37	16.63	17.29	17.19	16.57	17.1
	Scale Variance if Item Deleted	9.367	9.483	8.758	8.443	10.19	9.83
	Corrected Item-Total Correlation	0.456	0.569	0.651	0.76	0.527	0.523
	Squared Multiple Correlation	0.344	0.437	0.517	0.626	0.344	0.424
	Cronbach's Alpha if Item Deleted	0.816	0.785	0.766	0.74	0.795	0.795

Scale Statistics	Mean	Variance	Std. Variance	N of Items
	20.43	12.973	3.602	6

Figure 4.14 Reliability Score of Question in Section C1

The reliability analysis for the six items in Section C1 (see Figure 4.14), involving 70 respondents with a 100% response rate, revealed no missing data, allowing the analysis to proceed without adjustment. The Cronbach's Alpha value of 0.813 indicates strong internal consistency (Hair et al., 2016), confirming that all items measure the same construct consistently. Item correlations were positive and moderate, which all six items recorded Corrected Item-Total Correlation values above the 0.3 threshold, with at least 0.456 value for item 'Age', and all items were retained due to the overall reliability. The Alpha if Item Deleted values (0.740–0.816) were within the range of the overall α, indicating that removing any item would not enhance reliability. Although Item 'Age' (0.816) had the highest Alpha if Item Deleted value, the items were consistent and met strong psychometric standards to use in the descriptive analysis. Overall, the instrument demonstrated high internal consistency, no missing data issues, and strong relevance of all items, validating its suitability for further analysis. The next section will elaborate descriptively in detail according to the six items of the questionnaire results in Section C1.

	Strongly Disagree / Disagree %	Moderate %	Agree / Strongly Agree %
Age	24.3	51.4	24.3
Personal Experience	2.90	35.7	61.4
Income	24.3	45.7	30.0
Technical Skill	15.7	55.7	28.6
Knowledge	1.40	27.1	71.5
Lifestyle	10.0	55.7	34.3

Figure 4.15 The Result of Descriptive Analysis in Section C1

Figure 4.15 presenting result of a descriptive analysis conducted to assess the fundamental factors that may influence UHBE towards mainstream products based on six fundamental factors: Age, Personal Experience, Income, Technical Skills, Knowledge and Lifestyle. Based on the analysis, 24.3% of respondents disagree that 'age' not the main factor influences the unintended use of products, while 51.4% of respondents remain neutral, and 24.3% give an agreement. On the other hand, personal experience was believed as contribute factor, with 61.4% of respondents agreeing with the statement, 2.9% disagree, while 35.7% are neutral. Its indicates that individuals experience are the factor people using products a product in other ways, aligned with Wongkitruangreng (2018) founded in her study. However, individual or family income received mutual assessment, which 24.3% disagree, 45.7% stating neutrality, and 30.0% agree. Its indicate that income does not play a role influencing UHBE within users. Similar to the technical skills, respondent rated unsure if technical skill may drive to the UHBE, since they have given rating with 55.7% as neutral, 28.6% agreed and 15.7% disagreed. This implies that although technical skills may play a role in influencing the use of unwanted products, it is not the most determining factor in UHBE actions among users. Meanwhile, ‘lifestyle’ received a moderate agreement by respondent with only 34.3%. This outcome suggests that lifestyle may contribute to UHBE product use, but not as strong ‘knowledge’ and ‘personal experience’. To conclude the outcomes of Section C1, ‘knowledge’ indicated the most factor that contributes to UHBE interaction towards mainstream products. With the highest score of 71.5%, respondents make an agreement that highlight ‘knowledge’ is the most fundamental factor influencing how people use of products (Crilly, 2005), as well as in this case, outside of the original function.

The next Section C2, was the focus of the research to answer RQ1, the determination of the UHBE attributes in mainstream products. As illustrated in Figure 4.8 (on the pages 209), there are four dimensions to be evaluate by respondent; (1) Creativity / Curiosity, (2) Voluntary Simplicity, (3) Risk Taking, and (4) Multiple use. Through literature review study, a total of 32 attributes found within the notion of UHBE interaction that being groups according to 4-dimensions. In detail, all the attributes extracted within the research area such as unexpected behaviour, designing for appropriation, unorthodox use, non-international design, design by use, and unconscious interaction (Hassan et al., 2022).

Based on 32 attributes representing 4-dimensions, each outcome will be presented separately according to the dimension group. The main purpose is to determine the highest attribute for each dimension. In addition, the highest attribute will also represent each dimension in the survey study for the designer group through the PBA study. For reliability purposes, all items in Section C2 were tested to identify the level of reliability of the data survey. Figure 4.16 shows the results of the reliability analysis of the 32 attribute items representing the 4 main dimensions of UHBE using SPSS software.

Case Processing Summary	Valid		Excluded [a]		Total	
	N	Percent	N	Percent	N	Percent
	70	100	0	0	70	100

Reliability Statictics	Alpha	Cronbach's Alpha Based on Standardized Items	N of Item
	0.955	0.956	32

Figure 4.16 Reliability Score of 32 Attributes from Section C2 Question

Figure 4.16 presenting the analysis of 32 items derived from the SPSS result of Section C2 data analysis. The reliability analysis for the 32 items in Section C2, involving 70 respondents with a 100% response rate, revealed no missing data, allowing the analysis to proceed without adjustment. The Cronbach's Alpha value of 0.955 indicates excellent internal consistency (Hair et al., 2016), confirming that all items measure the same construct consistently and reliable. The following statement presenting reliability of the item for each dimension. The first dimension is creativity / curiosity, consist of 7 attributes such as; Creativeness, Innovativeness, Trial and error, Spontaneous, Belief, Perception, and Attitude. To find an attribute representation for the creativity / curiosity dimension, a frequency distribution analysis was conducted to obtain reliable results and confirmation. The following are the findings of the data obtained, as illustrated in Figure 4.18.

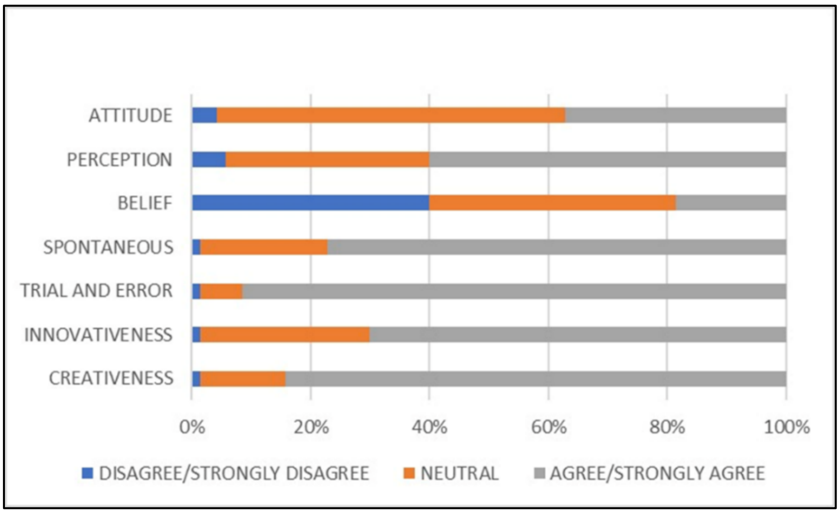


Figure 4.17 Diagram Representation of Frequency Distribution Analysis for 7 Attribution of Creativity / Curiosity Dimension

Figure 4.17 presents the results of perceptions from 70 respondents, representing a group of users regarding UHBE attributes. For the creativity/curiosity dimension, the data indicate that respondents agreed that creativity, innovation, trial and error, spontaneity, and perception are the five attributes most influencing UHBE among users. Each attribute recorded a percentage of over 60%, or at least 42 respondents, agreeing or strongly agreeing. In contrast, for the attribute of belief, the opinions were mixed, with 41.4% (29 respondents) remaining neutral and 40% (28 respondents) disagreeing. A similar pattern is seen for the attribute of attitude, where 56% (41 respondents) selected neutral, while only 37.1% (26 respondents) agreed or strongly agreed that attitude is a trait that triggers UHBE. In summary, for the creativity/curiosity dimension, the three attributes most strongly believed to drive UHBE among users are Spontaneous (77.1%), Creative (84.3%), and Trial and Error (91.4%). With the highest percentage, the trial-and-error attribute will officially represent the creativity/curiosity dimension. Figure 4.18 presents the summary item statistics describing the seven UHBE attributes under the creativity/curiosity dimension.

		Creativeness	Innovativeness	Trial and error	Spontaneous	Belief	Perception	Attitude
N	Valid	70	70	70	70	70	70	70
	Missing	0	0	0	0	0	0	0
Mean		4.31	3.91	4.33	4.06	2.8	3.63	3.41
Median		4	4	4	4	3	4	3
Mode		5	4	4	4	3	4	3
Std. Deviation		0.772	0.756	0.675	0.759	0.926	0.783	0.712
Variance		0.595	0.572	0.456	0.576	0.858	0.614	0.507
Range		3	3	3	3	4	4	3
Minimum		2	2	2	2	1	1	2
Maximum		5	5	5	5	5	5	5

Figure 4.18 The Summary Items Statistics of 7 Attributes of Creative / Curiosity Dimension

Figure 4.18 shows the overall attribute statistics for the creativity / curiosity dimension. Based on the previous information, the Trial-and-Error attribute has shown the highest percentage chosen by users to represent the first dimension. Through Figure 4.18, it can be proven that the Trial-and-Error attribute obtained the highest Mean value of 4.33 compared to the other 6 attributes. It clearly shows that the attribute is the strongest trait in the creativity / curiosity dimension based on users' perception.

For the second dimension, Voluntary Simplicity consists of 5 attributes: Influence of others, Lifestyle, Reference of experience (family / friends), Social Sharing, and Cultural conventions. The following are the results of the frequency distribution analysis obtained to determine and confirm the most attributes influencing UHBE for the dimension. Figure 4.19 indicates the results of the data obtained through SPSS software.

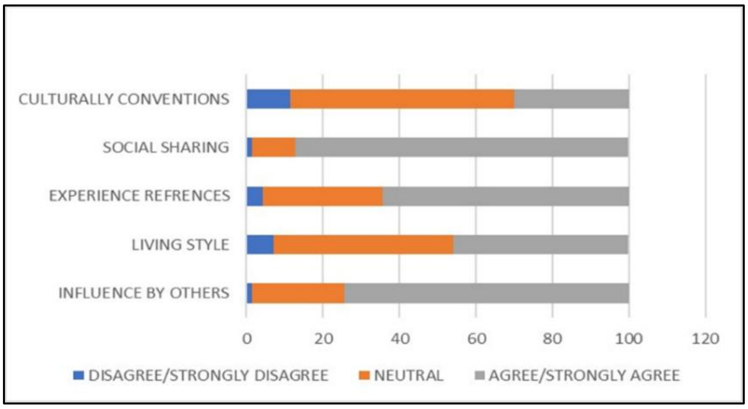


Figure 4.19 Diagram Representation of Frequency Distribution Analysis for 5 Attributions of Voluntary Simplicity Dimension

Figure 4.19 presents the results of perceptions from 70 respondents for the voluntary simplicity dimension. The data indicate that respondents agreed Influence by others, Experience references, and Social Sharing are the three attributes most influencing UHBE among users. Each attribute recorded a percentage of over 64%, or at least 45 respondents, agreeing or strongly agreeing. In contrast, for the attribute of culturally convention and living style, the opinions show uncertainty score among respondents with a neutral score exceeding the agree and disagree scores, which are 58.6% (Culturally Convention) and 47.1% (Living style), respectively. In summary, for the voluntary simplicity dimension, the three attributes most strongly believed to trigger UHBE among users are Influence by others (74.3%), Experience references (64.3%), and Social Sharing (87.1%). Represented the highest score, social sharing was the attribute officially represent the voluntary simplicity dimension. Figure 4.20 presents the summary item statistics describing the five UHBE attributes under the voluntary simplicity dimension.

		Influnce by others	Living style	Experience reference	Social sharing	Culturally Convention
N	Valid	70	70	70	70	70
	Missing	0	0	0	0	0
Mean		3.86	3.51	3.76	4.2	3.21
Median		4	3	4	4	3
Mode		4	3	4	4	3
Std. Deviation		0.643	0.812	0.77	0.694	0.74
Variance		0.414	0.659	0.592	0.481	0.548
Range		3	3	3	3	4
Minimum		2	2	2	2	1
Maximum		5	5	5	5	5

Figure 4.20 The Summary items Statistics of 5 attributes of Voluntary Simplicity Dimension

Figure 4.20 shows the overall attribute statistics for the voluntary simplicity dimension. Based on the previous information, the social sharing attribute has shown the highest percentage chosen by users to represent the second dimension. Through Figure 4.20, it can be proven that the social sharing attribute obtained the highest Mean value of 4.20 compared to the other 4 attributes. It clearly shows that the attribute is the strongest trait in the voluntary simplicity dimension based on users' perception.

For the third dimension, Risk-taking consists of 8 attributes; Unavailability of the actual product, unexpected situation, Save Cost, Convenient, Quick solution, Save Time, Current economic circumstances, and Location or space. The following are the results of the frequency distribution analysis obtained to determine and confirm the most attributes influencing UHBE for the dimension. Figure 4.21 indicates the results of the data obtained through SPSS software.

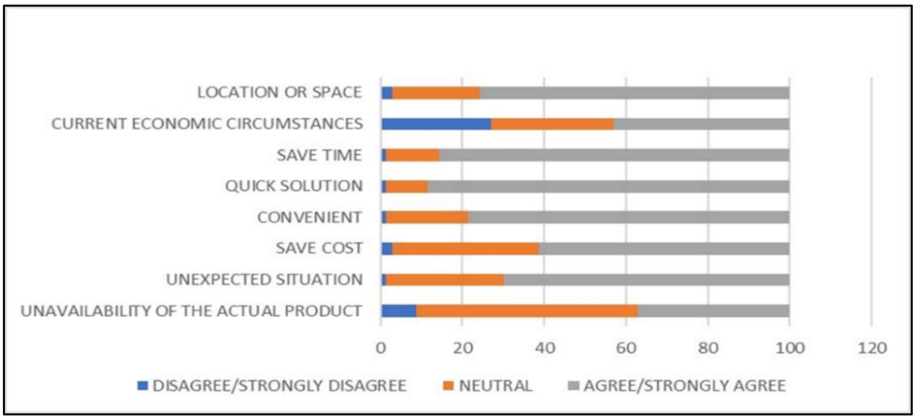


Figure 4.21 Diagram Representation of Frequency distribution analysis for 8 attributions of Risk-Taking Dimension

Figure 4.21 presents the results of perceptions from 70 respondents for the Risk-Taking dimension. The data indicate that respondents agreed unexpected situations (70%), save cost (61.4%), convenient (78.6%), quick solution (88.6%), save time (85.7%), and location or space (75.7%) are the six attributes most influencing UHBE among users. Each attribute recorded a percentage of at least 60%, or 43 respondents, agreeing and strongly agreeing. There is one attribute that shows uncertainty opinion among respondents with a neutral score exceeding the agree and disagree scores, which is 'unavailability of the actual product' attribute with a percentage of 54.3% or 38 respondents. However, current economic circumstances' attribute, which received balanced scores between agree (42.9%), moderate (30.0%), and disagree (27.1%). In summary, for the risk-taking dimension, the three attributes most strongly believed to drive UHBE interaction among users are quick solution, save cost and convenient. Represented the highest score, quick solution was the attribute officially represent the voluntary simplicity dimension. Figure 4.22 presents the summary item statistics describing the eight UHBE attributes under the risk -taking dimension.

		Unavailability of the actual product	Unexpected situation	Save Cost	Convenient	Quick solution	Save Time	Current economic circumstan	Location or space
N	Valid	70	70	70	70	70	70	70	70
	Missing	0	0	0	0	0	0	0	0
Mean		3.37	3.81	3.83	4.06	4.37	4.19	3.27	3.93
Median		3	4	4	4	4.5	4	3	4
Mode		3	4	4	4	5	4	4	4
Std. Deviation		0.765	0.666	0.834	0.74	0.726	0.708	0.992	0.729
Variance		0.585	0.443	0.695	0.547	0.527	0.501	0.983	0.531
Range		3	3	3	3	3	3	3	3
Minimum		2	2	2	2	2	2	2	2
Maximum		5	5	5	5	5	5	5	5

Figure 4.22 The Summary items Statistics of 8 attributes of Risk-Taking Dimension

Figure 4.22 shows the overall attribute statistics for the risk-taking dimension. Based on the previous information, the quick solution attribute has shown the highest percentage chosen by users to represent the third dimension. Through Figure 4.22, it can be proven that the quick solution attribute obtained the highest Mean value of 4.37 compared to the other 7 attributes. It clearly shows that the attribute is the strongest trait in the risk-taking dimension based on users' perception.

For the last dimension, Multiple use consists of 12 attributes; Materials cues, Product performance, Form cues, Object ability, Texture, Size, Usability, Fit (for purpose), Symbolic communication, Manipulability, Symbolic form of original product form, and Representative of original product function. The following are the results of the frequency distribution analysis obtained to determine and confirm the most attributes influencing UHBE for the dimension. Figure 4.23 indicates the results of the data obtained through SPSS software.

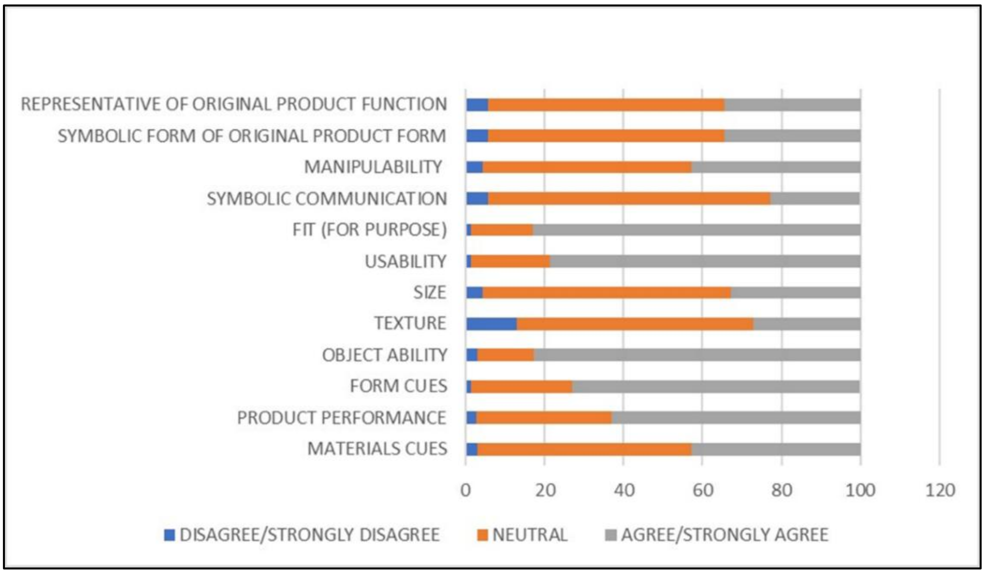


Figure 4.23 Diagram representation of Frequency Distribution Analysis for 12 attributions of Multiple-Use dimension

Figure 4.23 presents the results of perceptions from 70 respondents for the Multiple-use dimension. The data indicate that respondents agreed Product performance, Form cues, Object ability, Usability, and Fit (for purpose) are the five attributes most influencing UHBE among users. Each attribute recorded a percentage of at least 62%, or 44 respondents, agreeing and strongly agreeing. Compared to seven attributes show neutral rated by respondents, with over 52% or at least 37 out of 70 respondents. The most notable is the attribute Symbolic communication with 71.4% or at least 50 respondents choosing a neutral rated. Other attributes include Materials cues (54.3%), Texture (60%), Size (62.9%), Manipulability (52.9%), Symbolic form of original product form (60.0%), and Representative of original product function (60.0%). In summary, for the multiple-use dimension, the three attributes most strongly believed to drive UHBE interaction among users are Object ability, Usability, and Fit (for purpose). Represented the highest score, object ability was the attribute officially represent the multiple-use dimension. Figure 2.24 presents the summary item statistics describing the eight UHBE attributes under the multiple-use dimension.

		Materials cues	Product performance	Form cues	Object ability	Texture	Size	Usability	Fit (for purpose)	Symbolic communication	Manipulability	Symbolic form of original	Representative of original product
N	Valid	70	70	70	70	70	70	70	70	70	70	70	70
	Missing	0	0	0	0	0	0	0	0	0	0	0	0
Mean		3.51	3.69	3.84	4.16	3.21	3.4	4.00	4.16	3.23	3.56	3.37	3.39
Median		3	4	4	4	3	3	4	4	3	3	3	3
Mode		3	4	4	4	3	3	4	4	3	3	3	3
Std. Deviation		0.737	0.733	0.651	0.773	0.759	0.75	0.702	0.735	0.641	0.828	0.726	0.748
Variance		0.543	0.537	0.424	0.598	0.577	0.562	0.493	0.54	0.411	0.685	0.527	0.559
Range		3	4	3	3	3	3	3	3	3	3	3	3
Minimum		2	1	2	2	2	2	2	2	2	2	2	2
Maximum		5	5	5	5	5	5	5	5	5	5	5	5

Figure 4.24 The Summary items Statistics of 12 attributes of Multiple-Use Dimension

Figure 4.24 shows the overall attribute statistics for the multiple-use dimension. Based on the previous information, the object ability and Fit (for purpose) attribute has shown the highest percentage chosen by users to represent the fourth dimension. With the highest percentage of Agree and Strongly agree voted, both attributes obtained the same highest Mean value of 4.16 compared to the other 10 attributes. However, as mentioned earlier, for each dimension only one attribute will be presenting the dimension. Therefore, both attributes will be evaluated based on the highest score for strongly agree. As a result, object ability is the strongest attribute influencing UHBE for this dimension with the number of respondents who chose Strongly to agree is 25 respondents (35.7%) compared to Fit (for purpose) 24 respondents (34.3%). Through Figure 4.24, it can be proven that the object ability attribute obtained the highest Mean value of 4.16 compared to the other 11 attributes. It clearly shows that the attribute is the strongest trait in the multiple-use dimension based on users' perception.

The next section, Section D, consists of six questions in total. The assessment was designed to evaluate respondents' points of view on the effects of unintended interaction after using the product. Using SPSS, the Likert scale findings were analysed through Cronbach's Alpha to assess the reliability of the six items contributing to the evaluation score. The following are the findings from the survey conducted for Section D.

Case Processing Summary	Valid		Excluded a		Total	
	N	Percent	N	Percent	N	Percent
	70	100	0	0	70	100

Reliability Statictics	Alpha	Cronbach's Alpha Based on Standardized Items	N of Item
	0.909	0.911	6

Item Statistics		Q 1	Q 2	Q 3	Q 4	Q 5	Q 6
	Mean	4.06	4.1	4.27	4.37	4.33	4.17
	Std. Deviation	0.700	0.725	0.867	0.726	0.737	0.742
	N	70	70	70	70	70	70

Summary Item Statistics		Mean	Min	Max	Range	Max/Min	Variance	N of Items
	Items Mean	4.217	4.057	4.371	0.314	1.077	0.016	6

Item-Total Statistics		Q 1	Q 2	Q 3	Q 4	Q 5	Q 6
	Scale Mean if Item Delated	21.24	21.2	21.03	20.93	20.97	21.13
	Scale Variance if Item Deleted	10.216	9.959	9.593	9.604	9.941	9.882
	Corrected Item-Total Correlation	0.726	0.757	0.672	0.85	0.747	0.755
	Squared Multiple Correlation	0.555	0.59	0.531	0.791	0.712	0.605
	Cronbach's Alpha if Item Deleted	0.896	0.891	0.907	0.878	0.892	0.891

Scale Statistics	Mean	Variance	Std. Variance	N of Items
	25.3	13.952	3.735	6

Figure 4.25 Reliability Score of Question in Section D

The reliability analysis for the six items in Section D (see Figure 4.25), involving 70 respondents with a 100% response rate, revealed no missing data, allowing the analysis to proceed without adjustment. The Cronbach's Alpha value of 0.909 indicates excellence internal consistency (Hair et al., 2016), confirming that all items measure the same construct consistently. Item correlations were positive and moderate, which all six items recorded Corrected Item-Total Correlation values above the 0.3 threshold, with at least 0.672 value for question 3, and all items were retained due to the overall reliability. The Alpha if Item Deleted values (0.878–0.907) were within the range of the overall α, indicating that removing any item would not enhance reliability. Although question 3 (0.907) had the highest Alpha if Item Deleted value, the items were consistent and met strong psychometric standards to use in the descriptive analysis. Overall, the instrument demonstrated high internal consistency, no missing data issues, and strong relevance of all items, validating its suitability for further analysis. The next section will elaborate descriptively in detail according to the six items of the questionnaire results in Section D.

	Strongly Disagree / Disagree %	Moderate %	Agree / Strongly Agree %
Objects and situations affect the probability that human behaviour is changing.	1.4	17.1	81.5
Unintentional' behaviour occurs when the user is facing a specific problem	1.4	17.1	81.5
Unintentional behaviour helps you complete a goal or task in a certain situation	4.3	10	85.7
When discovering new functionality benefits users, they tend to repeat it.	1.4	10	88.6
When the behaviour is repeated often, it can become a habit in human life.	1.4	11.4	87.2
"Unintentional" behaviour becomes habitual; the act can be considered "with intent" to do it.	1.4	15.7	82.9

Figure 4.26 The Result of Descriptive Analysis in Section D

In Section D questionnaire, respondents were asked to think about how they would rate and describe the effect after experiencing and understanding UHBE based on their assumption. To describe the data, the total score was statistically using frequency distribution explain the level of response, opinion, and assessment by 70 respondents. The following, descriptive analysis was conducted to discuss in detail the results of the analysis obtained. Based on Figure 4.26, most respondents consistently showed high agreement across all six questions in Section D, reflecting a strong consensus on the effects of UHBE from users' perception. For Question 1, 81.5% agreed that the physicality of certain objects (mainstream products) and situations (context of use) can cause immediate, unplanned changes in human behaviour, while 17.1% were neutral and only 1.4% disagreed. Meanwhile, Question 2 recorded a similar agreement level (81.4%) regarding the unintended use of products out of their intention context when facing unsolvable problems at the time. Agreement increased slightly in Question 3 (85.7%), which addressed the role of intentional behaviour in completing tasks. The highest agreement was seen in Question 4 (88.6%), which linked beneficial UHBE interactions to the likelihood of repeating the behaviour when encountering similar problems. Question 5 reinforced this pattern, with 87.1% agreeing that repeated of UHBE become a habit. Finally, Question 6 showed strong support (82.8%) for the idea that unintended behaviour becomes habitual, it can be considered intentional when using a product for purposes beyond its original function. Overall, the data suggest a clear progression in respondents' agreement from recognising the unintended use of product occur without planned (Questions 1–2) to acknowledging its potential to form 'intentional', habitual behaviours (Questions 4–6), indicating a conceptual link between unintended interactions and the development of new usage behaviours.

Summary of Visual Inventory Analysis: Interpretation of Users' Perception towards UHBE attribution

The analysis of survey in Sections B, C, and D indicates that respondents are both aware of and understand the phenomenon of unintended use of product as discussed in this study. Their perceptions were shaped by their own knowledge and experiences, aided by the visual inventory provided in the questionnaire. Although Section A of the survey was also evaluated, it was not the primary focus for answering RQ1. Section A, which covered demographic factors such as age, races, educational background, and location, revealed that despite respondents' diverse profiles, the majority expressed similar perceptions in response to most questions. This consistency enabled the researcher to derive meaningful insights relevant to the research objectives. As explained earlier, the aim of this survey (Visual Inventory Analysis) was to identify the key attributes influencing UHBE in mainstream products among consumers, specifically within Sections B and C.

The findings identified four representative attributes across the four main dimensions adapted from Hirschman's Innovative Use Model (1980), which define the primary factors influencing the phenomenon under investigation. Respondents' perceptions were systematically analysed using SPSS version 28. These four attributes will be carried forward into the second survey study through Photo-based research (PBA), involving a group of product designers to assess their perceptions of the UHBE phenomenon. The attributes representation each dimension is listed in Table 4.7. The following section will present the conclusions of the UHBE attributes identified through the Visual Inventory Analysis, a method employing photo-based stimuli to capture user perceptions.

Table 4.7
Attribute Representation of Four Dimension of UHBE

	Dimension	**Attribute representative**	**Mean / Percent**
1	Curiosity / Creativity	Trial and error	4.33 / 91.4%
2	Voluntary Simplicity	Social Sharing	4.20 / 87.1%
3	Risk Taking	Quick solution	4.37 / 88.6%
4	Multiple use	Object ability	4.16 / 82.9%

Based on Table 4.7, four attributes were identified as representatives for each

UHBE dimension, each showing high mean values and strong levels of agreement among respondents. For the *Curiosity/Creativity* dimension, Trial and Error recorded the highest percentage of agreement (91.4%) with a mean score of 4.33, indicating a strong tendency among users to experiment and explore alternative product uses through unplanned interactions. This judgement aligns with Thorndike (1913) and Andre Lord (2021) through their research statement about the characteristic of trial-and-error attribute. In the *Voluntary Simplicity* dimension, Social Sharing achieved 87.1% agreement and a mean of 4.20, reflecting the role of sharing alternative product uses (both offline and online) in spreading UHBE behaviours to wider user groups. According to Suri (2005), conform to others show how human learns patterns of behaviour from others in social and cultural context. In this context, it shows that social sharing brings the same message as Suri argument. For the *Risk-Taking* dimension, Quick Solution had the highest mean score (4.37) and 88.6% agreement, highlighting the inclination of users to adopt immediate, and sometimes unconventional, or solutions when faced with problems, aligned with Wongkitrungrueng (2018) statement through her research findings. Finally, in the *Multiple-use* dimension, Object Ability recorded 82.9% agreement with a mean of 4.16, showing that users perceive a product's capacity to perform multiple functions as a key driver for alternative or unintended uses, as what Norman refer as product affordance. Collectively, these attributes capture the behavioural, technical, and social mechanisms underlying the emergence, spread, and normalisation of UHBE. To conclude, Visual inventory analysis was met the RO1, as well as answers the RQ1.

4.4 Photo-Based Research Analysis

As explained in the previous section, the representative images of the "context of UHBE" identified from the first study serve as tools to provide visual elicitation stimuli during the Photo-based Research (PBA) and Verbal Protocol experiment, as well as to ensure the reliability of the images and minimise bias in the PBA investigation. To achieve a more precise understanding, the PBA approach focuses on the leading actors in this design research, namely the group of designers. Photo-based Research (PBA) builds on the findings from the initial VIA field study. PBA is conducted as a visual elicitation stimulus to ensure the reliability of the images and to evaluate designers' responses to UHBE. PBA aims to examine designers' interpretations and reactions toward unintended use behaviour and user cognition in mainstream products. It is implemented to achieve the second objective, "To evaluate designers' responses towards unintended behaviour attributions through design protocol activity" and to answer the second research question in this thesis: "Why is the designer's interpretation of unintended human behaviour regarded as offering invaluable insights into design thinking during the early stages of new product concepts?" Figure 4.27 illustrate the Fragmentation of Photo-based Research Analysis stage.

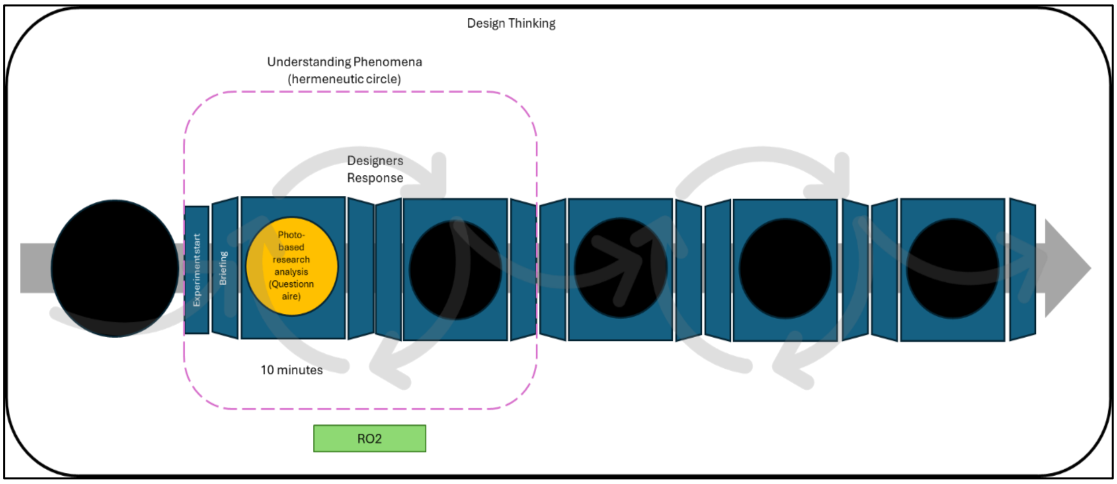


Figure 4.27 Fragmentation of Photo-based Research Analysis stage

4.4.1 Survey Conducting

In this research, a survey study was also conducted for PBA, as stated in Section 3.5.3. The objective was to assess the reliability of the photo uses and gather responses from a group of designers. The PBA evaluation outcomes help indicate the reliability of the selected photos as photo-elicitation for the next research experiment (VPA experiment). In this survey, 30 PBA questionnaires were distributed to 30 selected designers. Table 4.8 presents the details of the respondents involved in the PBA study. This survey involved a group of product designers selected based on their level of experience in the design industry. The survey activity was conducted prior to the VPA session, with a maximum duration of 10 minutes. Its purpose was to analyse photos prepared by the researcher, which were derived from the findings of the initial VIA fieldwork. In addition to the PBA evaluation, respondents could also use the information from the PBA as a visual elicitation stimulus during the VPA experiment sessions.

Table 4.8
Participants' Involvement in the Photo-based Research Analysis Study

Participants Category	**Gender**		**Total**
	Women > 20 years	Men > 20 years	
Designer	10	20	**30**
		Total	**30**

The group of designers was selected using snowball sampling technique. According to Cohen, Manion, and Morrison (2000), the snowball sampling method allows researchers to identify a small group of individuals who possess the required characteristics suitable for the study. This technique is proper when accessibility to the population is a challenge. The sample size for this study consisted of 30 participants. As suggested by Oppenheim (1992), Erdos (1972), and McDermott (2023), a minimum sample size of 30 is considered acceptable for the quantitative component of initial fieldwork research. In this study, all selected respondents are clearly defined in Table 4.9.

Table 4.9
Level of Design Experience and Designers' Category for Survey Study

	Years of Experience in Design field				
Designer Category	*1 – 5 years*	*6 – 9 years*	*10 – 19 years*	*> 20 years*	*Total*
Junior	10				**10**
Intermediate		8			**8**
Senior			**7**		**7**
Expert				**5**	**5**
Total					**30**

Due to specific factors, sensitivities, or limited communication networks, the researcher faced difficulties in obtaining the required number of respondents for the case study. Therefore, a personal approach was adopted by contacting industrial designers from various institutions, including private design firms and academic sectors, particularly in Ceramic Industrial Design, where some institutions have strict access policies for research projects. To avoid bias, the list of respondents was not limited to ceramic industrial design but also included experts from industrial art design and commercial design fields. Using the snowball method, each respondent also acted as an informant by recommending contacts who met the study criteria to be approached by the researcher. This process continued until all 30 required respondents were identified. The survey was conducted from 11 June 2023 to 11 August 2023, covering locations such as Kedah, Penang, Perak, Selangor, Negeri Sembilan, Kelantan, and Kuala Lumpur. The survey was carried out in a mobile format, based on locations agreed upon with the respondents near their respective areas.

4.4.2 Structuring questionnaire

PBA was conducted through a survey using a questionnaire developed based on Pauwels' theoretical framework of visual analysis. As explained in Chapter 3, Pauwels' integrated framework for visual social research consists of nine specific criteria under three main components for visual analysis purposes**.** In this study, the researcher identified several specific criteria to tailor the framework to the research scope. Four question sections were developed using Pauwels' framework for photo analysis, namely: (i) visual research reference, (ii) visual data resource, (iii) visual research focus and design, and (iv) overall analysis. To strengthen data collection, several sub-criteria were designed to evaluate respondents' responses and interpretations based on the specific criteria suggested in Pauwels' framework. This framework also emphasises the importance of text descriptions for each photo analysis to support respondent comprehension. The final step in Pauwels' framework involves carefully presenting photo plates that illustrate the theoretical points.

Based on the photo representations from the VIA evaluation, respondents confirmed the top five photos with the highest votes during the survey. However, only one photo with the highest votes was selected for use in the PBA. Along with this primary photo, several other images depicting the same situation (collected during the observation stage) were attached as supporting visuals for the PBA analysis. In addition to ensuring the reliability of photographs during the VIA study, the PBA research provides critical data to evaluate designers' interpretations and to compare them with users' perceptions of UHBE interactions. Both groups (designers and users) play distinct roles in relation to artifacts (products): designers create a product, whereas users utilise it. As previously mentioned, PBA serves as the foundation for the next study, the VPA. Figure 4.28 shows the top 5 UHBE contexts of use identified from the VIA study, while Figure 4.29 presents a sample of the questionnaire designed for designer evaluation.

Figure 4.28 Top Five vote of UHBE Photo context during VIA study

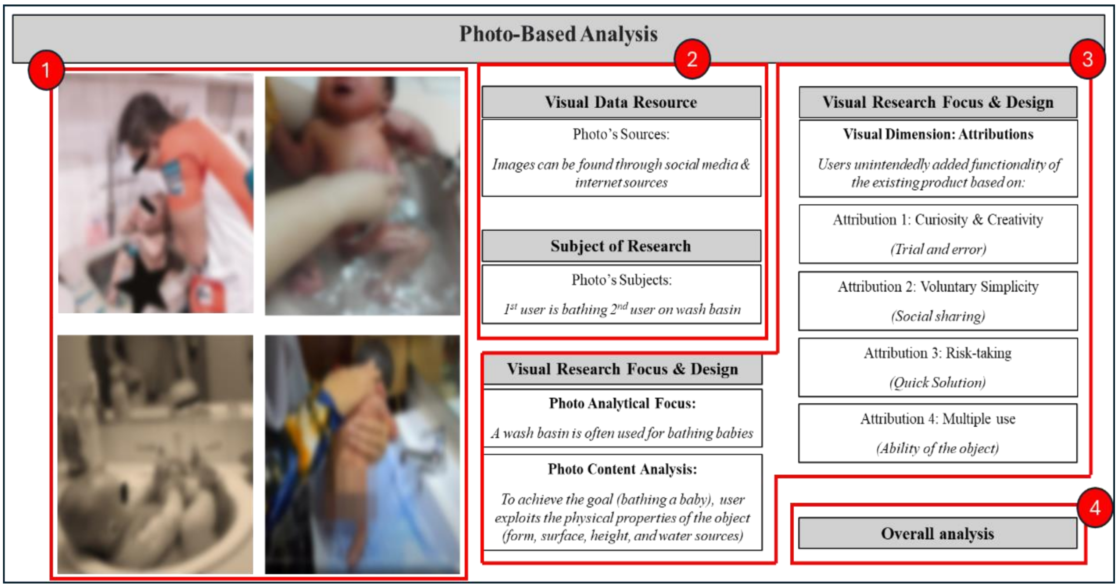


Figure 4.29 Sample of Questionnaire and Four sections of Photo-based Research Analysis based on Pauwels' Framework (2010)

Figure 4.29 illustrates the descriptive analysis of photo representation for the questionnaire form. According to Pauwel's framework, the visual analysis process continues by carefully presenting plates of photos depicting the theoretical point. For the purpose of collecting data from the designer group, there are four photos representing the unintended use towards mainstream products. There are four sections in the PBA questionnaire set to be evaluated by the respondents. The section composed of (1) visual research reference (four photo focus frame), (2) visual data resource &

subject of research (photo's sources and subjects), (3) visual research focus and design (analytical focus, content analysis, and visual dimension attributes), and (4) overall analysis; which adapted from Pauwel's integrated framework of visual research. Based on visual research reference, there are four photos of a situation where someone is bathing their baby in a washbasin. Through the analysis of visual data resources, the photo was collected through the internet and social media platforms (considered public posts). Following clockwise, the photo was originally extracted through (i) blog, (ii) YouTube, (iii) website, and (iv) Instagram. In the subject of research analysis, the photo depicts a situation where someone (first user: parent/caregiver) is bathing a baby (second user) in a wash basin, demonstrating the unintended behaviour by adding or creating another function for the wash basin product. For visual research focus and design analysis, the photo analytical focus shows that a wash basin is often used by people for the purpose of bathing their babies. For photo content analysis, the photo illustrates that to achieve the goal (bathing a baby), the user exploits the physical properties of the object (form, surface, height, and water sources). User seeks opportunities by exploiting the physical properties of the wash basin and water sources.

This interaction occurs through one of the attributes that drives users to their problems of bathing a baby (in certain situations) and using a wash basin as a replacement for a baby bathtub by referring to the physical properties of the wash basin and having a direct water source. This photo is representative of the idea that humans tend to explore the properties of things to meet a certain objective, as proposed by Suri (2005), Norman (1988), and Hirschman (1980). For visual dimension, there are four attributes of UHBE showing that users unintendedly added functionality of the existing product based on (i) Curiosity & Creativity: trial and error, (ii) Voluntary Simplicity: Social sharing, (iii) Risk-taking: Quick Solution, and (iv) Multiple use: Ability of the object. Those four attributes are attributes that influence UHBE (as proposed in the Hirchmans' model of innovativeness), used to collect and compare the perception between designers and users. The instruments in this study were tested for reliability using the Cronbach Alpha method. The analysis was conducted in accordance with Hair et al. recommendation and the result of analysis will be reported in next section.

4.4.3 The Result: Designer Response Towards UHBE Attributes Through Photo-Based Analysis and Verbal Analysis

As mentioned in Chapter One, the Research Objective two is: to evaluate designers' responses towards unintended behaviour attributions through verbal protocol analysis and design activity. To achieve the objective, this study conducts survey research and verbal approaches (interview) to obtain the data. These approaches were conducted to answer the Research Question 2: Why is the designer's interpretation of unintended human behaviour regarded as offering invaluable insights into design thinking during the early stages of new product concepts? Thus, this section will present the outcomes of survey study and verbal approach which conducted towards designers' group as active respondents, to assess their response towards UHBE phenomenon and the attribution based on user perception. This section encompasses two analysis segments: Photo-based Research Analysis (PBA) and Verbal protocol analysis episode 1 (VPAE1). The findings will be presented and discussed regarding four components: (1) a descriptive analysis of photo-based analysis; (2) an analysis of respondents' frequency distribution; and (3) a Cronbach's Alpha analysis, and (4) a descriptive analysis of respondents' verbal response based on photo elicitation.

Demography Profile

This study uses descriptive frequency analysis to examine the frequency distribution of survey respondents. Its indicates that 30 local designers participated as active participants in the survey study. The descriptive analysis of respondents has been conducted based on three elements: (1) gender; (2) designer categories; and (3) years of design experiences.

Table 4.10
The Frequency Distribution of respondents from Designers' group

Demography Profile		**Frequency (*f*)**	**Valid Percent (%)**
Gender	Male	20	66.7
	Female	10	33.3
Category	Junior	10	33.3
	Intermediate	8	26.7
	Senior	7	23.3
	Expert	5	16.7

Design Experience	1 – 5 years	10	33.3
	6 – 9 years	8	26.7
	10 - 19 years	7	23.3
	20 > years	5	16.7

Table 4.10 indicated the demographic profiles of the designers involved in the survey study through Photo-based research and Verbal Protocol Analysis. From the overall population (n=30) based on gender, there are 20 male designers with a percentage of 66.7%. However, due to pandemic condition and unavailability (time constraint) of female participant to participate in the mobile experiment, only 10 female designers with 33.3% involved in this study. The second item assesses the categories of designers, which consist of four categories of design experience: Junior category (10 designers), Intermediate (8 designers), Senior (7 designers), and Expert (5 designers). The third item assesses the years of designer's experience in the design field; there are four categories of design experience consisting of 1-5 years (10 designers), 6-9 years (8 designers), 10-19 years (7 designers) and 20 years above (5 designers) are participated in the survey study.

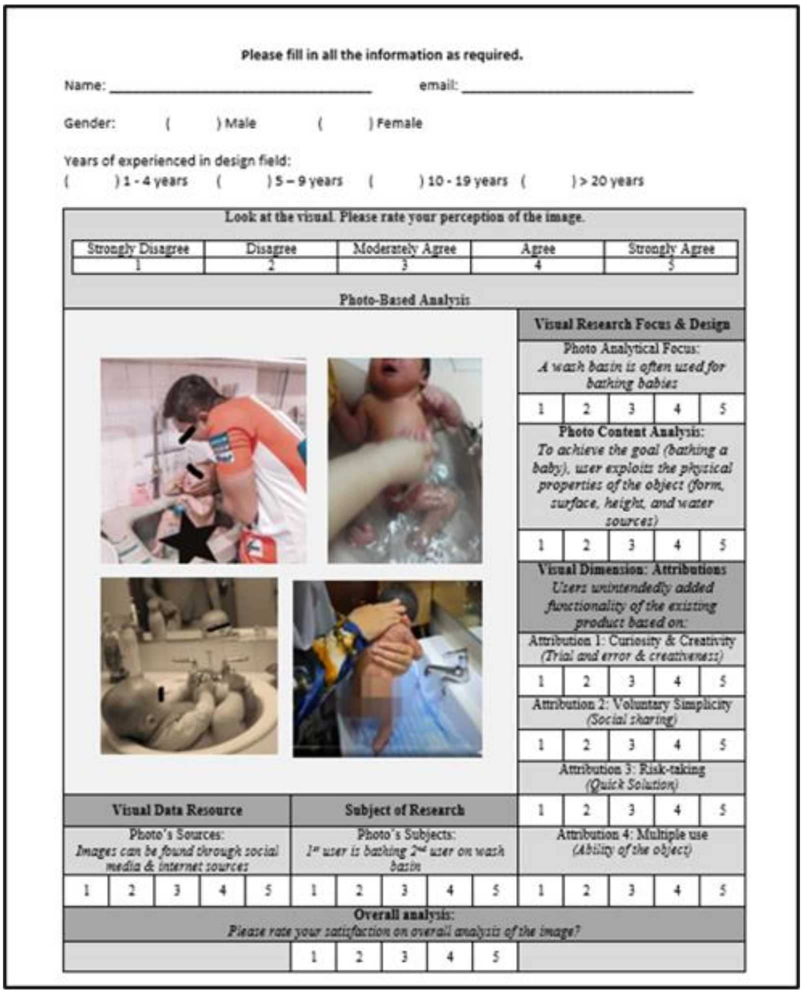
Table 4.11
Design Experience Crosstabulation

		Designer Experience				
		1-5 years (Junior)	6-9 years ntermediate)	10-19 years (Senior)	20 years above (Expert)	**Total**
Gender	Male	7	2	6	5	**20**
	Female	3	6	1	-	**10**
Total		**10**	**8**	**7**	**5**	**30**

According to the Table 4.11, there are 10 Junior designers involved in survey study consist of 7 male and 3 female designers. At the Intermediate level, there are 2 male's designers out of 8 designers. For Senior level, there are 7 designers involved in this survey consist of 6 male and 1 female. In expert level, there are 5 designers involved in this survey study with no female participate at this level. All the designers were selected using a snowball approach from a clearly defined group, as mentioned in Chapter Three. However, in the context of Malaysia designer's level of experience, the determination of designer level followed a research by a previous researcher in the same field with suggested a combination of student designers and designers in the study to provide meaningful results and allow researchers to study the different levels of career development thinking (student to expert). This statement was supported by Lawson and Dorst (2009), Dorst (2011), Abidin (2012), and Anwar (2016).

Photo-based Research Analysis

As noted in the previous section, the purpose of photo-based research analysis is to assess designers' response towards attribution of UHBE through photo stimuli. It also to obtain the reliability of photo elicitation stimuli for further experiment (the VPA study). As mentioned earlier, the photo has been extracted through three different approaches during observation activities: (i) natural observation (researchers' sources), (ii) voluntary images (participation sharing), and (iii) social media (public posts).



Please fill in all the information as required.

Name: ______________________________ email: ____________________________

Gender: ( ) Male ( ) Female

Years of experienced in design field:
( ) 1 - 4 years ( ) 5 – 9 years ( ) 10 - 19 years ( ) > 20 years

Look at the visual. Please rate your perception of the image.

Strongly Disagree	Disagree	Moderately Agree	Agree	Strongly Agree
1	2	3	4	5

Photo-Based Analysis

Visual Research Focus & Design

Photo Analytical Focus: *A wash basin is often used for bathing babies*

1 2 3 4 5

Photo Content Analysis: *To achieve the goal (bathing a baby), user exploits the physical properties of the object (form, surface, height, and water sources)*

1 2 3 4 5

Visual Dimension: Attributions *Users unintendedly added functionality of the existing product based on:*

Attribution 1: Curiosity & Creativity *(Trial and error & creativeness)*

1 2 3 4 5

Attribution 2: Voluntary Simplicity *(Social sharing)*

1 2 3 4 5

Attribution 3: Risk-taking *(Quick Solution)*

1 2 3 4 5

Attribution 4: Multiple use *(Ability of the object)*

1 2 3 4 5

Visual Data Resource	**Subject of Research**
Photo's Sources: *Images can be found through social media & internet sources*	Photo's Subjects: *1st user is bathing 2nd user on wash basin*
1 2 3 4 5	1 2 3 4 5

Overall analysis: *Please rate your satisfaction on overall analysis of the image?*

1 2 3 4 5

Figure 4.30 Layout of Questionnaire Set designed for Survey Study in Photo-based Research Analysis

In VIA study, fifteen photos representing the unintended use of product has been analyse from users' perception. However, in this study, only one representative photo of UHBE derived from users voted being uses. As for survey purpose, the representative photo (bathe baby in wash basin) was preview in four different views, depicted four individuals interacted the same context, using a wash basin to bathe their babies. This context reflects unintended use of product among users. Fundamentally, wash basin is a fixed bathroom sink that is attached to a water supply and drainage system, designed for hand and face washing. However, wash basin has been using unintendedly that was not design for that purpose, in this case bathe a baby. Based on user determination, wash basin considering a research 'subject' to be analyse and discussed from designers' perspective. Figure 4.30 represented the result of photo-based analysis designed for survey purpose through questionnaire sheet. Through PBA, the attributes of unintended interaction will be identify based on thirty designer respond.

Items Reliability Analysis

This section will present evaluation score of questionnaires set used in survey study. As mentioned earlier, the designers were requested to evaluate and rate the analysis of PBA. As mentioned ealier, there are nine criteria out of four sections to be evaluated and rate by the respondents as following; (1) visual data resource, (2) subject of research, (3) photo analytical focus, (4) content analysis, (5) visual dimension: attributes 1, (6) visual dimension: attributes 2, (7) visual dimension: attributes 3, (8) visual dimension: attributes 4, and (9) overall analysis, which adapted from Pauwel's integrated framework of visual research. Item question 5 to 8 representing the most attributes influencing users interacted with mainstream product unintendedly, based on users' perception during VIA study. There are trial and error, social sharing, quick solution, and object ability. By using SPSS ver 28 software, the data using of the Likert scale (a 5-point Likert scale, ranging from 1: "strongly disagree" to 5: "strongly agree) was performed through Cronbach's Alpha analysis to evaluate the reliability of the scale created by the total of the nine items that will contributes to the evaluation score. The result of the Cronbach Alpha analysis will be critically elaborated and discussed based on Hair et al. (2016) procedure. The following are the results of the survey conducted through the PBA questionnaire set. Figure 4.31 shows the reliability scale for all 9 items.

Case Processing Summary	Valid		Excluded a		Total	
	N	Percent	N	Percent	N	Percent
	30	100	0	0	30	100

Reliability Statictics	Alpha	Cronbach's Alpha Based on Standardized Items	N of Item
	0.811	0.818	9

Item Statistics	VDR	SoR	PAF	PCA	VD1	VD2	VD3	VD4	OA
Mean	4.13	4.07	3.90	4.33	4.17	4.17	4.30	4.30	4.07
Std. Deviation	0.973	0.907	1.094	0.758	0.95	0.747	0.794	0.596	1.015
N	30	30	30	30	30	30	30	30	30

Summary Item Statistics	Mean	Min	Max	Range	Max/Min	Variance	N of Items
Items Mean	4.159	3.900	4.333	0.433	1.111	0.019	9

Item-Total Statistics	VDR	SoR	PAF	PCA	VD1	VD2	VD3	VD4	OA
Scale Mean if Item Delated	33.30	33.37	33.53	33.10	33.27	33.27	33.13	33.13	33.37
Scale Variance if Item Deleted	19.803	19.551	20.602	20.576	18.133	22.133	22.257	21.499	18.516
Corrected Item-Total Correlation	0.508	0.595	0.338	0.582	0.756	0.350	0.302	0.596	0.642
Squared Multiple Correlation	0.621	0.582	0.289	0.465	0.657	0.368	0.231	0.452	0.644
Cronbach's Alpha if Item Deleted	0.793	0.781	0.820	0.785	0.757	0.809	0.815	0.789	0.773

Scale Statistics	Mean	Variance	Std. Variance	N of Items
	37.43	25.151	5.015	9

Figure 4.31 Reliability Score of Nine items in Questionnaire Set

The reliability analysis for the nine items (see Figure 4.31), involving 30 respondents with a 100% response rate, revealed no missing data, allowing the analysis to proceed without adjustment. The Cronbach's Alpha value of 0.811 indicates strong internal consistency (Hair et al., 2016), confirming that all items measure the same construct consistently. Item correlations were positive and moderate, which all nine items recorded Corrected Item-Total Correlation values above the 0.3 threshold, with at least 0.302 value for question 7, and all items were retained due to the overall reliability. The Alpha if Item Deleted values (0.757–0.820) were within the range of the overall α=0.811, indicating that removing any item would not enhance reliability. Although question 3 (0.820) had the highest Alpha if Item Deleted value, the items were consistent and met strong psychometric standards to use in the descriptive analysis. Overall, the instrument demonstrated high internal consistency, no missing data issues, and strong relevance of all items, validating its suitability for further analysis. The next section will elaborate descriptively in detail according to the nine items of the questionnaire results.

In the questionnaire form, the question was intent to focused on the attributes of

UHBE phenomena based on designers' perception and determination towards four dimensions. The respondents rated their response through photo-based research analysis. To interpret the data results, the total score of the Likert scale was evaluated statistically through frequency distribution to facilitate the level of designers' agreement. Meanwhile, descriptive analysis was conducted to discuss in detail the results of the analysis founded.

Figure 4.32 (on the next pages) presents the results of the responses from 30 designers to the phenomenon of unintended product use. First, the analysis was conducted on all components of the questionnaire with reference to the photo of the ' visual data resource' (VDR). It was used as a stimulus for the designer to understand the real context of this research. The photo-based assessment showed that all nine elements were rated as "agree" and "strongly agree.". Through frequency distribution, the VDR (item 1) obtained 73.3%, or 22 respondents, who rated 'agree' and 'strongly agree' that the photo displayed can be seen or found through social media or internet sources. Based on this rating, the photo represents the context of UHBE and shows people bathing a baby in a basin are considered reliable and valid for this research as well as for future studies. However, only 20.0% (6 respondents) expressed uncertainty, and 6.7% (2 respondents) disagreed or strongly disagreed with the representation of the photo.

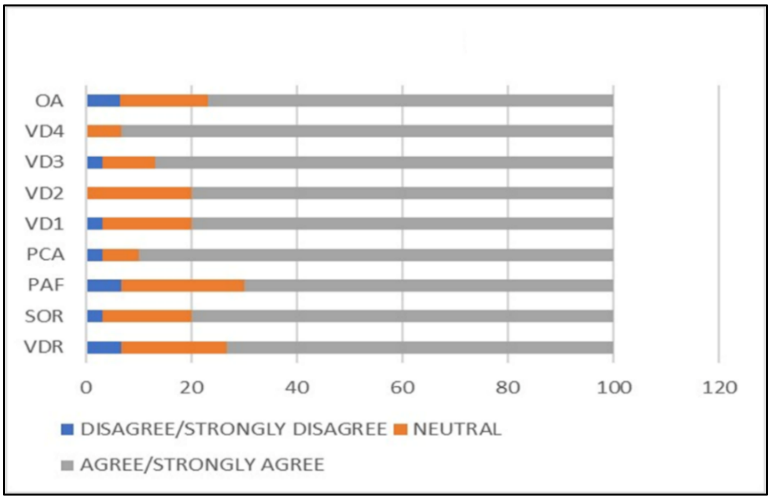


Figure 4.32 Diagram Representation of Frequency Distribution of Designers' Response towards UHBE Attributes

For the second question (item 2), the 'subject of research' (SOR) indicated that 80.0%, or 24 out of 30 designers, agreed or strongly agreed that the subject depicted in the photo reference clearly illustrates both the first user and the second user using the washbasin as a 'tool' to bathe the baby. They agreed that the first user (parent/guardian) bathed the second user (baby) using a commercial washbasin. Meanwhile, five (16.7%) designers were unsure about the subject of the study, and one respondent disagreed or strongly disagreed with it. For the third question, 'Research Design Focus & Visual' (item 3) was divided into three assessment components: photo analytical focus (PAF), photo content analysis (PCA) and visual dimension (VD). In the PAF section, the question related to "Washbasin is always used to bathe babies" obtained the lowest agree and strongly agree rating of the entire nine questions in the questionnaire, which was 70%. 23.3% of designers disagreed or strongly disagreed with the statement, while 6.7% (2 respondents) were unsure. Based on the percentage of agreement (70%), the majority of designers were aware that commercial washbasin products are often used outside the original context; in this case, they are used to bathe babies.

However, designers are less interested in developing an approach or facility to understand the situation. Meanwhile, in the photo content analysis (PCA) section, designers gave the highest agreement score to the question (item 4), "To achieve the goal (bathing babies), users exploit the physical properties of the object, such as shape, surface, height, and water source, to perform the activity." This score indicates that 90% (27 respondents) of designers agree with the statement regarding the product's ability to trigger unintentional behaviour based on their daily needs and context of use.

The analysis of items 5 to 8 is the 'visual dimension' (VD), which consists of four user-defined UHBE attributes, including VD1: trial and error, VD2: social sharing, VD3: quick solution and VD4: object capability. Designers were asked to respond to the UHBE attribution that they felt most influenced users to use the washbasin in a way other than its original function. Based on the analysis, the majority of respondents responded highly to the object capability attribute (VD4), which was felt to trigger the most unwanted behavioural interactions, with 28 out of 30 designers, or 90%, giving a rating of 'agree' or 'strongly agree'. The second highest attribute was the quick solution (VD3), with 86.7% of designers rating it as 'agree' or 'strongly agree'. The social sharing (VD3) and trial and error (VD1) attributes came next, scoring 80% each. Based on the responses, it shows that designers strongly agree with the image depicted, namely that users continue to exploit the physical properties of objects unintentionally while interacting with the product, choosing V4 as the attribute that most influenced UHBE. Meanwhile, the attributes of trial and error and social sharing are not the primary influencers of UHBE among users, according to designers. Finally, the overall analysis (OA) (item 9) indicates that designers reported an average satisfaction rate of 76.7% with the photo-based analysis conducted in this research, while 16.7% expressed uncertainty and 6.6% disagreed. Figure 4.33 shows a summary of the statistical findings of the photo-based research analysis according to the responses by the designer group.

Visual Research Reference	Scale Analysis	Visual Data Resource		Visual Rersearch Focus & Design						Overall Analysis
						Visual Dimension: Attribution				
		Source	Subject	Analytical Focus	Content Analysis	Curiosity & Creativity: Trial & Error / Creativeness	Voluntary Simplicity: Social Sharing	Risk-Taking: Quick Solution	Multiple Use: Object Ability	
	Strongly Disagree / Disagree [%]	6.7	3.3	6.7	3.3	3.3	0.0	3.3	0.0	6.6
	Moderately Agree [%]	20.0	16.7	23.3	6.7	16.7	20.0	10.0	6.7	16.7
	Strongly Agree / Agree [%]	73.3	80.0	70.0	90.0	80.0	80.0	86.7	93.3	76.7

Figure 4.33 Result of Designers response towards UHBE attributes in Mainstream Product

Based on the summary in Figure 4.33, the data clearly indicated the designers' response to the UHBE phenomenon based on their understanding and knowledge in product design. They believe that the product physically has the ability to influence human behaviour and interaction with mainstream products unintendly, as stated by Suri (2005). This agreement aligned with Norman's (1988) concept of product affordances, where people experience everyday objects based on the capabilities, characteristics, and affordance to perform as what people need. However, upon reviewing the previous analysis of UHBE attributes from user perceptions, clear differences emerge when compared to the designer group. As discussed in Section 4.2.5, the user respondents identified the attribute of “quick solution” as the most influential factor driving UHBE towards mainstream products. This attribute refers to instances where a specific task must be completed but the required product is unavailable, prompting users to adopt a quick, short-term fix. In doing so, users unintendedly engaged with the product in ways that diverged from its intended function, as revealed in the VIA findings.

The two findings reveal a divergence of opinion between designer and user groups. This disparity in viewpoints is crucial for designers to consider, as using a product beyond its intended function can result in unforeseen consequences, including potential safety risks. However, the discussion on differentiation between designer response and user perception towards UHBE phenomenon will be discusses in section 4.5.10.

As previously stated, the PBA study aims to understand and evaluate designers' responses to the UHBE phenomenon in its entirety, as well to obtain reliability of the photo's representation UHBE as subject of research. Through a critical analysis and supported by the assessment using survey research, the findings help to justify the use of images as reliable visual elicitation stimuli, (see Crilly, 2005), as the 'tool' for the study of VPAE1. The reliability of the questionnaire design in the survey research was also assessed using Alpha Croncbach analysis, which showed strong internal consistency of the reliability coefficients in each questionnaire component. For that reason, the photos of subject research are reliable to be used for VPAE1 study.

On the other hand, to gather more information on how designers respond to UHBE interactions, this study conducted in-depth interview sessions with designers. This approach aims to explore how designers interpret UHBE attributes based on user judgements, drawing on their experiences, knowledge, potential, and reasoning regarding UHBE considerations in their design decisions. Consequently, the following section will provide a detailed discussion of the results from the interview session with designers, utilising the experiment through verbal protocol analysis episode (VPAE1). The continuation of this investigation can help researchers understand in-depth designers' thoughts, thus building a grounded theory of the UHBE phenomenon based on designer interpretation.

4.5 Mastery Experiment of Verbal Protocol Analysis

In this study, Verbal Protocol Analysis (VPA) is employed as the primary method for collecting data on designers' cognitive thinking processes, which also addresses Research Question 2. The aim of VPA in this study is to understand and identify the relationships that influence how designers think, communicate, and interact during design activities. As argued by Valkenburg and Dorst (1998), verbal protocol analysis is the best method in behavioural sciences research due to its superiority in revealing some of the cognitive processes of humans. It is in line with the main aim of conducting VPA to investigate designers' cognitive activity in (i) response to the phenomenon towards attributions of unintended use of the product, (ii) the link of the thinking process and interaction during design protocol, and (iii) the reflective practice of designer sketches activity to a solution of existing problems (as a contribution to the idea-generating and its implementation in the design process). The decision to employ VPA was made according to the appropriate method of collecting data for empirical studies based on the synthesis of design activities as stated in section 3.3.4.As stated in Chapters Two and Three, research based on the VPA approach illustrates the elements of subject exploration, school of thought and theoretical knowledge. Accordingly, all the characteristics stated are included in this research to investigate the activities of designers who unintendedly display their way of interacting with the object of study, body gesture, eye tracking, verbal affirmation and spontaneous movement throughout the VPA episode. The principles of thought, emotion, hand movement, focus and interaction with the subject of study during the experiment must be recorded consistently and documented systematically. In short, the implementation of the VPA experiment must be able to observe behaviour, record moments of gestures, and interpret the thoughts and results of the designer's sketches from various angles in a planned control room. Generally, to ensure internal validity of the data collection and analysis in any research work, the researchers are advised to employ six strategies composed of triangulation of data, member checking, long-term and repeated observations at the research site, peer examination, participatory modes of research, and clarification of researcher bias. For that purpose, Creswell (2009) proposed a three-component strategy to ensure validity and reliability in qualitative study. Thus, the following methods will be employed in the experiment of verbal protocol analysis in this study to ensure the validity and reliability of the research.

1. A detailed account of the focus of the study: As outlined by LeCompte & Goetz (1984), this research has clearly defined the role of the researcher, the criteria and rationale for informant selection, and the context from which the data will be collected.
2. Triangulation or multiple methods of data collection and analysis: As emphasised by Merriam (1988), this study employs a triangulation approach in both data collection and analysis to enhance internal validity and reliability. The triangulation method in the verbal protocol includes protocol data,

transcriptions, video data, retrospective notes, and coded data analysis.

3. Data collection and analysis report: Creswell (2009) highlights the importance of preparing detailed reports for all data collection and analysis processes to ensure that the research methods are presented clearly and accurately.

Fundamentally, the VPA experiment in this study is divided into three series of activity episodes, which are designed as a data collection method to explore designers' cognitive thinking, interaction, and reflective practice (see Figure 4.34).

(i) Response to phenomenon through photo elicitation PBA (VPAE1),
(ii) Reflective thinking and interaction – moment inspiration (VPAE2)
(iii)Reflective practice – design sketches activity (VPAE3).

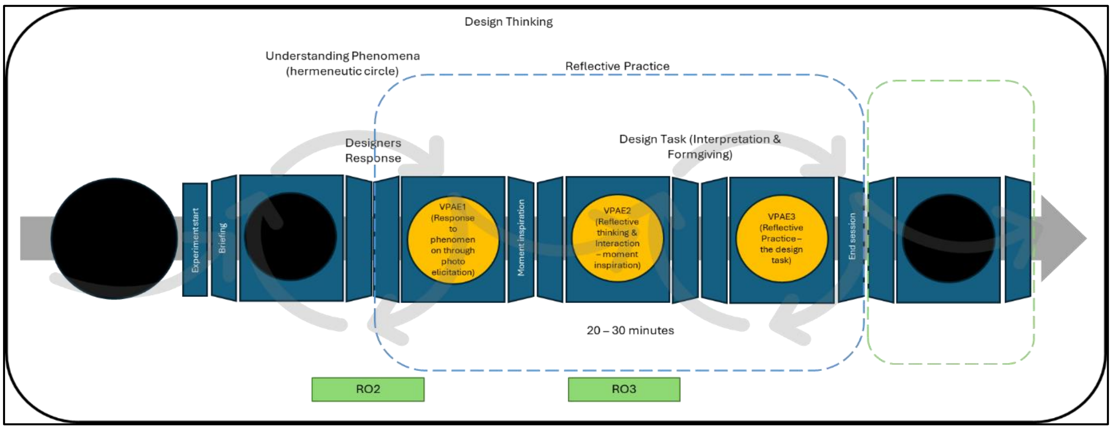


Figure 4.34 Fragmentations of Verbal Protocol Analysis Episode begin after Preliminary Fieldwork study, and Photo-based Research Analysis

The VPAE1, VPAE2, and VPAE3 episodes were conducted to fulfil the requirements of RO2. Although all three VPA experiments were carried out consecutively, the evaluation and analysis were conducted separately. The VPAE1 experiment was designed to elicit spontaneous responses from designers during semi-structured interviews based on the UHBE phenomenon, supported by the PBA questionnaire as a photo-elicitation tool. Meanwhile, observations in VPAE2 and VPAE3 allowed the intuitive process to emerge, and the quantified design data could be linked and analysed. These three protocol experiment series will be further explained in Section 4.4.3. The following section covers: (i) the list of designers involved, (ii) the materials and tools used, (iii) the VPA procedure, (iv) VPA analysis, and (v) the reliability and validity of VPA across all three protocol experiments.

4.5.1 The Designers (participants)

As explained in section 3.4.4, the VPA experiment involved 30 designers, consisting of industrial design practitioners, industrial design students, and educators from Peninsular Malaysia. The sample size was adequate for the purpose of this research as suggested by Oppenheim (1992).

Table 4.12
Years of Designer experience and level of Designers' category for VPA experiment

	Years of Experience in Design field				
Designer Category	***1 - 5 years***	***6 – 9 years***	***10 – 19 years***	***> 20 years***	***Total***
Junior	10				10
Intermediate		8			8
Senior			7		7
Expert				5	5
Total					**30**

Using a snowball sampling approach, all subjects were classified according to levels of experience in the field of design, whether in the industry, the education sector, or the student group (Table 4.7). The designers participated voluntarily by responding into the VPA experiment according to the researcher's recommendations and procedures. Table 4.12 indicates the four levels of subjects classified according to their years of experience in the field of design. These levels are divided into the categories of Junior, Intermediate, Senior, and Expert. The Junior category consists of final-year Diploma and Degree students in product design with less than five years of experience in design activities. The Intermediate category includes students enrolled in product design courses and industry practitioners with approximately 6 to 9 years of experience in design activities. This group comprises bachelor's and master's degree students in design, as well as employees in the product design or industrial design industry. The Senior category is designated for product designers with 10 to 19 years of experience in design activities. The Expert category consists of professionals with 20 years or more of design experience. Within the Expert category, there is a mix of designers from both industry and academia to ensure diverse data variations in the VPA experiment. Among the industry representatives who participated as respondents are the Malaysian Design Council (MRM), Roca Industries Sdn. Bhd., UP Ceramic Industries, and Top Glove

Sdn. Bhd. For the academic group, participating universities with experienced design professionals include Universiti Teknologi MARA (UiTM), Universiti Teknologi Malaysia (UTM), Universiti Putra Malaysia (UPM), Universiti Sains Malaysia (USM), and Universiti Sultan Zainal Abidin (UniSZA). However, some respondents have since transitioned into different fields to expand their careers.

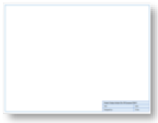
Typically, protocol analysis is conducted at locations determined by the researcher based on the laboratory settings provided. However, due to the constraints encountered during data collection, as described in Section 1.10 (scope of the study), the researcher decided that the protocol analysis sessions and locations would be conducted in a mobile manner. Therefore, each VPA session location was determined according to the respondents' nearest locality, ensuring convenience for both parties, and utilised rented premises or flexible spaces for the VPA lab setup. Based on the respondents' locations obtained via the snowball approach, the data collection spanned across eight states: Kuala Lumpur, Selangor, Melaka, Negeri Sembilan, Kelantan, Kedah, Perak, and Penang. Meeting locations included office spaces (e.g., Regus), co-working spaces (e.g., MBox), hotels, personal homes, faculty offices/meeting rooms, and open workspaces. The VPA data collection period lasted for 60 days, from 11 June 2023 to 11 August 2023, following the approval of data collection by UiTM's REC.

4.5.2 Protocol Instrumentations

In conducting the VPAE1, VPAE2, and VPAE3 experiments, several research requirements were prepared in advance for all three protocol analysis procedures. Each requirement in the experiment serves a specific role in assisting the researcher to carry out data collection activities smoothly and without any issues. Table 4.13 presents the list of materials, tools, and devices used in the Verbal Protocol Analysis experiments.

Table 4.13
Material, Tools and Device use in the VPA Procedure

Material / Tool / Device	Roles in research activities
	Akaso Brave 7: Was selected as the main equipment in this study to visually record the entire process of designer sketches and conversations. During the procedure, the main camera was placed on the left side of the designer to get a full perspective of the VPA procedure especially during the sketching activity.

	Remax Voice Recorder: The audio recorder was utilised to document the VPA. Throughout the study, the voice recorder is positioned adjacent to the designer to mitigate any extraneous noise that may disrupt the dialogue during the procedure. Long-duration sound recording using an integrated microphone & external high-power speaker enabling recording for 13 hours.
	Tripod: A tripod is a portable three-legged frame or stand used as a platform for supporting the weight and maintaining the stability of video recorder.
	Tablet Samsung: The tablet was uses in this study for the purpose of playing video of subject research. The video play roles as reference during reflective session.
	Artefact: Wash Basin: The Wash basin used in this study was selected from a standardized type to avoid bias. It serves as an artefact for the representation of the research subject used for reference to the designer when a conversation session is in progress. The Artefact is set to the right of the designer to facilitate interaction. Due to the weight of the object, the material was selected from PU PVA Plastic as for easy handling and portable.
	A3 Paper: A3 paper is used as a standard in design sketches. This sketch paper is specially prepared for design activity during VPA session along with information that must be filled in by participants.
	Pencil: A pencil used for artistic sketching and drawing.
	Artificial Baby: Artificial baby use for representation of baby in the study for the purpose of respondent simulation and interaction session if require.

4.5.3 Setup Design Protocol Strategy of VPA Study / Experiments Procedure of VPA Study

In order to formulate the suitability of the approach or improvement to the methodology used in the study, it is essential to identify the 'designerly' way of knowing, thinking, responding and reflecting in action (Cross, 2006). In interpreting the UHBE phenomenon, an investigation format strategy was designed to evaluate the potential of UHBE in design based on the designer's perspective through uncovering (i) the designers' Response to phenomenon through photo elicitation (PBA), (ii) designers' Reflective thinking and interaction (moment inspiration analysis on multiple mediator), and (iii) designers' Reflective practice (the design task) based on problem framing and recommendation. Thus, Verbal Protocol Analysis (VPA) was set up to investigate how designers respond and reflect-in-action towards UHBE in the control experiment protocol. Then, design a task that is representative of design activities, ensuring it is complex enough to elicit a wide range of cognitive processes but manageable within the study's time constraints.

As stated in Section 4.5, the primary purpose of this study is to identify and understand the key components of interaction, behaviour, and communication among designers during design activities. To enhance knowledge of the design process, an accurate and systematic strategy plays a significant role in data collection activities. This is crucial to ensure that the researcher has a clear understanding of the entire process and paradigm of the VPA experiment according to the planned procedure. Therefore, a systematic procedure was designed to ensure the feasibility of the study follows the established workflow. Figure 4.35 illustrates the process flow of the VPAE1, VPAE2, and VPAE3 experiments, which were conducted based on the characteristics of data collection through VPA.

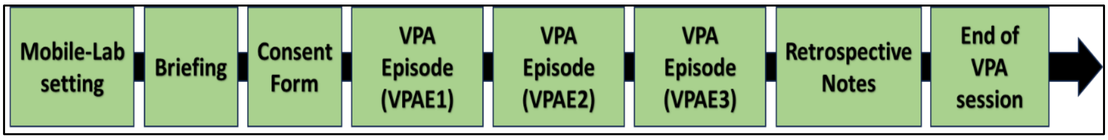


Figure 4.35 Flowchart of VPA Study

Figure 4.35 outlines the workflow of the VPA data collection process, which is structured according to the main objectives of this study. It begins with the preparation of research requirements (materials, equipment, and mobile lab setup), followed by the researcher's briefing, the respondents' completion of consent forms, the VPA episodes, and discussion until the experiment concludes. During the VPA, designers were given 30–40 minutes for the three episodes of the protocol, using short-term memory to complete the task. However, if designers required additional time, it was extended up to 45 minutes. This empirical study aims to collect in-depth qualitative data reflecting all arranged artificial situations. Designers were instructed to verbalize everything that came to mind while working on the design protocol and tasks. During the design tasks, the designers' verbalizations were recorded using both audio and video devices. Concurrent protocols were applied to capture real-time thought processes. Before the VPAE3 episode ended, a conversation was held between the researcher and the designer to identify and analyze any elements that might assist with the VPA experiment, this is referred to as retrospective notes. Figure 4.36 illustrates the positions of the designers and the researcher during the actual VPAE session. There are three episodes of the protocol, as highlighted below.

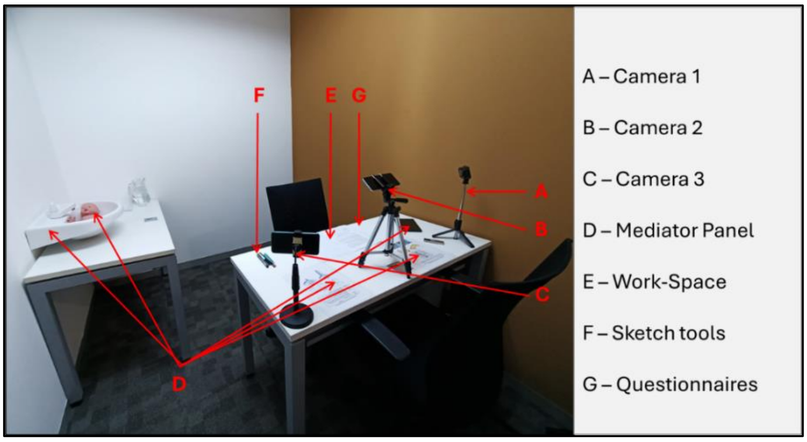


Figure 4.36 Simulation Position of Designers and the Researcher in the actual VPAE Format Strategy


Figure 4.37 Individual Observation setup for VPA Experiment Setting

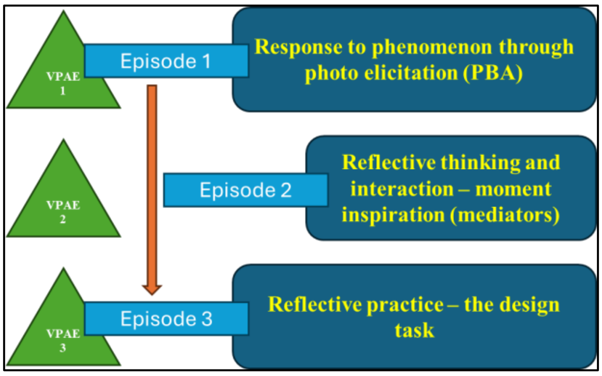


Figure 4.38 Stages of VPA Episode Conducted

Figure 4.37 shows a visual representation of the complete mobile laboratory-based setup for the VPA design protocol. The designers sit facing the center of the mediator panel, with two panels on the left side and three panels on the right side, while

Camera 1 focuses on the subjects. A3 cartridge paper is placed at the center of the workspace, with a pencil or technical pen positioned to the right, enabling Camera 2 to capture and record the individual design task. Camera 3, positioned on the right side of the designers, captures their gestures, facial expressions, and eye contact with the mediators. The researcher monitors the time settings during the experiment to track the design performance time of the designers. As explained earlier in Section 4.5, the VPA experiment comprises three main data collection activities, each of which is evaluated separately. The following (Figure 4.38) describes the breakdown of the VPA activities, conducted back-to-back according to the procedures.

4.5.4 EPISODE 1: VPAE1 - Response to phenomenon through photo elicitation (PBA)

The task aims:

1. Observe how designers' response towards the **phenomenon through photo elicitation.**

The task:

Description: Understanding UHBe interaction based on phenomenon (framing perception). The subject (designer) can give an opinion on UHBe phenomena based on the subject's experience and skills through the provided VRR. As per discussed in PBA session, the image in the VRR that is used acts as the main 'representative' of the study to obtain utterances significance when the experiment takes place. Through the approach of "seeing and perceiving" the phenomena, the subjects' perception will assess how they interact with the phenomena (Katja Tschimmel, 2011). The objective of the experiment is to see how subjects respond towards

The first episode, VPAE1, is a continuation of the PBA, where the activity is conducted through verbal elicitation—an investigation aimed at obtaining further insights into how designers respond and think aloud regarding the UHBE phenomenon in everyday products through perception, analysis, and reflection, using PBA stimuli accompanied by a set of short questions. In this episode, the interview questions are structured using a semi-structured verbal interaction interview (open-ended questions). While interacting with the PBA questionnaire form, designers respond to seven concise questions prepared by the researcher. The open-ended questions are designed to allow unrestricted responses, as well as a continuity source from the PBA, which will be further evaluated separately (see Collier & Collier, 1986). In addition, designers must evaluate four key attributes that trigger the UHBE phenomenon and provide responses on how these attributes can be incorporated as elements to be considered during the design thinking and idea-generation process to assist designers. The final part of the questions focuses on designers' reflections on the issues raised and the values that can be derived from this behavioural research. The following are the questions that designers must answer based on their experience and perspectives on the UHBE phenomenon. These are divided into three question components, as outlined below.

Reflection in action to Phenomena (Perception)

1. *What is your understanding of the phenomenon of unintended use of products in everyday life?*

Reflection in action to Attributes (Analysis)

2. *Based on photo analysis, psychological factors motivate unintended behaviour through the attributes of trial and error and creativity. How do you respond?*
3. *Based on image analysis, social and cultural context motivate unintended behaviour through social sharing attributes. How do you respond?*
4. *Based on image analysis, the context of use motivates human unintended behaviour through the attributes of a quick solution. How do you respond?*
5. *Based on image analysis, the propensity multiple uses factor motivates unintended behaviour through the object's ability (affordance) and fit for purpose attributes. How do you respond?*

Reflection in action to Value (Reflective)

6. *In your opinion, why do designers pay less attention to unintentional behaviour among users?*
7. *Personally, are unintended interactions in mainstream products valuable in the new product concept?*

In the first episode, each designer was allocated 10 minutes, during which all conversations and reflections were recorded using audio, visual, and video equipment. All remarks made by the designers were analysed according to the research framework as outlined in Section 4.5.5. The data analysis was conducted individually and then consolidated using a grounded theory approach through open coding, transforming the responses into numerical data to summarise the feedback from all participating designers. A detailed explanation of the VPAE1 data analysis process will be presented in Section 4.5.5.

4.5.5 EPISODE 2: VPAE2 – Reflective thinking and interaction – moment inspiration

The task aims:

1. Observe how designers interact with the mediators while framing the problem.
2. Integrates their thought in design strategies and decision-making.

The Task:

Description: Framing problem related to the attribute of UHBe (Analysis). The subject based on their design thinking will emphasize, define, and interpret the problem. The subject during the analysis stages may interact with the mediators provided to experience the context, reframe the problem, re-act to attributes, and strategize their thoughts and decision-making.

For the VPAE2 and VPAE3 episodes, the focus was on the designers' reflective practices, based on their thought processes regarding UHBE, using existing products referred to as artifacts (i.e., a wash basin with standard dimensions and form) for reasoning purposes. VPAE2 commenced immediately after VPAE1 with a brief briefing session, introducing five information panels (multiple mediators) that designers could utilise during the VPAE2 and VPAE3 activities. These five influence panels served as 'stimuli' to trigger the designers' thinking during the wash basin product design activity. The five panels consisted of:

(i) Video recordings (users completing tasks or interacting with the product context),

(ii) Artificial wash basin (with standard dimensions and form),

(iii) Technical information (wash basin dimensions),

(iv) Ergonomic information (product specifications and baby positioning during the bathing procedure),

(v) An artificial doll (used as a tool or simulation to assist designers during the design activity).

Figure 4.39 shows the five mediator panels used in VPAE2 to collect data on reflective thinking and stimulated interactions, placed close to the respondents' positions. In VPAE2, besides evaluating eye contact interactions, the designers' body gestures and uncertain behaviours were also recorded, highlighting their emphasis or suggestions expressed during the think-aloud process.

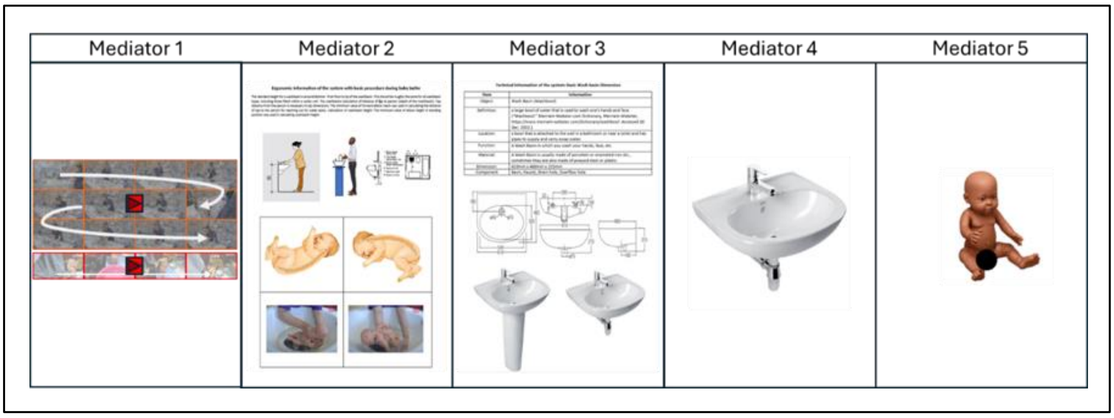


Figure 4.39 The Multiple Mediators use for Design Protocol Analysis Session

In this activity, the researcher observed how designers interacted with the multiple mediators provided to assist the idea-generation process throughout VPAE2 and VPAE3. Observations were conducted by interpreting the designers' eye contact with all mediators, including video recordings, artificial products, and a doll used for interactive purposes. The observation also focused on which ergonomic aspects influenced the designers during their thinking and sketching activities, as well as the technical elements they considered important when developing new product concepts based on their reflective thinking. In this study, a multiple mediator refers to a tool or technology that facilitates interaction and connection between designers, users, products, and the design process. As explained by Schön (1983), the use of multiple mediators reflects how research related to design and sketching can stimulate creative thinking. These mediators play a critical role in bridging the gap between theoretical design concepts and practical applications, while also serving as tools to understand real-world contexts. Multiple mediators are employed in this research to enhance understanding of user needs, improve collaboration among design team members, and streamline the design process. In this study, the mediators act as intermediary resources that help designers translate complex design problems into tangible ideas. The researcher utilized video demonstrations, an artificial product, technical information, ergonomic data, and an artificial doll as simulation tools to facilitate designer interaction during the design activity.

Table 4.14 presents a detailed explanation of the combination, techniques, and modifications of the multiple mediators used in the VPAE2 and VPAE3 episodes of this research. The analysis of VPAE2 will be explained in the following section.

Table 4.14
Information of Multiple Mediators uses in the Study

Mediator	**Indicator explanation**
Video Analysis	Video is an electronic medium that has functions such as attention, affection, cognitive, and compensatory functions to attract attention and direct concentration of the audience on the video material. Video is also a tool to arouse the emotions and attitudes of the audience, understand and remember the message or information contained in the image or symbol, as well as to organize and recall the information that has been obtained. Video is a medium of two-way interaction that involves communication between two parties. Analysis through video has been used in many areas; especially in the sociology field that traditionally uses observation theory techniques (Strauss and Corbin 1990). Interpretation through video carries rich information between a source and a receiver. In this design protocol, video demo was used as a tool for investigating UHBE interactions and for stimulating participants' reflection, as well as to identify whether this source (a gesture formation) will sketch explicitly or implicitly.
Ergonomic Component	Ergonomics plays a crucial role in cultural and behavioural studies by examining how products used, systems, and environments can be designed to fit the diverse physical and cognitive characteristics of different user populations. In behavioural studies, the role of ergonomics includes aspects of cultural adaptation, behavioural insights, usability and accessibility, health and safety, user-centered design, and contextual understanding. By integrating ergonomic principles as a mediator into this study, designers can create products that are more inclusive, effective, and satisfying for users worldwide, ultimately enhancing both user experience and product success.
Technical Component / Dimension	The technical information provided serves as a reference source for the main components of the product study such as basins, drain holes, faucet and overflow holes. By characterizing each of these component functions, it is easier for designers to build understanding specifically to certain parts rather than through the object as a whole. Through the representation of this mediator, gives the researcher the opportunity to see the designer's thinking pattern on the dependence of the main components in the sketch during the design activity.
Product as Mediator for the experiment	Using products as mediators in experiments during the design activity involves utilizing the product itself as a tool to facilitate interaction, gather data, and understand user behaviour and preferences. This approach allows designers to iterate and refine their designs based on real-world feedback and interactions (Bødker, S., & Grønbæk, K. ,1991). This approach is evident in various fields, including participatory design, design thinking, human-computer interaction, and educational design research (Sanders and Stappers, 2014; Drain & Sanders, 2019). By iterating on prototypes and experimental products, designers can create solutions that are better aligned with user needs and contexts, ultimately leading to more successful and impactful designs (Brown, 2009).
Artificial Doll	In product design studies related to infant interaction, artificial dolls are used as a proxy to simulate real infant involvement. This approach helps researchers to provide a prop to the designers to assess design usability, safety and ergonomic features without the ethical and practical challenges associated with actual infant use. The artificial doll functions as a consistent and controlled mediator, allowing respondents to create real moments of various situations and interactions that would be faced by a real baby, thus providing valuable insight into the effectiveness and suitability of the product for the intended user.

4.5.6 EPISODE 3: VPAE3 - Reflective practice – the design task

The task aims:

1. Observe how designers set their parameter thinking while working on sketches activity towards the issue.
2. Indicates the requirement any functionality, element, or component for a specific design concept.
3. Integrates the value of UHBE in form giving

Description: Reflecting on the problem framing through sketch activity. Subject may use their experiences, design skills, and knowledge to construct a baby bath product concept. Here the subject allows them to generate their ideas into any kind of form and concept according to their consideration and reflection-in-action.

The task:

Design Brief: Context of use

Calibrating Functions
Objective of the experiment: Calibrating designer's sense and awareness to product function, element, and dimension towards the context of use.

Designer task: To sketch new proposal of the design concept. You may use whatever mediators (as provided) you might think of in organizing practical needs into your design. Please make sure that the design has the typical necessities covered (basin, faucet, drain hole and overflow hole). It must appeal to a wide range of users. Use your experience and practical understanding to comprehend the issues related within the product. The responses are anonymous to improve the existing function and prioritise new features.
-Instruction: Participant may to refer to the design brief, questionnaire, video reference, ergonomics information and product as provided. There is also an artificial object provided for your references.
-Within design brief, there are technical drawing of the product. Participant may use the technical drawing prepared for them as guided master drawing. You may explore through imitation of situation.
-Use a pencil to structure your ideation and confirm your final idea using a pen.
-Each element provided by participant will be important for product usability potential.
-Please provide any written information that you think would be useful in making your design concept more informative.

The most respondent experiencing in the context is the use of a wash basin for the purpose of bathing the baby. The results found that factors influence unintentional behaviours of using wash basin in different way. They underlined some factors that contributed these behaviours:

1. Time concern and easier way to complete the task.
2. The form of wash basin resembles the shape of a baby bathtub, which is the perfect size for a baby, and can also help eliminate the wastage of water when used as a baby bathtub.
3. Conforming to others. Experienced from parent and family.
4. Social media influenced.
5. Trial and error, risk taking.
6. Save cost.
7. The consideration of back pain for mothers during their confinement period.
8. It is practical to bathe a baby in a standing position rather than bending since these mothers are not encouraged to sit.
9. The practice of bathing babies in the basin is based on their own parents' 'traditional' practice.
10. When in public places such as the mall, baby care centers and nursing room at Rest and Service Areas, there are only conventional basins provided for bathing babies in specific emergencies (vomiting, diarrhea, etc.).
11. The problem of bringing a conventional baby bathtub during vacations or traveling with babies, whereby some accommodations like hotels do not provide conventional baby bathtubs.

Based on the situation, the participants refer to the four UHBE attributes to come up with the solution based

During the episode VPAE2 and VPAE3, the designers were face-to-face with the researcher to observe how designers set their parameter thinking while working on the sketch activity. The VPA session officially in effect when designers started to work on the experiment (VPAE2 & VPAE3). At this point, designers began to think aloud about what they think and feel while creating an idea on a piece of drawing paper set in front of them. For example, to verbalise and describe aloud what they are thinking as they generate a conceptual product ideation (sketching) based on their perceptions, analysis and reflection on the PBA provided. The designers are free to come up with any type of ideation (in this case, a wash basin with the bathing babies features), either with a pedestal or without, portable, permanent, wall-mounted or with a tabletop. The designers are also free from their sketching style to project their new product concept using pencil or permanent ink as provided. During the whole episode, the session was being recorded (both visual and sound) by the researcher to prevent missing any information during the experiment.

4.5.7 Workspace, Capture Procedures and Technologies

Before the three VPA sessions were conducted, the researcher needed to ensure that the location and laboratory environment were comfortable for the designers during the design protocol process. This included sensitivity to noise from surrounding activities, as the designers had to verbalise their thoughts while the researcher recorded them using appropriate equipment. To ensure a suitable environment, the researcher opted to conduct the VPA sessions in specific locations recommended by the designers, using a mobile setup. As mentioned earlier, in this VPA study, only one series of VPA sessions was conducted, encompassing four characteristics of unintentional interactions in everyday human behaviour. Therefore, each designer was required to participate in the related VPA session until completion. Each designer was provided with research materials, a consent form, five multiple mediators, and one set of drawing paper along with drawing tools for idea generation activities, based on the design activity framework set by the researcher. Once the protocol space was prepared, the researcher briefed the designers with general information about the upcoming VPA session (e.g., experiment objectives and task instructions). Designers were also required to fill out a personal descriptive form prepared by the researcher to collect specific personal information for research purposes (e.g., name, location, age, educational background, and years of design experience).

The requirement to characterize design patterns and activities in this study was planned as outlined in Chapter Three. It was essential for this study to observe design activities repeatedly to successfully synthesize the discussions. Therefore, the technical aspects of capturing and storing observational data (recordings) were critical in conducting this VPA research. This section explains the approach and capture technology used, considering the most practical methods to avoid discomfort among designers during trials and actual experiments. The main reason for implementing three capture strategies (Cameras 1, 2, and 3) in the VPA experiment was to ensure that the designed methodology was relevant and could measure details precisely as planned. Contextual elements allow us to control the participant population and compare findings with other researchers conducting similar experiments. For technical preparation, the researcher developed the setup based on recommendations from Anwar et al. (2015) and Abidin et al. (2008). This referred to a closed-circuit television (CCTV) approach, with three camera angles arranged as follows: (1) left side view, (2) top view, and (3) right side view, to record the entire workspace within a simulated environment (designed to resemble a real designer's working space). Figure 4.40 shows the capture strategy development, enabling quantitative data calculation supported by direct evidence data input. The strategically developed protocol analysis setup was intended to create a comfortable environment for designers while engaging in design activities. In front of the designers' workspace, the mediator panels acted as influential elements, serving the purposes of (i) providing sources of inspiration or brainstorming input, and (ii) guiding the review of the most relevant information for the designers while creating their design. With the complete contextual setup in place, the data collection strategy was established to control the interaction between the researcher and the subjects. The camera system was fully automated and integrated with a data storage system. All design activities observed in this experiment were documented and recorded from every camera angle, including facial expressions and body language, particularly when these reflected the profile of sketch development. The three observation angles and recording strategies, as illustrated in Figure 4.40, show the recording perspectives during the design episodes. For instance, three recording channels were used: Channel 1 was set to a full left-side view with control over three mediator panels (on the right), Channel 2 provided a top view of the designer's workspace, and Channel 3 offered a full right-side view of the designer with control over up to two mediator panels (on the left). Through the VPA experience, the subtle features of concept reinforcement by designers during the sketching process led to a diversity of conceptual elements in the outputs produced. This raises the question: how do designers evaluate the needs and considerations of the UHBE phenomenon in each of their idea conceptualizations? Throughout the 30–40 minutes of design activity, this empirical study established in-depth quantitative data that reflected all the artificial situations that had been arranged.

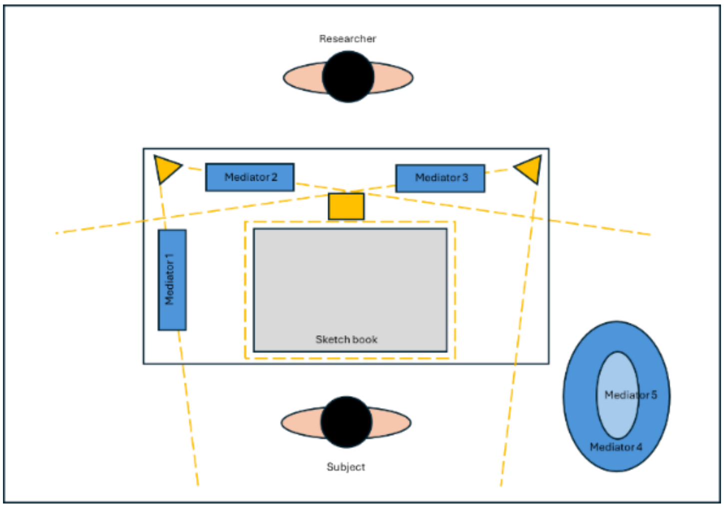


Figure 4.40 Development of Video, Visual and Audio capture strategies in the VPA Procedure

4.5.8 The Analysis of VPA Data

The VPA data analysis follows three strategic components recommended by Creswell (2009): (1) detailed focus on the study, (2) triangulation through multiple data collection and analysis methods, and (3) comprehensive reporting of data collection and analysis. These strategies were applied in the verbal protocol analysis experiments to ensure the validity and reliability of the data. Data from the three design protocol episodes were analysed separately according to sub-topics, aiming to generate robust scientific evidence to address knowledge gaps. The primary objective is to identify elements that contribute to a more inclusive understanding framework, advancing designers' thinking and enhancing their competitive capabilities. Findings from VPAE1, VPAE2, and VPAE3 are expected to answer the second research question, specifically exploring how designers' interpretations of unintended human behaviour provide valuable insights into design thinking during the early stages of developing new product concepts. This analysis supports the development of knowledge that informs both theoretical understanding and practical design strategies. To achieve a comprehensive analysis, this section presents a systematic discussion on organising, preparing, and analysing VPA episode data. Valkenburg (2000) emphasises that raw protocol data must be processed, categorised, and structured to become suitable for analysis. In this study, raw data serve as first-hand evidence, relying on recorded videotapes and written verbal transcripts. Transcripts ensure that interactions during sketching, eye contact, body language, and tone of speech are preserved. As described in Section 4.4.3, the VPA episodes are divided into three VPAEs, and data analysis is conducted in three corresponding phases aligned with the research objectives and questions. Data were extracted through visual, video, and audio recordings, capturing verbal conversations, gestures, facial expressions, and eye contact. Organising and preparing these raw data is a complex process, influenced by the methods of data extraction. Qualitative data analysis requires a multi-level approach, and this study applies Creswell's (2009) guidelines for transcription and multi-stage analysis of VPA data. The process ensures that all relevant behavioural and interactional details are systematically captured, coded, and interpreted to generate meaningful insights. Figure 4.41 illustrates the data management and analysis process, reflecting Creswell's recommendations and demonstrating a structured approach to handling complex VPA data for reliable and valid qualitative findings.

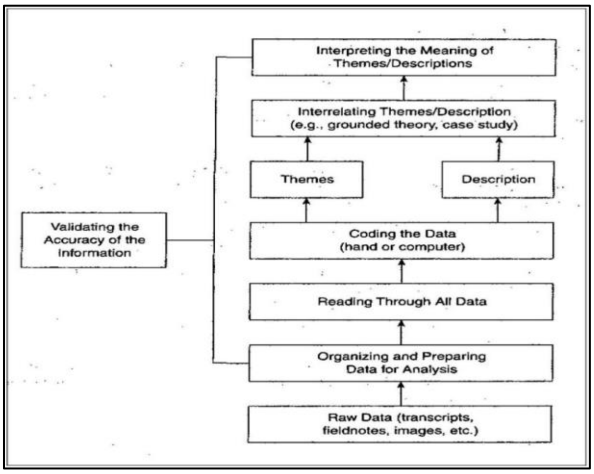


Figure 4.41 Data Analysis in Qualitative Research, adapted from Creswell (2009)

The initial stage of preparing VPA data involves processing and critically preparing video data (raw data from the VPA study) through video editing and merging of footage from CAM1 and CAM2 to create a single, well-prepared video file using VSDC Video Editor Software. The purpose of this process is to ensure that the designer’s sketching activity on A3 paper, body language, and intonation can be observed simultaneously, even from different perspectives. The video editing process was repeated for all 30 respondents involved in the VPAE sessions. To avoid bias in the data or any form of information processing, the researcher appointed two research assistants for the video editing and transcription processes. Both research assistants (master’s in photography and creative imaging) were tasked to ensure data accuracy and high-quality screenshots for printing and publication purposes. The recorded VPA data (video) and audio were submitted for transcription and further editing of the data. The prepared data were coded according to the respondents' registration numbers to ensure that any information required for analysis could be easily retrieved, as recommended by Creswell (2009) (see Figure 4.42) Figure 4.43 (next pages) presents a sample of the written verbal transcription of the VPA study, includes basic information about the designer, such as respondent ID, name, category of design experience, time and date, and protocol activity, all manually recorded. In the written verbal transcription, details about the interaction during the protocol (think-aloud and sketching activities), such as phrases, utterances, body language, and intonation, were carefully documented line by line. To structure the activity, the written verbal transcription was categorised into four sets of categories to enable a systematic analysis procedure, separated by vertical lines as illustrated in Figure 4.43 and Table 4.15.

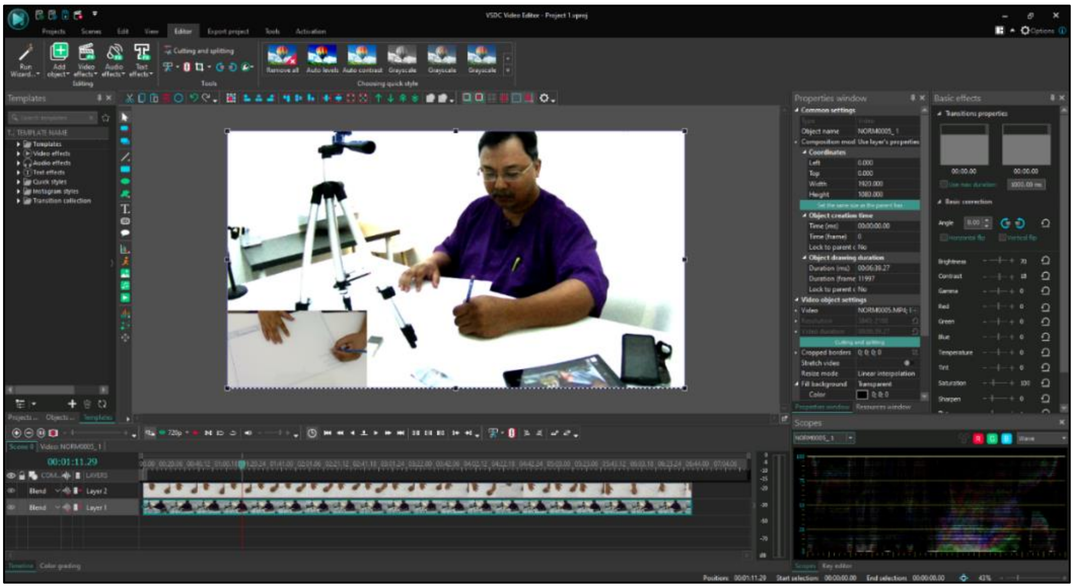


Figure 4.42 Video Editing Process using VSDC Video Editor

Table 4.15
The Four Categories of Written Verbal Transcription

Category Item	Description of the category
Time	a segment in which the exact timing for each activity was recorded.
Transcription of the Protocol	a segment in which all verbatim responses of participants were transcribed.
Designers 'Activity: Thematic Category	a segment in which the fundamental activities of each designer were evaluated and coded.
Designers 'Reflective Practice	a section where every designer's reflective practice activity was being analyse and coded (see Schön (1983), Valkenburg (2000) and Valkenburg and Dorst (1998). The encoding of protocol activity segments as naming. Moving, reflecting and framing (refer to Table 4.11) are presented as Blue, Yellow, Pink and Turquoise, where every designer's reflective practice activity was being coded using colour code preferences

Time	Transcription of the Protocol	igner activity: Thematic Category	Designer Reflective practice			
			Naming	Framing	Moving	Reflecting
00.01	My opinion about the unintended use of such products... In my view, we as users are random. We see things that are around us that can be used. And then... used for our benefit. Unintentionally.					
00.30	Examples like a fence that can be used to hang clothes, besides the wall fence of my house I put shoes and so on... dry clothes and others. From my other point of view, this thing may be the same as everyone else. What I do, others do too..					
01:47	How to say... So this thing is like once we have done it, it will happen many times.. Maintain a daily routine. daily creativity.					
	Frequency of Effective Design Activity					

Figure 4.43 The Sample of Written Verbal Data Transcribing of the VPA Protocol

In line with the main language (Bahasa Melayu), the protocol activities were conducted in a mix of Bahasa Melayu and English, depending on the designers' preference and proficiency. A total of 30 participants took part in the VPA experiment, resulting in 30 sets of protocol data collected during the study. During transcription, some respondents expressed their thoughts using ambiguous words or incomplete sentence fragments, often in everyday language. This is a common occurrence when extracting verbal data, whether manually or using software. Translating these phrases into equivalent English proved challenging for computer software due to the subtlety and ambiguity of the verbal statements. To preserve meaning, translation and transcription were carried out manually by a research assistant, ensuring the overall intent of the respondents was captured. This limitation did not affect the processing of the original data, the interpretation of the results, or the integrity of the experiment. As previously mentioned, designers participated in three VPAE episodes. The following section illustrates a sample of the VPA data analysis procedure conducted across these three sessions, as shown in Figure 4.44. To provide an example of transcription and coding, a segment of the protocol from Respondent VPAE16, classified at the Junior experience level, is reproduced. In this thesis, the verbal protocol of Respondent VPAE16 is presented according to the sub-topic analysis process employed in the study, demonstrating the method of data segmentation, coding, and analysis applied throughout the three VPAE sessions.

VPAE16 Subject: Nurul Najeeha Nordin (Junior)
Date of VPA Session: 21st June 2023

Time	Transcription of the Protocol	Designer activity: Thematic Category	Designer Reflective Practice			
			Naming	Framing	Moving	Reflecting
01:12	For me, **over a long period of time, this product can be damaged**. Then, **bathing in a laundry basin..., he has a drawback as well**.......	Constructing information				RP
01:20	And what causes **us not to consider** the product in the design is **possible in terms of the length of time of the activity.**	Constructing information		FP		
01:42	Perhaps users **are more comfortable doing so**. They are more comfortable in that shape, that's why **they feel and are comfortable using it that way**. I think it has value.	Constructing information				RPh
02:01	…………………..	Constructing information			GI	
25:21	…dan itu saja….				S	
Frequency of Effective Design Activity			**22%**	**8%**	**0%**	**32%**

Figure 4.44 The Sample of Verbal Protocol Transcription of Respondent VPAE16 (00:01 – 25:21)

Overall, protocol data are rich but unstructured, requiring a clear segmentation process based on the designer's interaction with the phenomenon and design reasoning model. Qualitative content analysis was employed to transcribe the VPA of the design protocol (Miles, Huberman, & Johnny, 2013), and segments were classified thematically to identify expressions, phrases, utterances, and discourse forming coherent ideas, actions, or thoughts (Valkenburg, 2000). The transcription was processed and coded through four main steps: (1) segmenting; (2) highlighting emphasis in each phrase, utterance, or discourse; (3) identifying the designer's activities; and (4) mapping reflective practices using a coding frame adapted from Valkenburg and Dorst's (1998) classification (see Table 4.16). The Valkenburg and Dorst model comprises four components applied to encode the segmented dialogue: (i) naming, (ii) framing, (iii) moving, and (iv) reflecting.

Table 4.16
The Four Theoretical Components of Valkenburg and Dorst's (1998) Reflective Practice

Segmented processing and coding transcription	**Description**
segmenting phrases, utterances, and discourse;	Each utterance expressed by the respondents was divided according to segmentation criteria such as sentence by sentence, verbal exchange (which includes non-verbal cues and pauses), or by semantic and syntactic criteria for identifying discrete utterances. This method of segmentation can reduce the likelihood of losing elements of interaction between utterances by each respondent. The utterances were divided into meaningful segments that reflect coherent activities (see Figure 4.45)
highlighting the emphasis in each phrase/utterance/discourse	Emphasis was identified by observing the actions of the designer and the goals present in their mind. Emphasized utterances are highlighted in bold (see Figure 4.29), indicating the respondent's approach in planning strategies to solve problems by formulating ideas perceived as having potential (see Figure 4.45)
identifying the designer's activity	Identifying and coding the designer's sub-activities is done through observing their actions and the goals present in their mind. The main thematic activity is represented by constructing information and sketching (see Figure 4.45). Each sub-activity of reflective practice was categorized to emphasize the differences between activities within the same group and was represented by the respective code. The codes representing the sub-activities are: *Identifying Material (IM), Identifying Component (IC), Framing Problem (FP), Fixing Goal (FG), Framing Solution (FS), Sketching (S), Detailing Design Concept (DDc), Generating Ideation (GI), Reflecting on Phenomenon (RPh), Reflecting on Attribute (RA), Reflecting on Problem (RP), Clarifying Solution (CS), and Reflecting on Experience (REx)* (see Figure 4.45)
identifying and coding designers" reflective practice	The coding method used the 'designer's reflective practice' approach by Valkenburg (2000), adapted to the designer's reflective practice activities coded in each utterance. To code each reflective practice, this study used four color codes (Blue, Yellow, Pink, and Turquoise), representing the

four reflective practices identified by Valkenburg (2000): Blue (Naming), Yellow (Moving), Pink (Reflecting), and Turquoise (Framing). The aim was to determine the designer's reflective practices according to the correct sequential flow. This represents a systematic coding approach to explain behavioral patterns in the designer's sketching activities. Each reflective practice is matched with sub-activities as follows:
Naming: Identifying material (IM), Identifying component (IC),
Framing: Framing problem (FP), Fixing goal (FG), Frame solution (FS),
Moving: Sketching (S), Detail design concept (DDc), Generate Idea (GI),
Reflecting: Reflecting to phenomenon (RPh), Reflecting to attribute (RA), Reflecting to Problem (RP), Clarifying solution (CS), Reflecting to experience (REx) (see Figure 4.45)

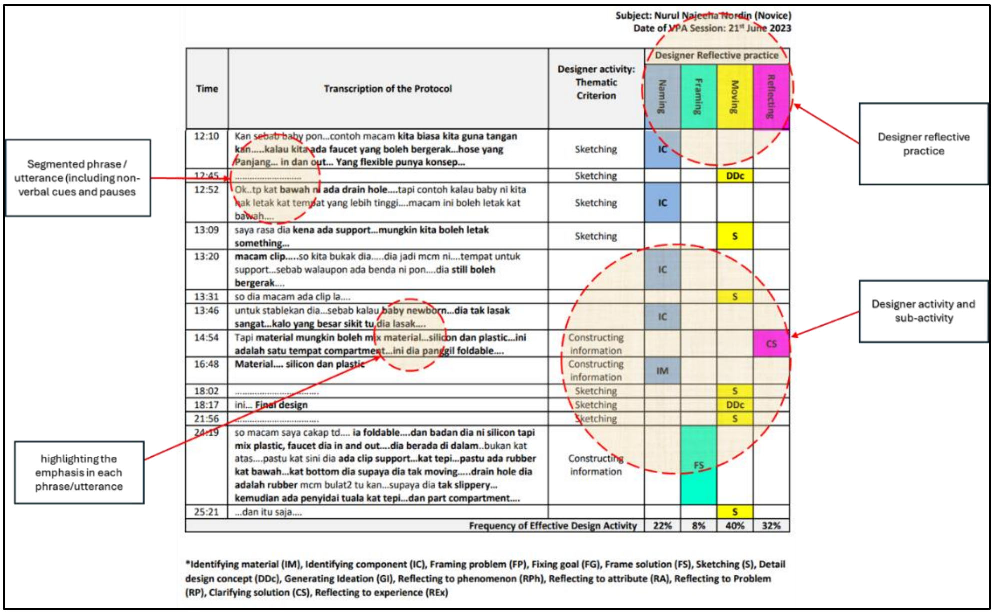


Figure 4.45 The Sample of Transcription Component

VPAE1: RESPONSE ANALYSIS (Grounded theory)

In this sub-topic, the analysis of VPAE1 data is to achieve the second research objective; to evaluate designers' responses towards unintended behaviour attributions through verbal protocol analysis and design activity. The outcome of the study is hoped to answer the second research question: "Why is the designer's interpretation of unintended human behaviour regarded as offering invaluable insights into design thinking during the early stages of new product concepts?" The episode of VPA is based on the four attributes of unintended interaction in everyday human behaviour. Each designer was given a questionnaire consisting of images of UHBE representation. The photo depicts the subtle and creative ways in which people interact with the product unintendedly, in this case, bathing baby in the wash basin. The respondent were asked to answer seven questions and respond to their thought based on visual research references as photo stimulation. In this study, designers' reflection and responses were identified through the propositions, which are based on given photos (visual research references), as underlines:

1. Reflection-in-action on phenomena: Generally, photo analysis, according to Merriam-Webster (2006), is a detailed examination of anything complex to understand its nature or to determine its essential features: thorough study. This activity is to see what designers' reflection-in-action to phenomena analysis based on given photos.
   Q1. What is your understanding of the unintended use of products in everyday life?
2. Reflection-in-action to the attributes: Oxman (2002) proposed that "the thinking eye" is claimed as a standard way of defining human perception-in-action. Given. M.L. (2014) said, "Perception is a mode of apprehending reality and experience through the senses, thus enabling discernment of figure, form, language, behaviour, and action. Individual perception influences opinion, judgment, understanding of a situation or person, the meaning of an experience, and how one responds to a situation. A common way of defining perception is "how we see things." However, perception is a process involving not only the senses but also complex underlying mechanisms." This activity is to see what designers' reflection-in-action to the attributes of unintended interaction in everyday human behaviour as pictured in given photos.
   Q2. Based on photo analysis, psychological factors motivate unintended behaviour through trial and error and creativity. How do you respond?
   Q3. Based on photo analysis, social and cultural context motivate unintended behaviour through social sharing attributes. How do you respond?
   Q4. Based on photo analysis, situational aspects motivate unintended behaviour through the attributes of a quick solution. How do you respond?
   Q5. Based on photo analysis, the propensity multiple uses factor motivates unintended behaviour through the object's ability (affordance) and fit for purpose attributes. How do you respond?
3. Reflection-in-action to value: In Valkenburg and Dorst (1998), reflection-in-action is a spontaneous and rational action that can lead to making value innovation. This activity is to see what designers' reflection-in-action based on their analysis given photos.
   Q6. In your opinion, why do designers pay less attention to unintentional behaviour among users?
   Q7. Personally, unintended interactions in mainstream products are valuable in The design concept?

Based on the designers' reflections and responses, the process of coding VPAE1 data is an important part of the analytical process of analysing qualitative research. In this study, data generated from VPA allows researchers to interpret, organise, and structure research observations and interpretations into meaningful theories. According to Creswell (2009), coding in qualitative research through explicit explanation and abstract thought allows researchers to be reflexive, critical, and rigorous with the findings. Thus, this study focuses on generating theoretical ideas from the VPAE1 data collected. A theory elucidates a framework of conceptual interrelations, wherein concepts, constructions, and principles are delineated; the application area is specified; the rationale for the existence of relationships is articulated; and potential outcomes in various scenarios are forecasted (Wacker, 2008, p. 7). It is a model or illustration that describes how something functions by showing its elements to one another (Friedman, 2006). A theory is also regarded as a set of propositions that provides principles of analysis or explanations about a phenomenon, enabling design researchers to structure and organise their observations, formulate questions, and develop generalizable answers that are beneficial to people across different times and contexts. Corbin and Straus (2008) explained, 'a grounded theory is one that is inductively derived from the study of the phenomena it represents' (Corbin and Straus, p. 23). Therefore, the coding of VPAE1 data into information categories is employed as an analytical approach in this study. The development of grounded theory in this research is aligned with the focus of Research Objective 2.

The Grounded Theory approach aimed at constructing theories grounded in collected VPA data. In this context, coding methods play a pivotal role in systematically interpreting and analysing VPAE1 data. Corbin and Strauss (2008) introduced a structured coding approach through three main stages: Open Coding, Axial Coding, and Selective Coding. This process enables researchers to generate categories, themes, and relationships between concepts, forming the foundation of a theory. According to Charmaz (1983, p. 125), the core elements of Corbin and Strauss approach are:

1. Inquiry shaped by the aims to discover social & social psychological processes.
2. Data collection and analysis phases of the project proceed simultaneously.
3. Analytic process employed prompts theory discovery and development rather than verification of pre-existing theories (inductive)
4. Theoretical sampling refine, elaborates and exhausts conceptual categories.
5. The systematic application of the grounded theory analytic method will progressively lead to more abstract analytic levels.

In this thesis, the qualitative inquiry coding of VPA data refers to words or short phrases that typically provide a summative, salient, essence-capturing, or evocative attribute of a portion of language-based data. As previously mentioned, the raw VPA data contains a mix of Malay and English. Therefore, for the purpose of coding, English is prioritised to determine the underlying meaning of expressions for generating initial categories. Each expression is carefully translated and coded to avoid any loss of meaning intended by the respondents. The next process involves filtering the data, organising it, and preparing a way to make comparisons with other data segments. Based on the systematic coding approach by Corbin and Strauss (2008), it is divided into three stages: (i) Open Coding, (ii) Axial Coding, and (iii) Selective Coding. Open Coding represents the first stage of the coding process, where VPAE1 data is analysed in detail to identify units of meaning, such as concepts, categories, and properties that emerge from the data. The primary goal of open coding is to uncover hidden meanings and generate initial categories. At this stage, coding is entirely VPAE1 data-driven, with no preconceived assumptions, and involves fragmenting the data into smaller units for deeper analysis. Researchers inductively identify concepts and repeatedly read data transcripts to understand the content. Significant words, phrases, or sentences are identified and labelled with appropriate codes. These codes are then compared to find similarities and differences (Strauss & Corbin, 1990). The iterative nature of Open Coding allows researchers to refine categories progressively (Holton, 2007). Creswell (2009) emphasizes the importance of identifying recurring patterns and themes during this stage to develop a solid foundation for subsequent coding. Figure 4.46 indicates a sample of open coding conducted for the utterance analysis of VPAE1 data.

Label of transcribing data (Mix-language)	Subject ID	Open Category (English)
"It is **based on situation"** "Unintendedly use a product to **fullfill need"**	(N6,S1)	- Context of use - goal or purpose
"use the product to **meet the need"**	(S4)	- goal or purpose
"It's based-on **creativity" "product ability"** **"kesesuaian"** **"memudahkan"**	(J7,J9,N4,J8, E1,E3)	- human cognitive thinking - product knowledge
There was a **product opportunity** that was needed when it wasn't available.	(E2,S7)	- Product understanding
Produk sedia ada **hampir mencapai fungsi** produk yang sepatutnya.	(E5)	- Sensory innovativeness
Pengguna menggunakan produk mengikut **logic** sekiranya ia sesuai untuk digunakan dan yang diinginkan.	(J1)	- Cognitive innovativeness

Penggunaan produk tidak sengaja adalah **random**. Produk **di sekeliling** kita boleh digunakan untuk **kepentingan** kita tanpa tak sengaja.	(J2)	- Environment influences - goal or purpose
kreativiti yang digunakan dalam keadaan segera, untuk penjimatan, tiada kos, produk sedia ada, tapi function yang lain.	(J3,J6,J10,N3)	- Immediate reaction to problem - economic constraints
Penggunaan produk secara tidak sengaja ialah focus yang lain dari focus yang asal, tetapi tengok situasi juga.	(J4)	- Cognitive innovativeness - Context of use
Tingkahlaku tidak sengaja, saya juga pernah gunakan produk bukan fungsi yang asal. Ia multitask.	(J5)	- Product understanding
Banyak pengalaman saya pernah buat.	(N7)	- Experience-based knowledge
Tingkahlaku ini, tak betul dari segi keselamatan itu sangat rendah.	(N1)	- Risk-based decision making - Negative consequence
Penggunaan produk harian ini tak semua produk memenuhi konsep penggunaan, sebab **tak semua produk sempurna**,	(N2)	- Dissatisfaction with current product
Produk yang digunakan secara tak sengaja menunjukkan pengguna kreatif, nampak fungsi lain. Cuma produk tak long lasting.	(N5)	- Human creative way
Tingkahlaku tidak sengaja terhadap produk oleh pengguna sebab samada user tak ada produk tersebut. User guna produk yang berdekatan dengan kita yang boleh berfungsi seperti produk yang kita nak. Kita buat jugak sebab produk tersebut boleh (mampu).	(S6)	- Context of use - Product affordance
kalau based on function ok saja, tapi kalau safety maybe certain part tak sesuai.	(J8)	- Risk-based decision making
Ia based on tempat, and situasi orang tu… user akan cari benda yang senang dia nak capai, yang multi purpose punya barang.	(S3)	- Context of use - Product affordance
kemampuan manusia untuk berfikir secara kreatif ini mereka akan sentiasa berfikir bagaimanakah produk itu dapat digunakan dengan lebih berfungsi kepada mereka.	(S5)	- Human creative way - transforming usage of the current product - goal or purpose
secara spontan itu, benda yang tiada dapat digunakan untuk dia sebagai alternatif.	(S2)	- Spontaneous reaction - Unexpected condition
Tingkahlaku secara tidak sengaja ini, dia berdasarkan kepada Tindakan sengaja. Reflex dan non-reflexive.	(E4)	- involuntary (automatic) action

Figure 4.46 Sample of Open Coding from a study of Designers' Perception towards UHBE Phenomenon (Question 1)

The second stage of the coding process is axial coding. Through axial coding, the researcher focuses on relationships between categories identified during Open Coding (Charmaz, 2006; Dey, 1999). During the process, researchers organise fragmented data and establish connections between different concepts into more abstract conceptual categories. Axial Coding emphasizes the interaction and relationship between main categories and subcategories, linking them to their contexts and conditions. Researchers select relevant main categories and connect them with subcategories (for example, the properties and dimensions of the data). The properties and characteristics of a category pertain to elements such as the conditions, causes, and effects of a process that assist the researcher in understanding when, how, and why an event occurs. In other words, axial coding tracks the evolution of a principal category, even if it is in an early phase of growth. Creswell (2009) describes the systematic methodology of axial coding, which involves sorting, synthesizing, and organizing extensive data sets and reconfiguring them in novel formats following open coding. At this stage, the previously introduced open codes have been amalgamated, redefined, and systematically structured with respect to one another. This structured approach builds a more organised framework for understanding the phenomenon under study (Birks & Mills, 2015). Axial Coding helps in synthesizing data into broader categories that provide greater explanatory power (Kelle, 2007). Saldana (2009) highlights how Axial Coding provides the opportunity to deepen analysis by identifying contextual and processual dimensions within the data. Nonetheless, the researcher revisits each verbal transcription to refine the open codes into axial codes that reflect perceptions. The grouping of open codes using axial coding succeeded by re-coding, may need to be repeated several times for each axial code. Figure 4.47 indicates the sample Axial coding conducted for the utterance analysis of data VPAE1.

Open Category	Subject ID	Correlation between category
- Context of use - goal or purpose	(N6, S1, S4)	occurs based on the context of use to fulfill a certain goal or purpose
- human cognitive thinking	(J7, J9, N4, J8, E1, E3)	involves human cognitive thinking in creative ways
- Product understanding - product knowledge	(E2,S7.J5)	shows individual has product knowledge and understanding
- Sensory innovativeness - Cognitive innovativeness	(E5, J1, J4)	shows individuals have cognitive, sensory innovativeness towards new experiences
- Environment influences - Immediate reaction to problem - economic constraints	(J2, J3, J6, J10, N3)	an immediate reaction to a problem whether from the environment or economic constraints
- Experience-based knowledge	(N7)	can happen repeatedly based on Experience-based knowledge
- Risk-based decision making - Negative consequence	(N1, J8)	indicates Risk-based decision-making that may cause negative consequences to the individual
- Dissatisfaction with current product	(N2)	illustrates dissatisfaction with the current product
- Human creative way - transforming usage of the current product - goal or purpose	(N5, S5)	illustrates people transforming usage of the current product for a specific goal or purpose in everyday life
- Context of use - Product affordance	(S3, S6)	shows user's ability to identify product affordance in a specific context
- Involuntary (automatic) action - Spontaneous reaction - Unexpected condition	(E4, S2)	an involuntary action and spontaneous reaction in a given set or unexpected condition

Figure 4.47 Sample of Axial Coding from Designers' Perception towards UHBE Phenomenon (Question 1)

The final stage, Selective Coding, involves identifying a core category that represents the central theme of the study. This core category is systematically connected with other categories to form a coherent and unified theoretical framework. Through this process, all categories are integrated to highlight the phenomenon under investigation. Researchers then construct a narrative theory by linking the core category with other categories, validating it against the original data, and refining it to ensure consistency and alignment (Strauss & Corbin, 1998). This stage provides a comprehensive understanding of the research phenomenon and strengthens theory-building (Bryant & Charmaz, 2007). According to Creswell (2009), Selective Coding ensures that the resulting theory is grounded, credible, and practically relevant to addressing the research problem. Figure 4.48 illustrates a sample of selective coding of VPAE1 data, while Figure 4.49 presents a sample linking the relation of the VPAE1 Open coding, Axial coding, and Selective coding between categories.

Correlation between category	Subject ID	Selective Coding
occurs based on the context of use to fulfill a certain goal or purpose an immediate reaction to a problem whether from the environment or economic constraints	(N6, S1, S4, J7, J9, N4, J8, E1, E3)	Unintended human behaviour is an immediate reaction to problems arising from the environment, economic constraints, or context of use.
an involuntary action and spontaneous reaction in a given set or unexpected condition can happen repeatedly based on Experience-based knowledge	(N7, E4, S2)	Unintended human behaviour is a spontaneous reaction towards unexpected conditions that can happen repeatedly based on experience-based knowledge.
illustrates dissatisfaction with current product illustrates people transforming usage of the current product for a specific goal or purpose in everyday life	(N2, N5, S5)	Unintended human behaviour illustrates dissatisfaction with the current product and transforms its usage to meet specific goals or purposes in everyday life.
involves human cognitive thinking in creative ways shows that individuals have cognitive and sensory innovativeness towards new experiences	(J7, J9, N4, J8, E1, E3, E5, J1, J4)	Unintended human behaviour involves human cognitive thinking in creative ways and shows sensory innovativeness toward new experiences
indicates Risk-based decision-making that may cause negative consequences to the individual	(N1, J8)	Unintended human behaviour indicates Risk-based decision-making that may cause negative consequence to individual
shows individual has product knowledge and understanding shows user's ability to identify product affordance in a specific context	(E2, S7.J5, S3, S6)	Unintended human behaviour shows that individuals with product knowledge and understanding can identify product affordance in a specific context

Figure 4.48 Sample of Selective Coding from a study of Designers' Perception towards UHBE Phenomenon (Question 1)

Subject ID	Label of transcribing data (Mix-language)	Open Category (English)
(N6,S1)	"It is based on situation" "Unintendedly use a product to fullfill need"	- Context of use - goal or purpose
(S4)	"menggunakan produk untuk memenuhi keperluan"	- goal or purpose
(J7,J9,N4,N8, E1,E3)	"It's based-on creativity" "product ability" "kesesuaian" "memudahkan"	- human cognitive thinking - product knowledge
(E2,S7)	terdapat opportunity product yang diperlukan ketika itu tidak ada.	- Product understanding
(E5)	Produk sedia ada hampir mencapai fungsi produk yang sepatutnya.	- Sensory innovativeness
(J1)	Pengguna menggunakan produk mengikut logic sekiranya ia sesuai untuk digunakan dan yang diinginkan.	- Cognitive innovativeness
(J2)	Penggunaan produk tidak sengaja adalah random. Produk di sekeliling kita boleh digunakan untuk kepentingan kita tanpa tak sengaja.	- Environment influences - goal or purpose
(J3,J6,J10,N3)	kreativiti yang digunakan dalam keadaan segera, untuk penjimatan, tiada kos, produk sedia ada, tapi function yang lain.	- Immediate reaction to problem - economic constraints
(J4)	Penggunaan produk secara tidak sengaja ialah focus yang lain dari focus yang asal, tetapi tengok situasi juga.	- Cognitive innovativeness - Context of use
(J5)	Tingkahlaku tidak sengaja, saya juga pernah gunakan produk bukan fungsi yang asal. Ia multitask.	- Product understanding
(N7)	Banyak pengalaman saya pernah buat.	- Experience-based knowledge
(N1)	Tingkahlaku ini, tak betul dari segi keselamatan itu sangat rendah.	- Risk-based decision making - Negative consequence
(N2)	Penggunaan produk harian ini tak semua produk memenuhi konsep penggunaan, sebab tak semua produk sempurna,	- Dissatisfaction with current product
(N5)	Produk yang digunakan secara tak sengaja menunjukkan pengguna kreatif, nampak fungsi lain. Cuma produk tak long lasting.	- Human creative way
(S6)	Tingkahlaku tidak sengaja terhadap produk oleh pengguna sebab samada user tak ada produk tersebut. User guna produk yang berdekatan dengan kita yang boleh berfungsi seperti produk yang kita nak. Kita buat jugak sebab produk tersebut boleh (mampu).	- Context of use - Product affordance
(J8)	kalau based on function ok saja, tapi kalau safety maybe certain part tak sesuai.	- Risk-based decision making
(S3)	Ia based on tempat, and situasi orang tu... user akan cari benda yang senang dia nak capai, yang multi purpose punya barang.	- Context of use - Product affordance
(S5)	kemampuan manusia untuk berfikir secara kreatif ini mereka akan sentiasa berfikir bagaimanakah produk itu dapat digunakan dengan lebih berfungsi kepada mereka.	- Human creative way - transforming usage of the current product - goal or purpose
(S2)	secara spontan itu, benda yang tiada dapat digunakan untuk dia sebagai alternatif.	- Spontaneous reaction - Unexpected condition
(E4)	Tingkahlaku secara tidak sengaja ini, dia berdasarkan kepada Tindakan sengaja. Reflex dan non-reflexive.	- involuntary (automatic) action

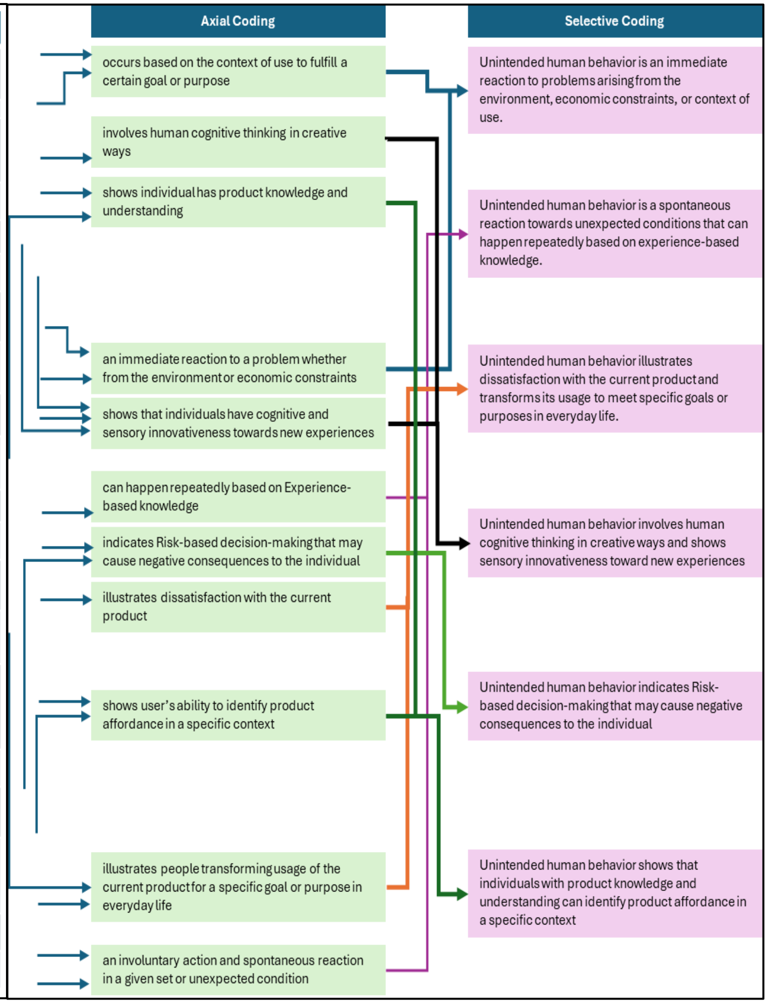


Figure 4.49 Sample of Linking the relation of The VPAE1 Open Coding, Axial Coding and Selective Coding between Categories

According to Corbin and Strauss (2008), coding in Grounded Theory is an iterative process in which researchers continuously analyse, compare, and refine categories based on emerging data. Supported by inductive principles (Glaser & Strauss, 1967), this approach allows theories to emerge directly from data. Charmaz (2014) emphasizes flexibility in coding, ensuring that the resulting theory accurately reflects the social reality under study. Clarke (2005) highlights the importance of situational analysis to contextualize categories within broader sociocultural frameworks. Saldana (2009) recommends maintaining detailed coding logs to track category development and ensure methodological transparency. The researcher's role is critical, acting as the primary analytical instrument. Researchers must critically analyse data, remain flexible to new interpretations, and reflect on potential biases affecting coding. Maintaining an audit trail enhances transparency and rigor (Lempert, 2007). Triangulating data sources and validating findings through member checking further strengthens credibility (Creswell, 2009). The coding process progresses through Open, Axial, and Selective Coding, enabling the construction of robust, data-driven theories (Corbin & Strauss, 2008). This methodology identifies relationships between categories and builds coherent theories, deepening understanding of the studied phenomenon and contributing to academic knowledge. Coding can also serve as a classification tool for qualitative analysis, while quantitative applications are feasible depending on research objectives. Namey et al. (2008) recommend determining theme frequencies based on participant mentions rather than total occurrences, supporting statistical validation.

In this study, VPAE1 data were quantified using SPSS version 28, applying descriptive statistical analysis such as frequency distribution to summarise findings meaningfully. Integrating qualitative and quantitative methods allows for comprehensive analysis, supporting central propositions with validated evidence. The results of this approach will be discussed in the next section, demonstrating the effectiveness of combining Grounded Theory coding with quantitative techniques to produce reliable, data-driven insights.

VPAE2: Analysis Eye Tracking and Body Gesture and Interaction

In this section, the research focuses on the interactions exhibited by the designers with the mediators provided throughout the VPA process. The primary objective of VPAE2 is to observe how designers interact with the mediators while framing the problem and how they integrate their thoughts into design strategies and decision-making. In other words, the observation aims to evaluate the designers' thought processes regarding the provided elements, which can reveal the priority aspects considered by designers when creating a new product concept for an existing product based on the context of UHBE. As stated in Section 4.4.5 and Table 4.17, five mediators were used to capture the designers' perspectives and assess their cognitive patterns during the design activity. In this study, bathing a baby in a wash basin can pose a risk of injury to the baby if not managed properly. Therefore, observations of designers' eye-tracking, body gestures, and interactions during the design process are assessed through image and video recordings placed in front of the designers. The collected image data for each designer is recorded numerically and will be presented in detail in next session. Table 4.17 shows a sample of data collected from designers in the Junior category.

Table 4.17
Sample Analysis of Total Interaction with the Mediator performed by Designers in the Junior Category

Category of Designer	No ID	Video	Ergonomic	Technical	Artefact	Artificial Doll
Junior	N1	1	11	76	5	1
	N2	4	3	41	5	1
	N3	18	15	27	5	0
	N4	4	8	38	12	1
	N5	9	9	31	0	0
	N6	3	3	19	1	0
	N7	11	8	49	4	0
	N8	14	10	7	1	0
	N9	7	5	15	6	6
	N10	10	4	21	0	0
Total		**81**	**76**	**324**	**39**	**9**

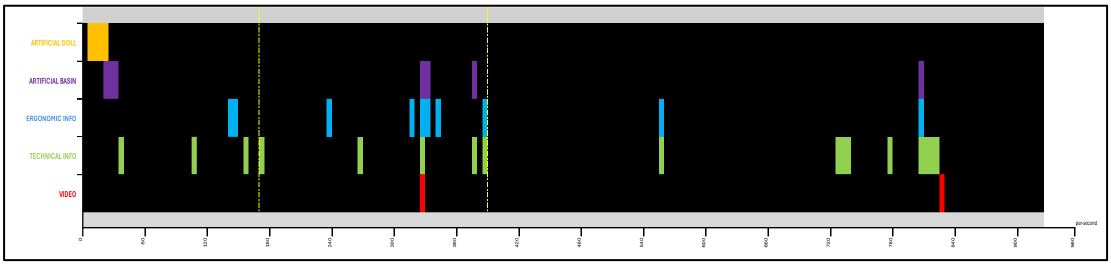


Figure 4.50 Sample Analysis of Reflective Thinking and Interaction towards Mediators performed by Senior Designer

Figure 4.50 presents a sample analysis of reflective thinking and interaction, illustrated through a coded matrix representing the total time spent by designers during the VPAE2 and VPAE3 episodes. The study of designer interactions with the mediators was recorded and colour-coded as follows: Red (video), Green (technical information), Blue (ergonomic information), Purple (artificial basin), and Orange (artificial doll). The black background code represents the total duration taken by the designer for the design protocol. Meanwhile, the yellow line indicates the level of abstraction during the designer's reflective practice. The overall number of interactions detected throughout VPAE2 is documented as shown in Figure 4.51.

Figure 4.51 Visual Sample of Eye Tracking, Body Gesture and Mediators' Interaction performed by Senior Designer

Figure 4.51, on the other hand, consists of several captured images showing the interactions, eye-tracking, and body gestures exhibited by designers during the VPAE2 episode. All these interactions were recorded via CAM1 and CAM3 as the designers engaged with the provided mediators. A more detailed explanation of the VPAE2 analysis will be presented in next section.

VPAE3: Design Episode Analysis of Reflective Practice

As mentioned in the previous section, there is only one episode of VPAE3 protocols generated by 30 designers, which makes a total of 30 VPA protocols collected. In this episode, all VPA data from the beginning of VPAE2 episode has been prepared and coded, as described in the previous sub-topic (e.g. video data processing, preparing written verbal transcription and organising coding). Meanwhile, using the reflective practice model, the transcription of VPA data has been analysed through: (1) identifying designer's reflective practice activity in each utterance; and (2) coding the designers' reflective practice using color coding preferences (coded matrix). In this section, we will briefly explain how the outcome of the analysis will be described. According to Andreasen (1991), the complexity of form development in design is based on its level of abstraction. Since Schön (1983) view design practice (e.g. sketching process) as reflective practice, therefore, the critical data analysis of the designers' reflective practice was based on Andreasen's level of abstraction, according to the following:

1. Abstract Level: A stage where the idea is fuzzy in nature and everything depends on the designer's experience, subjective interpretation, and influences from other objects and contexts. According to Abidin, Bjelland, and Øritsland (2008). Abstract is the level at which we question the choice and the orientation of the image elements.
2. Semi-concrete Level: A stage where the climax of the activities usually occurred and the idea is lifted. During this stage, the designer goes through a process of exploring form, addressing form in relation to certain dimensions of representation. This process of exploration and transformation then transcends to a concrete level. At this level, designer usually needs to consider the type of form (Abidin, Bjelland, and Øritsland, 2008).
3. Concrete Level: A stage where the elements of persuasion and design intent are emphasised. Although not part of the focus of this study, persuading the audience who will be interacting with and experiencing the product is part of the challenge at this stage. In other words, it is the level where designers make decisions that lead to a more detailed picture of the image developed so far.

In addition, the designers' reflective practices across various design activities are analysed and presented in a coded matrix, where the patterns of reflective practice can be observed based on colour codes, as well as the activities at each level of abstraction. Based on the VPA transcription, the coded matrix has been mapped according to the coding process of designers' reflective practices using three colour options. Furthermore, the relative percentage of time spent by the designers has also been calculated and analysed, indicating the total effective design time utilized by the designers and the percentage allocated to each reflective practice mechanism. Figure 4.52 presents a sample coded matrix of the designers' reflective practice based on abstraction levels in design activities and the effective design time performed by a Junior Designer.

Time	Transcription of the Protocol	Designer activity: Thematic Category	Designer Reflective practice			
			Naming	Framing	Moving	Reflecting
01:20	Observed phenomena	Constructing information		FP		
01:30	Ok firstly……….	Constructing information			S	
01:42	The one I designed is that he has a faucet, this pipe... I've noticed that if a person bathes a baby in the sink the tap is a bit dangerous... scared of hitting the baby's head... So I changed it a little bit, he has a design…	Constructing information	IC			
03:46	So I look at it as if I have a baby's body, I don't want to make it too deep….	Sketching		FS		
03:52	If you look at the video, they just have to hold the baby, they're scared to drown. So I made him curve a little.. He's like... Cut it in two, but it's not too deep. that's it..	Sketching			DDc	
04:00	for the basin with him has a faucet... the rest of the function is the same…	Sketching		FS		
04:11	Material if there is also (ceramic)... ceramic to bear the weight of a baby who in two or three months I think it's ok ja ceramic…	Constructing information	IM			
04:25	So I keep the material..	Sketching			S	
04:45	So far that's all…	Sketching			S	
		Frequency of Effective Design Activity	14%	18%	36%	31%

Figure 4.52 Sampel of Designers' Reflective Practice based on Abstraction Level in Design Activities and Effective Design Time perform by Junior Designer

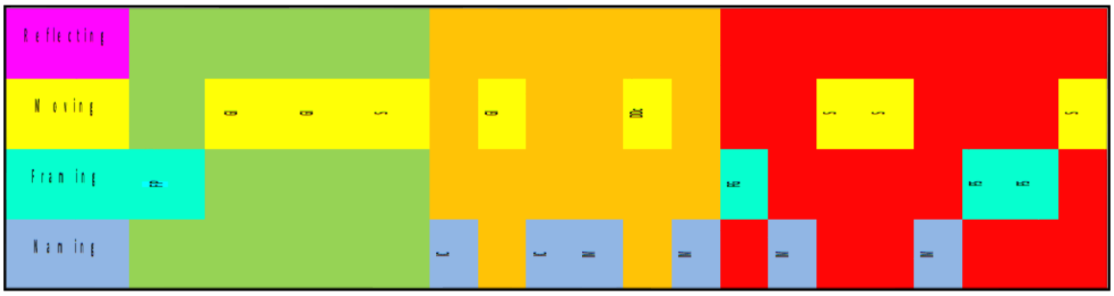


Figure 4.53 Sample of Coded Matrix (critical data analysis) of Designers' Reflective Practice based on Andreasen's Level of Abstraction in Design Activities

Figure 4.53 presents a colour-coded matrix visualisation illustrating a critical analysis of Junior designers' reflective practices during the creation of new product concepts. The data are analysed using two main dimensions: the mechanism of reflective practice and the level of abstraction of thought based on the Andreasen model. The right side of the diagram identifies the reflective practice mechanisms, coded by colour: pink for reflecting, yellow for moving, turquoise for framing, and blue for naming. These colours indicate how designers reassess decisions, advance ideas, reframe understanding, and cognitively label design elements throughout the process. The larger coloured blocks represent the level of abstraction in thinking: green denotes the abstract level, focusing on initial conceptual thinking and strategic planning; orange denotes the semi-concrete level, combining conceptual and physical ideas; and red denotes the concrete level, highlighting detailed thinking centered on the physical aspects of the product. This visualisation provides a clear overview of cognitive and reflective patterns in Junior designers' activities. Overall, this visualisation illustrates how designers actively engage in the reflection process at various levels of thinking, as well as how certain reflection mechanisms are more likely to occur at specific levels of abstraction. For example, the activity of reflecting occurs more at the abstract level, while moving and naming are more prominent at the concrete level, reflecting the dynamic interaction between reflection and cognition throughout the design process. The comparison between designers from the same category and level of expertise will be presented in next section. As mentioned in the Chapter Three, the episode of VPAE3 protocols will generate new product concepts of wash basin integrated with baby bathe features, which make a total of 30 sketches has been collected. The sample of the designer's reflective practice and sketch activity was illustrated in Figure 4.54 and Figure 4.55. The outcome from the VPAE3 episode of analysis will be presented in next section.

Figure 4.54 Sample of VPAE3 Session with the Designers

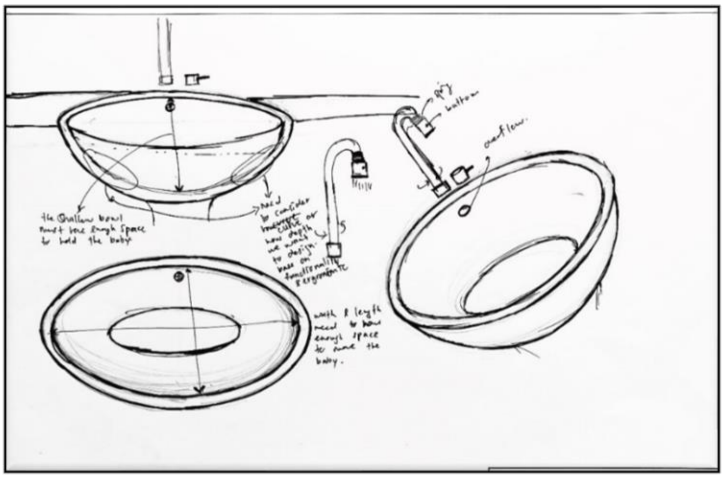


Figure 4.55 Sample of Sketching by Senior Designer during VPAE3 Episode of Reflective Practice

4.5.9 The Reliability and Validity of VPA Data Analysis

Reliability and validity are crucial elements in every qualitative research study. According to Creswell (2009), qualitative validity means that the researcher checks the accuracy of the findings by using specific procedures, while qualitative reliability indicates that the researcher's approach is consistent across different researchers and various projects. Specifically, for the VPA study, the reliability and validity of VPA data analysis refer to the extent to which the same results would be obtained if the research were repeated (Valkenburg, 2000). In addition, Smagorinsky (1989) highlights two justifications for evaluating the reliability and validity of VPA data:

1. Comparing the results of (1) concurrent protocols (verbal responses expressed simultaneously with task performance) and (2) retrospective protocols (subjects are asked to talk about the cognitive processes that occurred at an earlier time).
2. The identification of processes must be supported by some form of evidence.

According to Creswell (2009), one method to ensure internal validity and data verification is by conducting triangulation analysis. Triangulation analysis is an approach where data are analysed from multiple sources. Based on the works of Smagorinsky (1989) and Creswell (2009), a triangulation data analysis approach has been adopted by integrating data from various sources, including: (1) protocol data transcriptions, (2) video data, (3) interaction images, (4) retrospective notes, (5) data analysis from reflective practice analysis, and (6) coded matrix analysis.

4.5.10 The Result: Verbal Protocol Analysis for VPAE1, VPAE2, and VPAE3

Descriptive Analysis of VPAE1

As mentioned in sub-section 4.4.5, VPAE1 was conducted to understand designers' response to phenomenon through photo elicitation using PBA reference. In addition, this section will formulate designers' interpretation and reflection in building grounded theory of the UHBE phenomenon. In this section, descriptive analysis of VPAE1 is presented and discussed based on data which generate from VPA experiment, that will answer RQ2. The VPAE1 Experiment began after the briefs session was done, which designers were expressed their views and response using the photo elicitation approach through visual research reference resources (VRR) of PBA questionnaire. A total of seven questions from three sub-segments were responses by designers in the VPAE1 session as described in section 4.4.5. To facilitate the VPAE1 process, researchers read the question twice to make sure respondents understood the question clearly. In this analysis, designers' reflection and responses were identified through the propositions which are based on given photos (visual research references), as explained in VPAE1: response analysis (grounded theory).

There are seven questions pose based on three propositions. During the session during VPAE1 session the designer provided with a visual research reference that depicts the UHBE context. Then the VPAE1 quantified to describe, show or summarise the data findings in a meaningful way using descriptive statistical analysis: (i) Frequencies distribution analysis: a test used to display the frequency of occurrence of each score value, and (ii) Cross tabulation analysis: a test used to identify the relationship between variables based on the frequency test results. The VPAE1 data code was analysed through systematic coding design into a numeric value. The following (see Figure 4.56) are the results of the coding process based on the raw data from the VPAE1 for Question 1; What is your understanding of unintended use of products in everyday life?

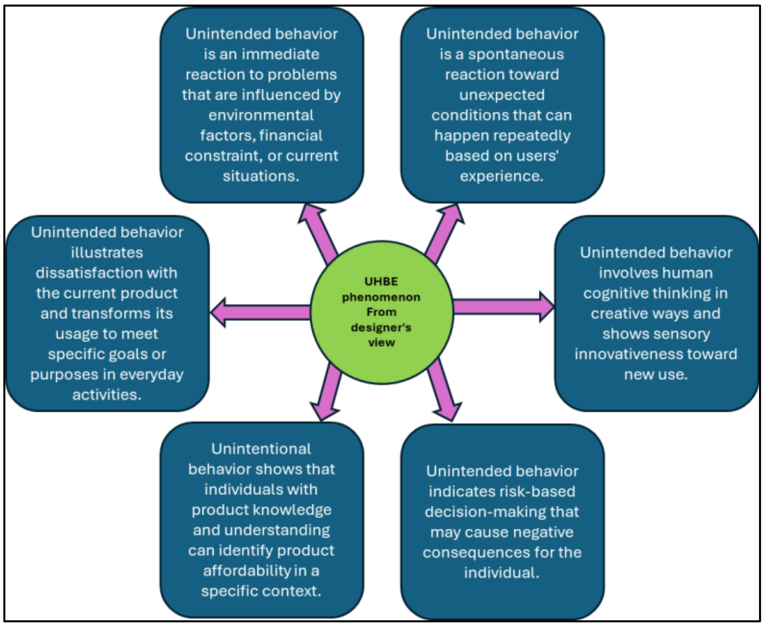


Figure 4.56 Designer Perspective towards UHBE Phenomenon

Table 4.18
Frequency and Cross Tabulation table between Designers' Perceptions of UHBE Phenomenon based on Photo Elicitation through VPAE1

Response towards phenomena of unintended human behaviour	**Frequency**	**Percent**	**Cross-tabulation**			
			Junior	Intermediate	Senior	Expert
Unintended behaviour is an immediate reaction to problems that are influenced by environmental factors, financial constraint, or current situations.	8	26.7%	2	2	2	2
			6.67%	6.67%	6.67%	6.67%
Unintended behaviour is a spontaneous reaction toward unexpected conditions that can happen repeatedly based on users' experience.	3	10.0%	0	1	1	1
			0%	3.33%	3.33%	.33%
Unintended behaviour involves human cognitive thinking in creative ways and shows sensory innovativeness toward new use.	9	30.0%	4	2	0	3
			13.3%	6.66%	0%	0.0%
Unintended behaviour indicates risk-based decision-making that may cause negative consequences for the individual.	2	6.6%	1	1	0	0
			3.30%	3.30%	0%	0%
Unintentional behaviour shows that individuals with product knowledge and understanding can identify product affordability in a specific context.	5	16.7%	1	0	3	1
			3.34%	0%	10.02%	.34%
Unintended behaviour illustrates dissatisfaction with the current product and transforms its usage to meet specific goals or purposes in everyday activities.	3	10.0%	0	2	1	0
			0%	6.67%	3.33%	0%

Based on Table 4.18, the results of question 1 indicate that there are six primary themes of perception formulation expressed by product designers in relation to the UHBE phenomenon. Each perception formulation, derived from systematic coding, includes the number of designers who shared that perspective, along with the percentage representing the total number of respondents. Unintended behaviour represents an immediate reaction to challenges influenced by environmental factors, financial constraints, or current situations. A total of 26.7% (n=8) of the designers indicated that unintended behaviour frequently arises as a response to these environmental challenges, financial limitations, or situational contexts (Junior (n=2), Intermediate (n=2), Senior (n=2), and Expert (n=2)). They posited that users adapt to such problems by spontaneously altering their product usage in response to unexpected circumstances. This perspective highlights how external factors can shape user behaviour, particularly when confronted with resource limitations, high product costs, or urgent needs that compel them to purpose the product for new functionalities. Furthermore, this phenomenon underscores users' flexibility in leveraging existing products to address their daily challenges, as suggested by Pillai et al. (2021).

For the second response, 10.0% of respondents (Intermediate (n=1), Senior (n=1), and Expert (n=1)) expressed the view that unintended behaviour is a spontaneous reaction to unexpected conditions. This behaviour can recur based on users' experiences. This phenomenon is closely linked to user experience; individuals who have repeatedly faced the same problem tend to develop specific behavioural patterns to adapt the product to their needs. This finding indicates that users do not consciously plan changes to the product; rather, they respond instinctively, drawing on past experiences, which aligns with the perspective of Kamil (2017). Such situations often arise with mainstream products that have become integrated into users' lives, leading to the creation of solutions without their realisation that they are modifying or augmenting the functionality of the existing product.

The third perception represents the most prevalent response among participants, with 30.0% (n=9) of designers indicating that unintended behaviour is linked to human cognitive thinking in creative ways, showcasing sensory innovativeness towards new uses. The data illustrates that Junior designers (n=4) constitute the largest group expressing this perception, followed by intermediate (n=2) and expert (n=3), with no contributions from senior designers. This group demonstrates sensory innovation, characterised by the unique and unexpected utilisation of the product, a feature associated with User-Human Behavioural Experience (UHBE). This perception highlights the creativity inherent in user interactions with the product. Some users do not merely adhere to the specifications set by the designer; instead, they adapt the product to fulfil their needs in a more practical manner. This aligns with the view of Hirschman (1980), which posits that individual interactions are influenced by cognitive processes that lead to unexpected and creative actions.

Fourth, there exists a perception that unintended behaviour reflects risk-based decision-making, which may lead to negative consequences for the individual. Notably, 6.6% (n=2) of the designers, comprising one Junior (n=1) and one intermediate (n=1), provided this response, whereas no senior or expert designers expressed a similar view. This suggests that users may be unaware of the repercussions of the alterations they make to the product's intended use. Such unintended actions can introduce safety risks, diminish the product's effectiveness, or result in long-term discomfort, thereby increasing the likelihood of injury. This finding reinforces the notion that UHBE may indeed result in adverse outcomes for individuals, as suggested by Hentschel (2011) and Wakkary et al. (2015).

Next, 16.7% of Juniors (n=1), seniors (n=3), and experts (n=1) indicated that unintended behaviour demonstrates how individuals with product knowledge can recognise the affordance of a product within a specific context. 'Affordance' refers to a characteristic or cue within a product that suggests how it can be utilised. Users who are knowledgeable about the product are able to identify additional functions that may be employed. This finding indicates that users with a deeper understanding of a product's design are more likely to discover new functionalities based on its shape, materials, or mechanisms. Consequently, users do not solely depend on the manufacturer's manual or instructions; they also investigate alternative uses of the product based on their own observations and experiences, as emphasised by Norman (1988) in his book.

The final perception of unintended behaviour illustrates a dissatisfaction with the current product, leading users to transform its usage to meet specific goals or purposes in their everyday activities. This perspective was shared by Intermediate (n=2) and Senior (n=1) respondents, representing 10.0% of the sample. This finding indicates that users experiencing issues with the existing product are likely to seek alternatives to adapt it to their needs for completing particular tasks. Such adaptations may include adding accessories, modifying functions, or combining the product with others to achieve the desired outcomes. This observation aligns with the view expressed by Kim et al. (2021), which suggests that individuals often modify existing product functionalities to fulfil specific objectives in their daily lives (Wongkitrungrueng, 2018). From this analysis, the designer's perceptions reveal that the phenomenon of unintended behaviour occurs in various forms and is influenced by factors such as spontaneous reactions, creativity, user experience, and dissatisfaction with the product. While this behaviour can foster positive outcomes, such as stimulating new innovations and enabling users to tailor products to their needs, it also poses risks, particularly when changes made by users could compromise the safety or efficacy of the product.

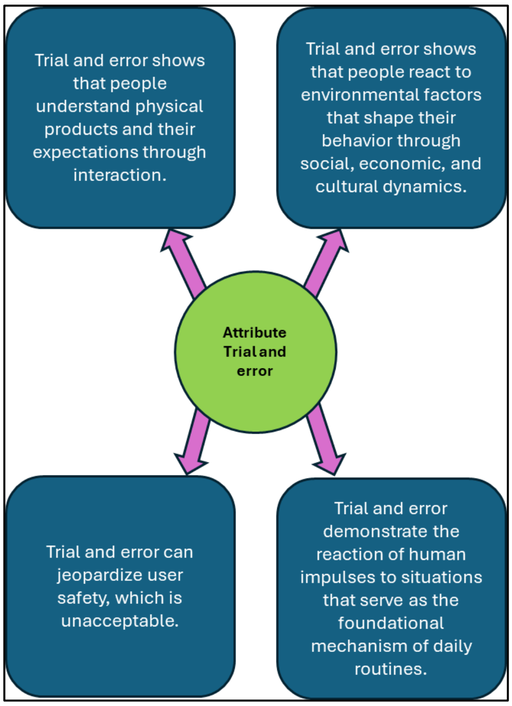


Figure 4.57 Designer Perspective towards Trial-and-Error Attributes

Table 4.19
Frequency and Cross-Tabulation table between Designers' Perceptions of Attribute Trial and Error based on Photo Elicitation through VPAE1

Response towards attribute: trial and error	**Frequency**	**%**	**Cross-tabulation**			
			Junior	Intermediate	Senior	Expert
Trial and error shows that people understand physical products and their expectations through interaction.	2	5.7%	0	1	1	0
			0%	3.35%	3.35%	0%
Trial and error shows that people react to environmental factors that shape their behaviour through social, economic, and cultural dynamics.	9	0.0%	2	4	2	1
			6.67%	13.33%	6.67%	3.33%
Trial and error can jeopardize user safety, which is unacceptable.	2	5.7%	0	1	0	1
			0%	3.35%	0%	3.35%
Trial and error demonstrate the reaction of human impulses to situations that serve as the foundational mechanism of daily routines.	17	6.6%	8	2	4	3
			26.64%	6.66%	13.31%	9.99%

Table 4.19 summarises the themes derived from the perceptions of 30 designers regarding question 2: Based on image analysis, psychological factors motivate unintended behaviour through the attributes of trial and error and creativity (see Figure 4.57). A total of 6.7% of respondents indicated that trial and error aids users in understanding physical products and forming their expectations through everyday interactions. This finding supports the notion that engaging in trial and error with everyday products can enhance users' comprehension of physical items to explore, as proposed by Dix (2017). However, only two designers shared this viewpoint, one from the Intermediate category and the other from the Senior category. Notably, neither Junior nor expert designers offered this response, indicating that more experienced product designers do not generally share this perspective.

Secondly, there is a perception that trial and error results from users' reactions to various environmental factors, including social, economic, and cultural influences. A significant 30.0% of respondents who expressed this viewpoint were from the Intermediate category (4 designers), followed by Junior (2 designers), Senior (2 designers), and Expert (1 designer). This perception indicates that designers at the early to intermediate levels are more inclined to associate trial and error with these environmental factors compared to their more experienced counterparts. The findings suggest that trial and error generally prompt users to experiment with a product in different ways as a response to their surroundings, encompassing social, economic, and cultural contexts, as proposed by Suri (2005). The third perception suggests that designers view a negative side of trial and error. Specifically, 6.7% of respondents (comprising one intermediary and one expert designer) indicated that trial and error could jeopardise user safety and is therefore unacceptable. While this percentage is small, it highlights the concerns among product designers regarding the potential risks associated with employing a trial-and-error approach. Expert designers, particularly those with extensive experience in consumer product design, underscore the significance of safety considerations in their feedback.

The last statement is that the most dominant response among designers is that trial and error reflects human instinctive responses to certain situations and functions as a basic mechanism in daily routines. A total of 56.6% of the total respondents gave this view, making it the most widely accepted perception. In detail, eight designers from the Junior category, two from the Intermediate, four from the Senior, and three from the

Expert expressed this view. This data shows that the majority of designers, including those with less experience, recognise that trial and error is part of the learning process and natural human interaction with products. This comment is in line with the statement by Wakkary et al. (2015) that human instinctive responses to certain situations influence their interactions with everyday products. Overall, the results of the study for the attribute trial and error show that designers' perceptions vary according to their level of experience. While most designers see it as a natural mechanism in daily life, some also emphasise environmental factors, product understanding, and concerns for user safety. These results can be an important reference in understanding how product designers consider trial and error aspects in their design process.

Table 4.20
Frequency and Cross Tabulation table between Designers' Perceptions of attribute Social Sharing based on Photo Elicitation through VPAE1

Response towards attribute: social sharing	**Frequency**	**Percent**	**Cross-tabulation**			
			Junior	Intermediate	Senior	Expert
Social sharing unintendedly demonstrates conformity characteristics, which aim to align attitudes, beliefs, and behaviours with others' norms through informational influence.	17	56.7%	7	7	1	2
			23.35%	23.35%	3.33%	6.67%
Social sharing refers to unwritten and informal norms that guide how individuals behave in certain situations and are often internalized by members of society.	5	16.7%	1	0	1	3
			3.34%	0%	3.34%	10.02%
Obedience is a fundamental aspect of social organization and authority, shaping how individuals interact within structured environments and respond to directives from those in power unintendedly.	2	6.6%	1	1	0	0
			3.30%	3.30%	0%	0%
Social sharing refers to persuasion, which is a powerful tool in shaping opinions and behaviours and is central to many aspects of human interaction and communication.	6	20.0%	1	0	5	0
			3.33%	0%	16.67%	0%

Based on Table 4.20, four main themes have been identified from the findings of this study regarding the attribute of social sharing, as addressed in Question 3: Image analysis indicates that social and cultural contexts motivate unintended behaviour through social sharing attributes (refer to Figure 4.58). The predominant theme expressed by respondents is that social sharing inadvertently reflects characteristics of conformity, whereby individuals adjust their attitudes, beliefs, and behaviours to align with social norms through informational influence. Notably, 56.7% of all respondents endorsed this perspective, marking it as the most widely accepted viewpoint for this attribute. The breakdown by category reveals that 7 Junior designers, 7 intermediate designers, 1 senior designer, and 2 expert designers shared this view. This outcome suggests that less experienced designers are more inclined to perceive social sharing as a mechanism fostering social conformity among users, which is consistent with the perspective articulated by Suri (2005) in his article, "Thoughtless Acts."

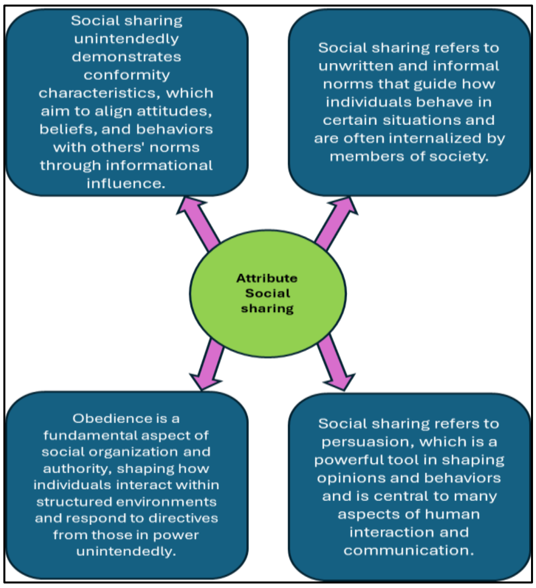


Figure 4.58 Designer Perspective towards Social Sharing Attributes

The second perception indicates that 16.7% of respondents believe social sharing pertains to unwritten and informal norms that influence how individuals behave in specific situations and are often internalised within the broader community. Five designers contributed to this perspective, including one from the Junior category, one from the senior category, and three from the expert category. The higher representation of expert designers in this viewpoint suggests that those with more experience in design may possess a greater awareness of the role that implicit social norms play in shaping user behaviour, in contrast to their younger or less experienced counterparts. This observation underscores the variations in perceptions among designers based on their experience in product design. For the third theme, 6.6% of respondents indicated that social sharing unconsciously fosters obedience, which is a fundamental element of social organisation and authority. This obedience affects how individuals engage with their perceived environment and how they react to the actions of the party sharing information. Only two designers expressed this perspective (Junior, n=1; Intermediate, n=1). Finally, 20.0% of respondents viewed social sharing as a potent means of persuasion that shapes opinions and behaviour and they regarded it as a crucial aspect of human interaction and communication. Six designers, one from the Junior category and five from the senior category, supported this perspective. Notably, neither intermediate nor expert designers echoed this view, suggesting that senior designers are more inclined to link social sharing with persuasive elements of unintended behaviour. Overall, the findings of this study reveal that designers' perceptions of social sharing differ according to their experience levels. While most perceive it as a mechanism for social conformity through informational influence, a subset of designers also connects it with unwritten norms, compliance with authority, and persuasive communication. This insight can aid in the development of product design strategies that take into account the indirect influence of social sharing on users' behaviour.

Table 4.21
Frequency and Cross Tabulation table between Designers' Perceptions of attribute Quick Solution based on Photo Elicitation through VPAE1

Response towards attribute: Quick Solution	**Frequency**	**Percent**	**Cross-tabulation**			
			Junior	Intermediate	Senior	Expert
A quick solution refers to people who often use readily available resources and straightforward methods, act on spontaneous urges without much thought, respond quickly to sudden stimuli, and make rapid decisions using mental shortcuts, especially in familiar situations.	11	36.6%	4	2	4	1
			13.31%	6.65%	13.31%	3.32%
Quick solutions portray people who are faced with a problem that needs an immediate solution or emergency by seeking quick fixes.	11	33.3%	3	4	2	2
			9.08%	12.10%	6.05%	6.05%
The quick solution is that behaviours that are culturally inappropriate or taboo, as well as actions that cause physical harm or endanger others, are both seen as unacceptable.	2	6.7%	0	1	0	1
			0%	3.35%	0%	3.35%
A quick solution is the process of generating new and original ideas, solutions, or expressions of value.	2	10.0%	2	0	0	0
			10.0%	0%	0%	0%
Quick solutions refer to time constraints and the desire to avoid failure or negative outcomes that often drive the preference for fast, low-risk solutions.	2	6.7%	1	1	0	0
			3.35%	3.35%	0%	0%
A quick solution shows that previous successful use of the product in other ways can reinforce its use in similar future situations.	2	6.7%	0	0	1	1
			0%	0%	3.35%	3.35%

Table 4.21 identifies six main themes of perception expressed by designers when interpreting the quick solution attribute for UHBE, based on Question 3: "Based on image analysis, situational aspects motivate unintended behaviour through the attributes of quick solutions (see Figure 4.59 on the next pages). How do you respond?" A total of 36.6% of respondents indicated that 'quick solution' refers to individuals who tend to utilise existing resources and simple steps to solve problems spontaneously, without extensive consideration. This attribute is also linked to swift responses to sudden stimuli and the employment of mental shortcuts, particularly in situations that are familiar to users. Eleven designers articulated this perception, comprising 4 Junior designers, 2 intermediate designers, 4 senior designers, and 1 expert designer. This finding aligns with the recognition of the importance of rapid decision-making when confronted with a problem and the need for prompt resolution (Beck et al., 1992; Beck, 2009).

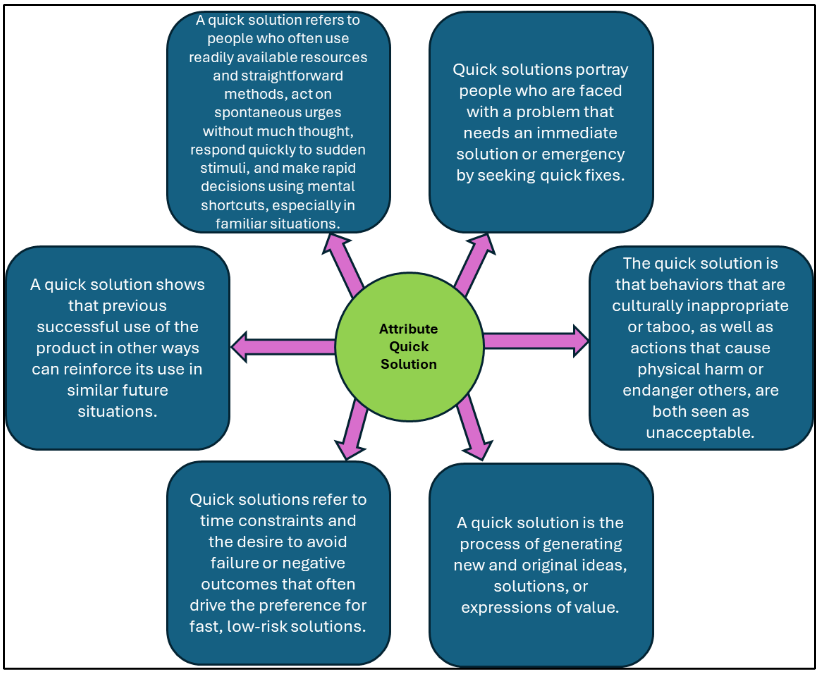


Figure 4.59 Designer Perspective towards Quick Solution Attributes

Compared to the second perception, 33.3% of respondents indicated that the term 'quick solution' refers to individuals facing problems that necessitate immediate resolutions or who are in emergency situations, leading them to seek rapid solutions without assessing the long-term consequences. Eleven designers shared this viewpoint, which includes a breakdown of 3 Junior designers, 4 intermediate designers, 2 senior designers, and 2 expert designers. This finding suggests a balanced range of perceptions among designers regarding the attribute of quick solutions. However, Menold (2014) describes these characteristics as potentially inappropriate, as they may result in unforeseen long-term effects.

Next, 6.7% of respondents perceived that quick solutions can be associated with actions that may not be appropriate within a cultural context and could potentially harm others. This includes solutions deemed unethical or contrary to social norms. Only two designers (one intermediate and one expert) expressed this viewpoint. This small percentage indicates that more experienced designers are more aware of the negative consequences that may arise when users take shortcuts by using products for unintended purposes.

Fourth, 10.0% of respondents perceive quick solutions as a means of generating new ideas and creative solutions that offer value in specific situations. Two Junior designers expressed this view, suggesting that individuals with less experience tend to associate quick actions with creativity and innovation. This aligns with Hirschman's (1980) proposition that the development of new solutions involves the creation of innovative ideas that provide value within certain contexts. However, no designers within the more experienced categories reported this perspective, indicating that they tend to be more cautious in viewing quick solutions as inherently innovative.6.7% of respondents believe that time constraints and the desire to avoid failure drive the adoption of quick solutions. This suggests that individuals opt for rapid responses, viewing them as low-risk options to ensure immediate resolution of problems. Two designers, one from the Junior category and one from the Intermediate category, support this perspective, while no Senior or Expert designers endorse it. This indicates that senior and expert designers prioritise the quality of solutions over the speed of their delivery.

The last response indicates that quick solutions can be linked to utilising the product in a manner that has previously demonstrated effectiveness, thereby reinforcing the user's tendency to repeat the same approach in similar circumstances. Theoretically, the act of repeating daily activities is posited to diminish the influence of behaviour that triggers unintentional interactions and prompts immediate actions that are perceived as effective and appropriate (Bargh et al. 2001). Two designers, one from the senior category and the other from the expert category, addressed this assertion. This suggests that more experienced designers are inclined to view quick solutions as behaviours acquired through prior experience. Overall, the results of this study indicate that perceptions of 'quick solutions' is different according to the level of experience of the designers. Junior and intermediate designers are more likely to see it as a spontaneous action or quick solution in emergency contexts, while senior and expert designers emphasise aspects of cultural implications, behavioural reinforcement, and the balance between efficiency and safety.

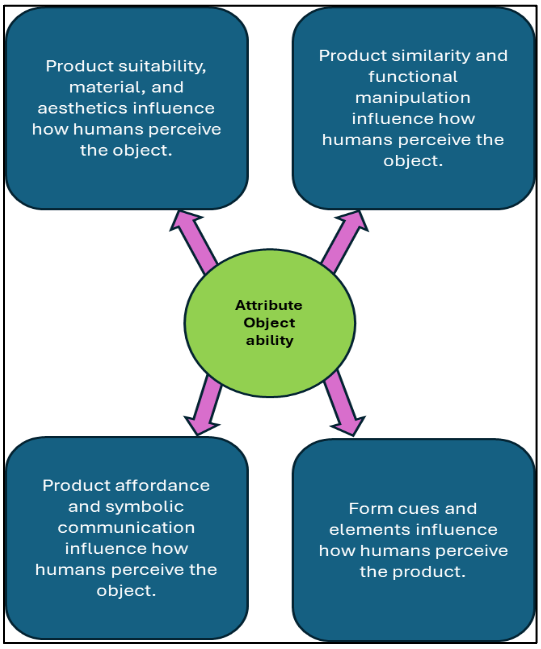


Figure 4.60 Designer Perspective towards Object Ability Attributes

Table 4.22
Frequency and Cross-Tabulation table between Designers' Perceptions of attribute Object Ability based on Photo Elicitation through VPAE1

Response towards attribute: Object ability	**Frequency**	**Percent**	**Cross-tabulation**			
			Junior	Intermediate	Senior	Expert
Product suitability, material, and aesthetics influence how humans perceive the object.	6	20.0%	2	0	3	1
			6.67%	0%	10.0%	3.33%
Product similarity and functional manipulation influence how humans perceive the object.	4	13.3%	1	1	1	1
			3.32%	3.32%	3.32%	3.32%
Form cues and elements influence how humans perceive the product.	13	43.4%	5	5	1	2
			16.7%	16.7%	3.33%	6.67%
Product affordance and symbolic communication influence how humans perceive the object.	7	23.3%	2	2	2	1
			6.66%	6.66%	6.66%	3.32%

Table 4.22 and Figure 4.60 outline the perceptions of 30 designers regarding the attribute of object ability in relation to unintended behaviour towards mainstream products, based on Question 5. This question asked respondents to consider how, according to image analysis, the propensity for multiple uses motivates unintended behaviour through the object's abilities (affordance) and fit-for-purpose attributes. The analysis revealed that 20.0% of respondents believe that product suitability, materials, and aesthetic qualities significantly influence how individuals evaluate a product. These elements directly affect the user experience and shape their understanding of the product's function and value. Consequently, users often develop new functions for existing products tailored to specific purposes. This perspective aligns with the Norman theory of affordance (1988) and Gibson (1977), which posits that affordance depends on the user's physical and perceptual capabilities, goals, and past experiences. Six designers expressed this viewpoint, comprising 2 Junior designers, 3 senior designers, and 1 expert designer.

For the second perception, 13.3% of respondents identified the similarity between products and the ability to manipulate their functions as a factor influencing how people understand objects. This suggests that users frequently draw comparisons with other products that share similar forms, adjusting their use of these products based on their pre-existing knowledge. Four designers expressed this viewpoint, representing each category (Junior, intermediate, senior, and expert). The balanced representation from all categories of designers indicates that this understanding is both logical and fundamental to their design approach. Third, 43.4% of respondents believed that form cues and basic design elements significantly influence how humans understand a product. For instance, visual elements such as line, shape, texture, and colour play a crucial role in shaping users' perceptions of the function and usability of an object, enabling the creation or addition of other functions (Kim et al., 2021; Kim 2020). This viewpoint represents the most prevalent opinion among designers, with thirteen individuals expressing this perspective (comprising 5 Juniors, 5 intermediates, 1 senior, and 2 experts). The findings indicate that designers at the Junior and intermediate levels are more inclined to assess the visual effect as the primary factor affecting user perception of the product, whereas more experienced designers tend to consider additional aspects, such as product function and material.

Fourth, designers regard product capabilities, often referred to as 'affordance', and symbolic communication as factors influencing the perception of an object. A total of 23.3% of respondents expressed this viewpoint, which included seven designers: two Juniors, two intermediates, two seniors, and one expert. 'Affordance' denotes an object's ability to indicate its intended use, while 'symbolic communication' encompasses the meanings conveyed through the shape, colour, and visual elements of a product. This perspective indicates that the roles of affordance and symbolic communication are recognised equally among designers across all experience levels. The conclusion regarding the perception of the attribute of object ability reveals that designers hold differing views. Junior and intermediate designers tend to place greater emphasis on the significance of visual elements and form cues. In contrast, senior and expert designers focus more on aspects such as product suitability, materials, affordance, and symbolic communication. Nevertheless, it is important to note that each perspective is influenced by the designer's individual views and their experience in designing consumer products.

Table 4.23
Frequency and Cross-Tabulation table between Designers' Perceptions of UHBE adaptation in Design Activity

Response towards consideration of UHBE	**Frequency**	**Percent**	**Cross-tabulation**			
			Junior	Intermediate	Senior	Expert
Designers mostly use creativity and intrinsic motivation to create products based on the intended purpose.	4	13.3%	0	1	2	1
			0%	3.32%	6.65%	3.32%
Designers are concentrating on the functional aspects of the product.	5	16.7%	1	0	2	2
			3.34%	0%	6.68%	6.68%
Designers mostly think about logic, bound within product objective and purpose, till ignoring user need.	4	13.3%	1	1	1	1
			3.32%	3.32%	3.32%	3.32%
In the design process, designers focus on solving a problem rather than finding it in users' lives. However, they are not decision-makers in final design ideation.	5	16.7%	5	0	0	0
			16.7%	0%	0%	0%
Designers have less experience and exposure to complex contexts, as well as limited sources of design inspiration.	7	23.3%	2	4	1	0
			6.66%	13.31%	3.33%	0%
Designers look forward to a new product design. However, designers do not consider unintended interactions due to the risk and concern associated with the manufacturing process.	5	16.7%	1	2	1	1
			3.34%	6.68%	3.34%	3.34%

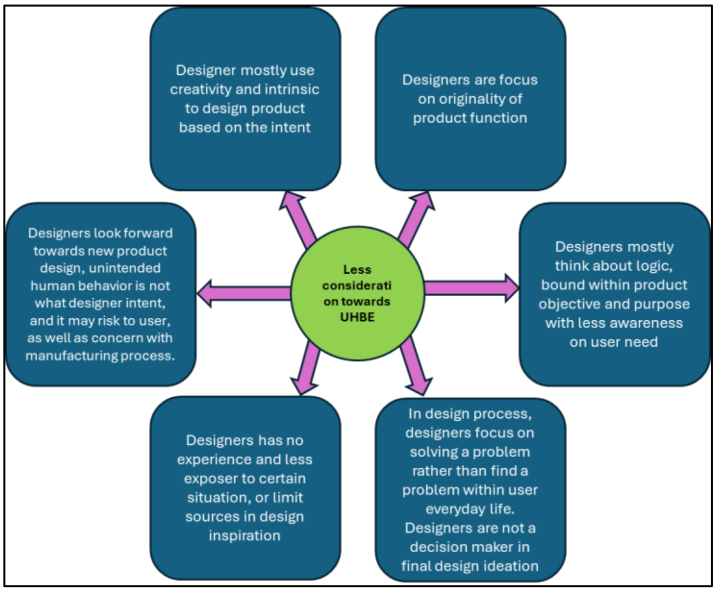


Figure 4.61 Designer Perspective towards UHBE consideration in Design Activity

Table 4.23 and Figure 4.61 present six primary themes identified by respondents regarding the reasons designers are less inclined to consider contingency behaviour in product design activities, in response to Question 6: In your opinion, why do designers pay less attention to unintentional behaviour among users? The table reveals that a significant number of designers prioritise the importance of the product, with (i) 16.7% of respondents suggesting they focus more on the functional aspects of the product and (ii) 23.3% of designers emphasising the original objectives of product creation along with the logical elements of its design. This perspective implies a neglect of understanding user needs in their daily tasks. A third perspective relates to creativity and intrinsic motivation linked to the product's original purpose, with 13.3% of respondents sharing this view, which also contributes to the insufficient consideration of user behaviour in product design activities. This finding indicates that designers tend to adhere more closely to the original design intention rather than engaging with human behavioural aspects. Specifically, five designers supported view (i), four designers responded to factor (ii), and another four contributed insights for factor (iii). The responses suggest that experience within the design field may lead designers to focus more on creative vision, design objectives, and the functional capabilities of the product, rather than on everyday user behaviour or interaction.

The responses highlighted that individual factor, including designer experience, exposure to complex usage contexts, and limited sources of inspiration, contributed to designers' lack of awareness regarding the existence of UHBE in products. A total of 23.3% of respondents acknowledged this viewpoint. Additionally, some designers admitted that they were less likely to consider UHBE because they felt comfortable with their own creative processes, which often favour simpler thinking over more complex approaches. This perspective was further supported by the fifth perception, which stated that designers tended to prioritise problem-solving over understanding users' lives. Specifically, 16.7% of respondents believed that, during the design process, the focus was more on resolving specific issues than on gaining a more profound understanding of how the product would be used in everyday situations. Moreover, the influence of decision-making power in the final design process restricted the consideration of unintended uses. Notably, five designers from the Junior category expressed this opinion, whereas there were no supporters of this view among Intermediate, Senior, or Expert designers. This suggests that Junior designers more swayed by the technical aspects of problem-solving than by a comprehensive understanding of product usage.

The last factor indicates that 16.7% of designers focused more on the new product design and disregarded UHBE interactions due to concerns about the risk of failure during the production stage. The presence of all designer categories in this perception suggests that risk factors in manufacturing are significant considerations. In conclusion, various factors such as creativity, product function, design logic, emphasis on problem-solving, lack of experience, and apprehensions about manufacturing risks shape designers' inclination to consider UHBE in product design. Junior designers tend to prioritise problem-solving, whereas intermediate designers exhibit greater awareness of their experiential limitations. Conversely, senior and expert designers concentrate more on product objectives, functions, and the implications of the manufacturing process. The responses provided can assist designers in recognising how product design may be enhanced by considering various factors, including UHBE interactions.

Table 4.24
Frequency and Cross-Tabulation table between Designers' Perceptions of UHBE Value for New Product Concept

Response towards value of UHBE	**Frequency**	**Percent**	**Cross-tabulation**			
			Junior	Intermediate	Senior	Expert
Understanding UHBE is seen as an initiative or solution for transforming ideas into innovative design concepts for existing	9	30.0%	2	4	2	1
			6.66%	13.33%	6.66%	3.33%

products.						
Researching UHBE through user experience and interaction holds potential and is valuable for developing new product design concepts.	10	33.3%	3	2	3	2
			9.99%	6.66	9.99%	6.66%
Understanding UHBE can create multiple applications in product design, benefiting users.	5	16.7%	3	2	0	0
			10.02%	6.68%	0%	0%
At times, understanding UHBE may not seem essential for product development.	2	6.7%	2	0	0	0
			6.70%	0%	0%	0%
Considering UHBE as a reference is advantageous for designers during the design and innovation process.	4	13.3%	0	0	2	2
			0%	0%	6.65%	6.65%

Table 4.24 and Figure 4.62 identify five main themes regarding how designers assess the potential of UHBE interaction as a source for creating new product design concepts during design activities, based on Question 7: Do you personally consider unintended interactions in everyday products to be valuable in the design concept? Firstly, most respondents articulated the view that research on UHBE, through observation, experience, and user interaction, holds potential for the development of new product design concepts. Specifically, 33.3% of respondents acknowledged that this initiative underscores the significance of UHBE as an exploratory tool for product innovation that is more attuned to user behaviour. Ten designers, including three Juniors, two intermediate, three seniors, and two expert designers, supported this perspective. The distribution of these perceptions shows that various levels of design experience widely acknowledge the importance of UHBE in influencing new products. The step of understanding UHBE as an initiative for processing ideas related to innovative design concepts for existing products has significant potential within design practice. This viewpoint garnered the second highest percentage of agreement regarding the value of UHBE in design activities, with 30.0% of respondents (comprising 2 Junior, 4 intermediate, 2 senior, and 1 expert designers) affirming that it can enhance innovative aspects and acknowledge the potential of UHBE to improve product design.

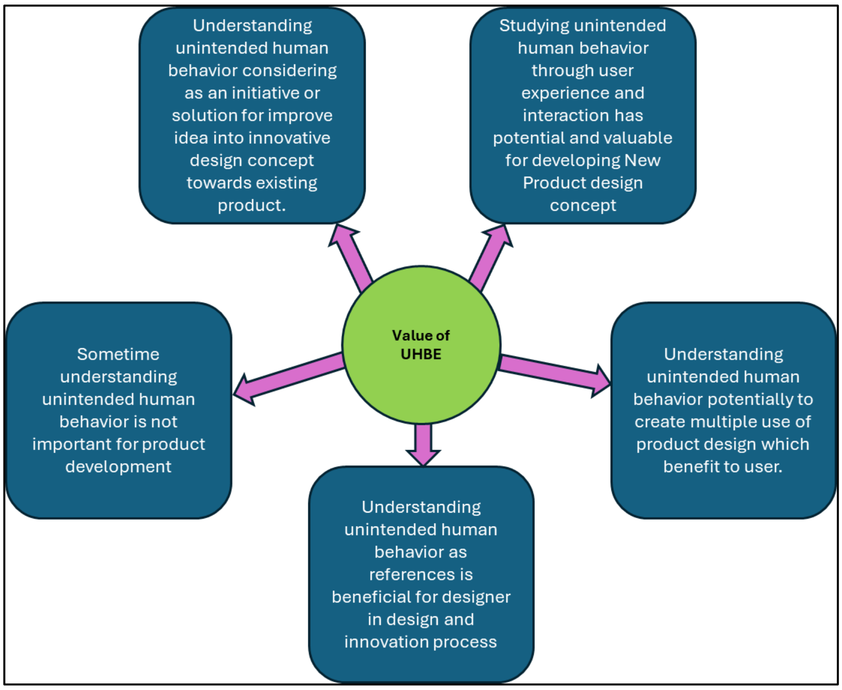


Figure 4.62 Designer Perspective towards UHBE Value for New Design Concept

The third perception indicates that designers concur that understanding UHBE can lead to the creation of multi-use products that benefit users. Specifically, 16.7% of respondents, equating to five designers, expressed agreement with this view, which included three Junior designers and two intermediate designers. This suggests that UHBE not only enhances product functionality but also creates opportunities for varied applications. However, it is noteworthy that this agreement did not encompass the perspectives of designers in the senior or expert categories. Additionally, this highlights that younger designer, who possess less experience in the field, are more inclined to perceive UHBE to generate diverse product usage variations, whereas their more experienced counterparts tend to concentrate on other critical aspects, such as the safety and sustainability of product design. Fourthly, 6.7% of respondents suggested that product development may not always view understanding UHBE as essential. This suggests that the presence of other more critical elements in product design may deprioritize the UHBE factor in some instances. Two designers provided response, both belonging to the Junior category. Finally, the designers' perspective on the potential of UHBE as a reference source indicates that it can provide an advantage in the innovative design process and assist them in making effective design decisions. A total of 13.3% of respondents expressed this view, four designers including two seniors and two experts, supporting it. This response suggests that those with more experience are more inclined to perceive UHBE as a strategic element in product design, recognizing its value as a method for generating new conceptual ideas. In conclusion, these findings reveal that most designers base their opinions on four components: (i) recognizing the significance of understanding UHBE in developing new product design concepts, (ii) acknowledging its value as a source of innovation and research grounded in user experience, (iii) noting its substantial impact on enriching design approaches and enhancing product competitiveness in the market, and (iv) fostering a higher level of critical thinking among designers to address hidden user needs. The mutual responses among designers highlights their similar levels of thinking and reinforces the potential for considering the interaction of UHBE.

Interpretation of Designers' responses and User Perception towards UHBE attribution

As outlined in section 4.3.2, this section will discuss and compare the responses of designers and the perceptions of users regarding the attribution of UHBE interaction in mainstream products. Researchers believe that this comparison will assist designers in identifying gaps between their knowledge and their users' actual perceptions while also offering critical perspectives throughout the initial design process. To enhance understanding, Table 4.25 (on the next pages) is included to illustrate the results of the comparison between designers' and users' perceptions of the UHBE attribute, derived from the 'dual' survey approach and in-depth interview sessions conducted.

Table 4.25
Comparison of Designers' Response (top) and User Perception (below) towards UHBE Attributes

Photo-based Research Analysis	**Scale Analysis**	**Dominant Attributes Analysis**			
		Curiosity & Creativity: Trial & Error / Creativeness	**Voluntary Simplicity: Social Sharing**	**Risk-Taking: Quick Solution**	**Multiple Use: Object Ability**
	Strongly Disagree / Disagree [%]	3.3	0.0	3.3	0.0
	Moderately Agree [%]	16.7	20.0	10.0	6.7
	Strongly Agree / Agree [%]	80.0	80.0	86.7	93.3

Visual Inventory Analysis	**Scale Analysis**	**Dominant Attributes Analysis**			
		Curiosity & Creativity: Trial & Error / Creativeness	**Voluntary Simplicity: Social Sharing**	**Risk-Taking: Quick Solution**	**Multiple Use: Object Ability**

	Strongly Disagree / Disagree [%]	1.4	0.0	0.0	1.4
	Moderately Agree [%]	17.1	12.9	11.4	14.3
	Strongly Agree / Agree [%]	81.5	87.2	88.6	84.3

Based on Table 4.25, the data was derived from findings obtained through photo-based research analysis, which captures designers' responses, and visual inventory analysis, which reflects users' perceptions. This investigation centred on the evaluation of four UHBE attributes, adapted from Hirschman's model of use innovativeness (1980). As previously discussed, both knowledge and experience are important factors that influence the perspectives of users and designers when interpreting the phenomenon of unintended product use. The data for the designer category clearly indicate that designers believe product characteristics (object ability attribute) are the most significant factor driving unintentional interactions, with a notable score of 93.3% compared to the other three attributes (trial and error, social sharing, and quick solution). Integrating responses from designers during the VPAE1 session, it is evident that most designers make judgements based on their understanding, knowledge, and experience regarding design affordance. As emphasised by Norman (1988), object 'affordance' refers to users' perceived action possibilities as a novel potential. This aligns with the designers' views on the 'object ability' attribute, which signals alternative uses or 'multiple use' of the product. For instance, aspects such as product form, suitability, material cues, and similarity serve as symbolic communication that may influence human perception of the product.

In the context of this research, the subject is the 'washbasin'. Physically, its form displays a concave, bowl-like shape that facilitates water containment and drainage. In terms of dimensions, standard household washbasin designs typically range from 50 to 80 cm in width and 40 to 60 cm in depth. The height of a washbasin is a crucial ergonomic consideration, generally positioned at 80 to 90 cm from the floor to ensure comfort for standing users. From the perspective of materials, washbasins are commonly manufactured from ceramic, porcelain, or vitreous China due to their durability, non-porous nature, and ease of maintenance. Unintentionally, the characteristics of the washbasin signal a 'hidden use' to users, suggesting additional functionalities beyond the original purpose. Most designers indicated that this 'signal' is conveyed through the product's shape, which resembles that of a baby bathtub or the ‘foetus form’, an ideal shape for a baby. This design may also help to eliminate water wastage when used for bathing, as opposed to a traditional baby bathtub available in the commercial market. Furthermore, the ‘affordance’ feature associated with the height of the washbasin inadvertently prompts additional uses for several reasons: (i) the consideration of back pain for mothers during their confinement period and (ii) the practicality of bathing a baby in a standing position rather than bending over, as sitting is not recommended for this purpose. Another respondent noted that additional factors contributing to the affordance feature of the washbasin include technical facilities such as water supply, faucet, and drainage (drain hole), which facilitate management during bath sessions for parents. The faucet and drain hole suggest to users a method of using the washbasin that deviates from its intended design for bathing purposes. Several respondents also mentioned that the material in the washbasin cognitively signals users to utilise the product in alternative ways. Overall, the statements provided by the designers indicate a strong emphasis on product affordance (object ability) as a key attribute influencing the interaction of Universal Home-Based Equipment (UHBE) with mainstream products.

However, from users' perspectives, they expressed differing views regarding the UHBE attribute. Table 4.25 reveals that the 'quick solution' context, representing a risk-taking dimension, drives UHBE interactions for the majority of users. A total of 88.6% of respondents agreed that the quick solution attribute influences users' actions in employing the product in various ways to complete everyday tasks immediately, even in the absence of an intended product. The emergency context may also contribute to UHBE actions, based on the urgency or need for immediate solutions. In Experiment VPAE1, designers provided insights as to why users feel that the quick solution attribute influences UHBE interactions. The designers believed that factors such as (i) time concerns, (ii) conformity to others, (iii) influence from social media, (iv) cost-saving, (v) lack of public facilities, (vi) trial and error, and (vii) travel issues are reasons why users interact unintentionally with the product. These statements align with the recognition of the rapid decision-making process when faced with unexpected contexts, prompting users to seek quick solutions (Beck, 1992; Beck, 2009). However, the unintended use of products is not recommended due to long-term effects on appropriation and safety aspects (Menold, 2014). Theoretically, the notion of unintended use based on the ‘quick solution’ approach will evolve to ‘intent to use’ when a ‘new function and solution’ meet the objective and are perceived as appropriate by the user (Bargh et al., 2001). To integrate this within human cognitive thinking, Hirschman (1980) proposed that finding new solutions is a process of idea creation (creative thinking) by “non-designers,” which should be accepted as a source of valuable potential in a social context. The findings indicate that the differing responses of designers and users highlight how product understanding can influence human experiences and behaviours. In the field of design, the term 'object affordance' is frequently utilised by both industry and academia (as referenced in Norman’s Affordance, 1980) to describe how an object’s design implies its intended use.

Concurrently, user experience and consumer research often refer to ‘use innovativeness’ to encapsulate the context of use in everyday life that shapes human behaviour, including unintended use of products. Despite these distinctions, the affordances approach allows for equal emphasis on two aspects: (i) the properties of the object and (ii) the perceptions of users, which are shaped by the social context of use and their experiences. This approach takes into account both objective and subjective aspects of affordance; that is, the inherent properties of the artefact, such as form, as well as the functionality of the product. As suggested by Norman (2013), good design not only provides useful capabilities but also ensures these are visible to users, drawing upon their experiences and other references that inform their interactions with the product (Norman, 1993, 1998, 2013).To conclude, users often engage in unintended actions out of necessity in their daily lives, influenced by time constraints, situational factors, and social context. In contrast, designers tend to emphasise the intrinsic characteristics of products, such as shape, size, performance, and feasibility, which can suggest alternative uses. This can lead users to perceive the product as having 'multiple uses'. The gap in perception can serve as an indicator of how much consideration designers accord to user experiences in the product design process. Furthermore, it can highlight areas for research aimed at creating innovative products that harmonise the perspectives of both designers and users. Consequently, this research also investigates how the capabilities of sink products can be enhanced based on real-world phenomena to better align with user needs and promote product sustainability.

Summary of Designer Response towards UHBE through PBA and VPAE1

Through critical analysis using photo stimuli derived from the PBA study, the UHBE attributes of mainstream products, as depicted in the PBA questionnaire, were identified and understood by the designers. As previously mentioned, the designers' reflections and responses to the UHBE phenomenon were explored through three propositions of questions based on the 'visual research reference' (VRR) photos. These propositions are outlined as follows: 1. Reflection-in-action concerning the phenomenon (Question 1); 2. Reflection-in-action regarding the attributes (Questions 2 to 5); and 3. Reflection-in-action relating to value (Questions 6 to 7), as stated in section 4.3.5 (EPISODE 1: VPAE1 - Response to phenomenon through photo elicitation (PBA photo representation).

Overall, it can be concluded that the findings from the VPAE1 study indicate that designers' responses to the understanding of UHBE in relation to mainstream products demonstrate significant acceptance, potential, and inherent value of all UHBE attributes examined. However, utilising products outside their original context may pose risks to users and diminish product quality. Although the user perception findings represent only a small fraction of the actual user group, they must be considered in all aspects of product and user safety. Most designers, including those in senior and expert categories, conveyed positive responses, emphasising the importance of prioritising safety and manufacturing process considerations. In summary, the designers' evaluation reflect a relevant response, particularly regarding the understanding of user needs and the practical use of products. The evaluation of the potential for UHBE interaction reveals acceptance and consideration among designers during the design of new concept products. Furthermore, the outcomes of this assessment inspire designers to generate new and innovative ideas through UHBE-based research resources. Through this research, consideration of user perceptions and designer responses has given us knowledge about how user experiences and contexts of use in human daily life can inadvertently add value to the field of design. These differences in views should be celebrated scientifically and strategically for the sustainability of product creation based on human factors. Through the PBA and VPAE1 studies, this study has partially achieved RO2 and partly answered RQ2. On the other hand, as contained in RQ2, how can UHBE attributes help designers inspire new product design concepts? For that purpose, a design episode was designed by assigning designers to reflect their thoughts during design activity through verbal protocol analysis. The subsequent section will elucidate the findings from the analysis of designers' reflective thinking and practice during the design activity.

Designers' Reflective thinking and interaction Process: a moment of inspiration through VPAE2

In this section, the findings will present and discuss the moments of inspiration that trigger designers' reflective thinking and their interactions with mediators, based on 30 responses during form reasoning in the VPA experiment. The aim of these experiments is to observe how designers engage with mediators while framing the problem and integrating their thoughts into design strategies related to the UHBE attributes, which focuses on the unintended use of a washbasin as for bathing a baby.

Analyse Mediator Interaction

As described in section 4.4.3, the VPAE2 (along with VPAE3) experiments begin after VPAE1 session, through a series of video recordings on camera 3, which recorded every interaction with the mediator, eye contact, body gesture language and uncertainty behaviour of the designer to show the affirmation of the designer's stance, practice and consideration of UHBE attribution throughout the think-aloud series (VPAE2 & VPAE3). Based the mediator's interaction during the design activity, this approach believed allows designers to iterate and refine their designs decision based on real-world feedback (Bødker, S., & Grønbæk, K.,1991). Designers able to create solutions that are aligned with user needs and real contexts, ultimately leading to more successful and impactful designs (Sanders and Stappers, 2008; Brown, 2009). Throughout the observations, a total of 1363 interactions were exhibited by the designer against the 5 mediators provided. Table 4.26 shows the overall data of the interaction results recorded by camera 3 against four categories of designers and five types of mediators.

Table 4.26
Summary of Designers' Reflective Thinking and Interaction on Influence Mediators (top: data information, bottom: graphical view)

Category of Designer	**Video**	**Ergonomic**	**Technical**	**Artefact**	**Doll**	**Total Interaction**	**Timing (min)**	**Range (per respondent)**
Junior	81	76	324	39	9	**529**	**302.22**	30.22
	15.30%	14.40%	**61.20%**	7.40%	1.70%			
Intermediate	64	90	160	30	8	**352**	**206.06**	26.16
	18.20%	25.60%	**45.50%**	8.50%	2.30%			
Senior	60	137	78	33	12	**320**	**127.03**	18.15
	18.80%	**42.80%**	24.40%	10.30%	3.80%			
Expert	30	33	46	46	7	**162**	**74.52**	15.30
	18.50%	20.40%	**28.40%**	**28.40%**	7.0%			
Total	**236**	**336**	**608**	**148**	**36**	**1363**	**710.37**	-

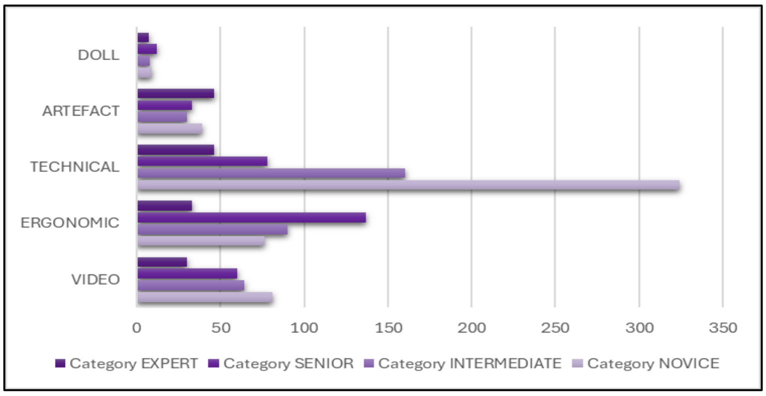


Figure 4.63 Result of the Percentage of Interaction embodied by 30 Designers

Table 4.26 and Figure 4.63 show the analysis of the percentage of reflective interaction embodied by 30 designers from four level of design experience categories. Based on the information, a total duration of interaction recorded for all respondents was 710:37 minutes, or equivalent to 12 hours 23 minutes. On average, the time taken by the designer for the VPAE2 and VPAE3 experiments is 30:22 minutes for Junior designers, 26:16 minutes for Intermediate designers, 18:15 minutes for Senior designers, and 15:30 minutes for Expert designers. To evaluate the amount of interaction done by each designer, camera 3 act to record designers' expression in every second in a moment of inspiration during think think-aloud and sketching activity. To assess and compare the interaction patterns of all designers during the moment-inspiration, each mediator is represented by a color code for evaluation purposes. As mentioned in earlier (see section 4.4.5: VPAE2 experiment), the analysis of the designer's interaction with the mediator was recorded and coded according to the color code; Red (video), Blue (technical information), Green (Ergonomic Information), Purple (Artificial basin), and Orange (artificial doll). Meanwhile, the black background represents the total time period taken by the designer for the design protocol. Meanwhile, the yellow line indicates the level of abstraction during designers' reflective practice which will be explained in the VPAE3 experiment later.

The Pattern of Designer Interaction Towards the Mediators

Through Table 4.26 information, Junior (10 respondents) and Intermediate (8 respondents) designers in the 'moment inspiration' session recorded the highest number of interactions with technical information mediators. As described in Table 4.26, the technical information panel composed of the technical drawing of standard washbasin, product dimension, parts and functionality. A total of 324 eye-tracking sessions were detected, or 61.20% compared to other mediators for Junior designers, while 160 (45.5%) interactions were identified by Intermediate designers. The data shows that young designers rely a lot on and refer to the technical resources of a product design compared to other mediators such video, artefacts, artificial dolls, and ergonomic information. Theoretically, the designers always refer to technical drawings of the existing product to communicate how a product should be designed technically, constructed, and functioning accordingly (Tornincasa, 2021). Some of designers have no experience in the case discussed, but aware the context of unintended use through social media platforms. Therefore, they more refer a technical information as a source of inspiration for framing the problem, finding a solution through design strategy for the purpose of new product concept creation. When look into the amount of time spend to the technical information mediator, Junior designers were spent 196:00 minutes, while Intermediate designers recorded 93:00 minutes. This factor is influenced by the level of experience and understanding of the designer in designing washbasin products, especially for young designers who are less experienced in designing the product.

Figure 4.64 (on the next pages) illustrated pattern of Junior designers' interaction towards mediators provides during moment-inspiration experiment, adapt from Leem and Lee' Interaction protocol analysis (2024). Through the figure, there are lot blueish (technical information mediator) code distribution within black code background. However, there are also reddish (video reference) and green (ergonomic information) code distribution, showing some designers look for other sources to integrate their design solution based on UHBE attributes.

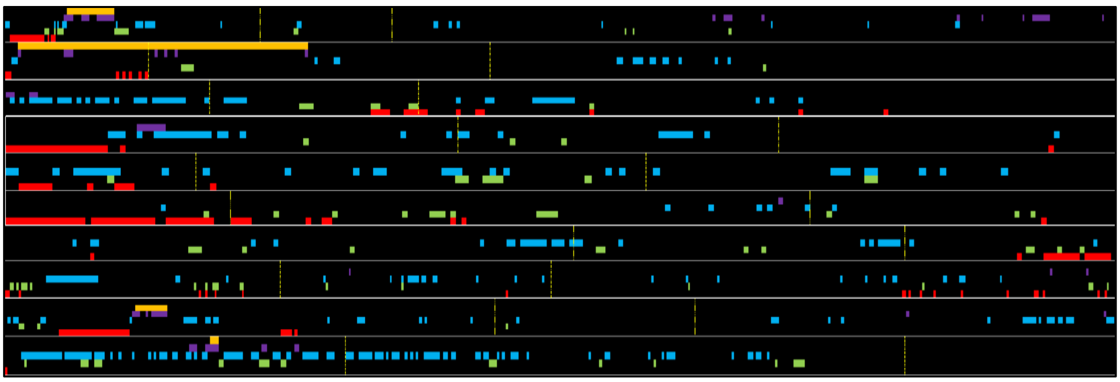


Figure 4.64 Summary of Junior's Designer Interaction towards Mediators during Form Reasoning

Figure 4.65 below illustrated pattern of Intermediate designers' interaction towards mediators provides during moment-inspiration experiment. Through the figure, there are balance distribution of blue, red and green code within black background. However, the technical information (bluish distribution) interaction still over than other mediators, showing intermediated designers considering on variety sources to integrate their design solution based on UHBE attributes.

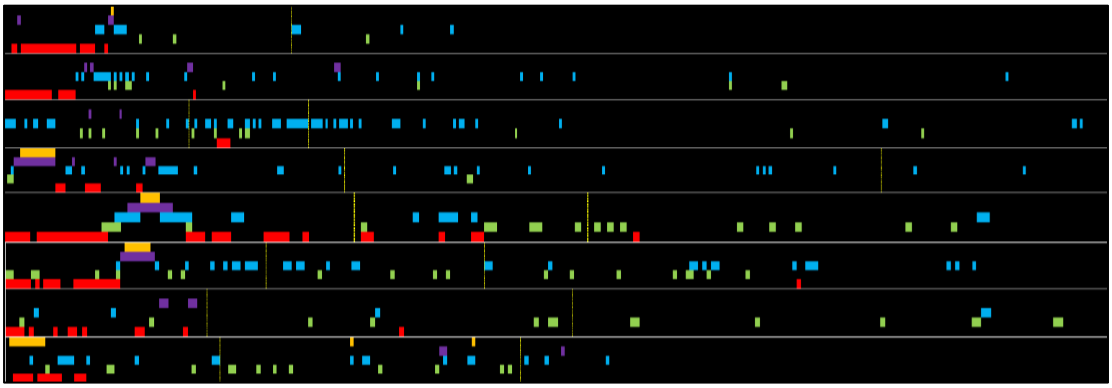


Figure 4.65 Summary of Intermediate's Designer Interaction towards Mediators during Form Reasoning

For senior category designers (7 respondents), 137 or 42.8% of the interaction were made specifically focus on ergonomic information (foetal form and other ergonomic information regarding washbasin height) mediators. Through the results on Table 4.26, it is shown that senior designers who have lots of experience in designing products prioritize human factor aspect in their task designing a washbasin design with baby bathe features, as reflect to the subject of research towards UHBE phenomenon. This factor may be influenced by the level of knowledge and the importance of ergonomic element in design to appropriate to the needs, abilities, safety concern, as well to improve overall system performance of new washbasin concept, as suggested in the International Ergonomics Association (2020) on the definition and domains of Ergonomics. The considerations taken by senior designers were also explained by Sanders & McCormick (1993), that engineering psychology approach will improve the relationship between humans and products through better design for the user products. Senior designers are seen as more experienced in design because they integrate ergonomic principles consideration in UHBE design concept.

The rationale for ergonomic elements in design by designers is to ensure a safe, efficient, and comfortable, that meets user needs. As stated by Karwowski (2011), users are expecting product functions to be safe, reliable, and efficient. In addition, among the factors that are believed to influence the consideration of design based on ergonomic characteristics is because the design task given in the design activity is concerned primarily with human anatomical characteristic as they relate to physical activity within first user (parent) and second user (baby) (Chaffin and Anderson, 1993; Kroemer et al., 1994; Karwowski and Marras, 1999). Figure 4.66 illustrated pattern of Senior designers' interaction towards mediators provides during moment-inspiration experiment. Through the figure, there are green distribution code within black background. However, there are reddish and blueish distribution code, showing that senior designers also considering other mediator than focusing more on ergonomic aspect for their intended washbasin design with baby bathe solution.

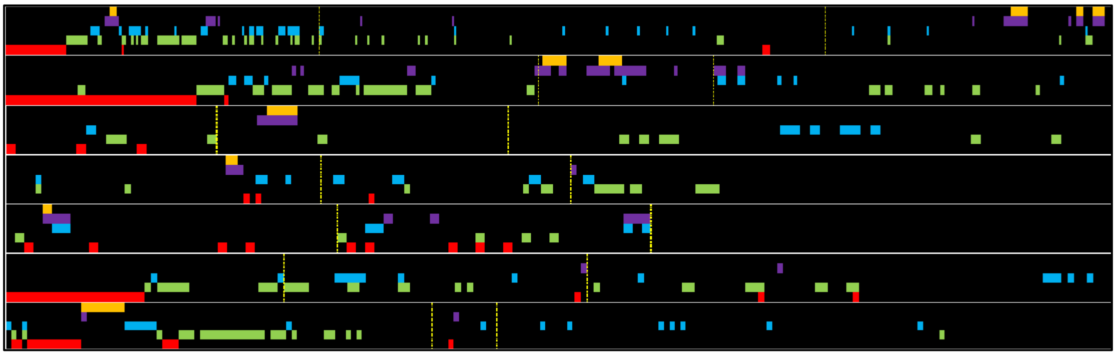


Figure 4.66 Summary of Seniors' Designer Interaction towards Mediators during Form Reasoning

Meanwhile, for expert designers (5 respondents) indicated that artefact reference (artificial wash basin) and technical aspects are most important in considering product with UHBE attribute features, as for their new product concept. Based on the Table 4.26, a total of 46 interactions were produced by expert designers for both artefact and technical mediators. The emphasis on artefacts shows that expert designers focus more on existing product references in processing and designing of the final decision for the form construction. This approach allows designers to iterate and refine their designs based on real-world usage feedback and interactions (Bødker, S., & Grønbæk, K. ,1991). Interacting with the existing products assist expert designers to facilitate the context, ideation, and understand user unintended behaviour and attributes. Meanwhile, expert designers are also seen to prioritize technical aspects such as dimensions, product component, functionality, and product systems to ensure effectiveness and user friendly, as well provide safety element and satisfaction. The consideration of artefacts and technical aspects in design decision is in line with the views of most scholars in engineering design and industrial design. As emphasized by Ulrich & Eppinger (2015), the integration of technical aspects such as dimensions and functions in the product design process is important to meet user needs and achieve market success. This statement supports the view of Pahl, Beitz, & Grote (2007) who emphasize a systematic approach in engineering design, through technical considerations in the development of effective and innovative products. In addition, the physicality of the actual product also influences the usability and user experience of everyday products (Norman, 2013). This statement shows that expert designers emphasize the integration of technical aspects and existing product performance for new product design concept to ensure that the design to be produce can functional well, meet user needs, and successful in the market. Figure 4.67 illustrated pattern of Expert designers' interaction towards mediators provides during moment-inspiration experiment. Through the analysis, there are balance distribution code within black background, consist of technical (green), artefact (orange) and ergonomic (blue) element. However, in the beginning of the experiment, there are some designer focuses on video references to understand the phenomenon using washbasin in unintendedly. It can conclude that expert designer's tent to refer to every element of mediators provide by the researcher to evaluate how designer think and interact with other material for design unintended behavioural design based, for their intended washbasin design with baby bathe solution.

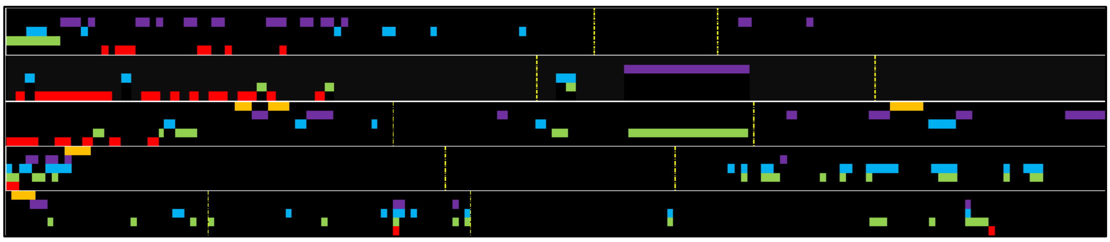


Figure 4.67 Summary of Experts' Designer Interaction towards Mediators during Form Reasoning

On the other hand, based on observations conducted through video and photo recordings, there are less interaction between designers and mediators capture by camera 3. At least 18 designers interact with the artificial doll to influence their form construction. As mentioned by some designers, artificial doll was also help them influencing form construction other than ergonomic information and video sources to understand context of unintended use. Meanwhile, at least once, all designers referred to the video reference and ergonomic information as for their design inspiration.

However, different for the artefact source where there was one designer who did not directly refer to the mediator throughout the design activity. The difference in the reliance on mediator sources by designers can be illustrated by whether they (i) have experience in the context of sink use as performed by the user, or (ii) have a holistic understanding of how the behaviour is performed, (iii) feel that certain sources are sufficient to interpret the behaviour. This statement was supported by several designers after the VPA session, based on their experience with the behaviour of bathing babies using the existing washbasin. Throughout the VPAE2 assessment, the assertion of ideas, suggestions and arguments by designers was also demonstrated through the designers' body language representations, eye pointing and uncertain behaviour. Emphasis through body and facial expressions showed that designers channelled experience, knowledge and considerations in design thinking based on their respective design practices. When the mediator resource was placed on the designers' desk, designers demonstrated eye behaviour to convey the focus of their thoughts. In addition, eye contact facilitated the designers' interaction with the surrounding mediators. Designers used their gaze or shared gaze when addressing the mediator. Gaze contact refers to the process of observing information or images in the mediator, while shared gaze refers to the situation when designers redirect their gaze to the mediator without having to focus on the information or image as a single object. An overview of the designers' reflective thinking through eye tracking, body gesture, uncertainty expression and mediators' interactions in the VPAE2 experiment (moment of inspiration) is presented in Figure 4.68.

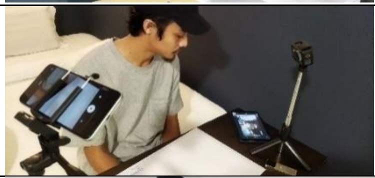
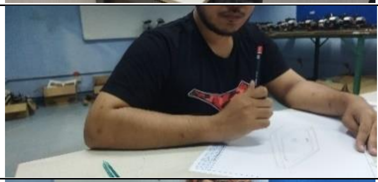
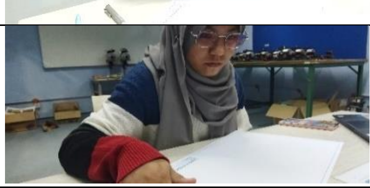
Interaction	Sample of interaction during moment of inspiration	Interaction description
Body gesture language		The subject focuses on information explanation through body gesture language to support the cognitive thought.
Eye-contact		Subjects interact with the mediators to study human behaviour into design solutions.
Object interaction		The subject engages with the mediators to solve issues and generate ideas.
Uncertainty behaviour		The subject shows uncertainty behaviour to emphasis on the proposed concept.
Eye-contact		The subject refers to the mediator making sure all parts of the product concept fulfill the requirements.
Object interaction		The subject interacts closely towards the mediator.
Eye contact		The subject refers to the mediator getting some information about the product.

Figure 4.68 Sample of Moment Inspiration recorded by Camera 3

Summary of Designers' Interaction protocol analysis

The conclusion that can be made from designers' moment inspiration during the design sketching activity at VPAE2, which conducted within short-term memory, indicated that most of designers utilized the mediators to align the design requirements with their cognitive considerations on UHBE attributions. The study identified that eye and body movements during the experiment contributed to the design generation process through cognitive connection. Fundamentally, these five mediators have their respective roles as central normal design process in raising ideas, safety considerations and innovation elements in design thinking to generate a new product concept of washbasin with integrated of bathe baby features. Through the approach conducted to achieve objective VPAE2, which is to observe how designers interact with the mediators while framing the problem and integrates their thought in design strategies regarding study of unintended use of wash basin, the results have been successfully achieved.

Therefore, this research shows that ‘eye’ behaviour (Malandro, Barker, and Barker, 1989) plays an important role in establishing and defining relationships, influencing the development of interactions, or constructing forms. The designers’ eagerness to express interest in the contacted mediator facilitates the collection of information about design strategies for the UHBE study. In addition to conveying design emotions, eye contact (especially when the gaze is shifted or directed upwards) serves a non-visual purpose to minimize distractions for the designer. Stopping to observe the mediator helps the designer in structuring their thoughts, a phenomenon referred to as uncertainty behaviour. Thus, the researchers argue that the use of mediators plays an important role in bridging the gap between theoretical and practical design concepts, as well as a tool for understanding the real context (Leem and Lee, 2024; Anwar et al. 2016). In this research, interaction protocol analysis has successfully answered RQ2, which is designer response and interpretation towards UHBE attributes provide valuable insight into design thinking at the early stage of new product concepts through mediators’ interaction evaluation. Figure 4.69 (on the next pages) illustrate comparison between four designer categories interaction towards Mediators.

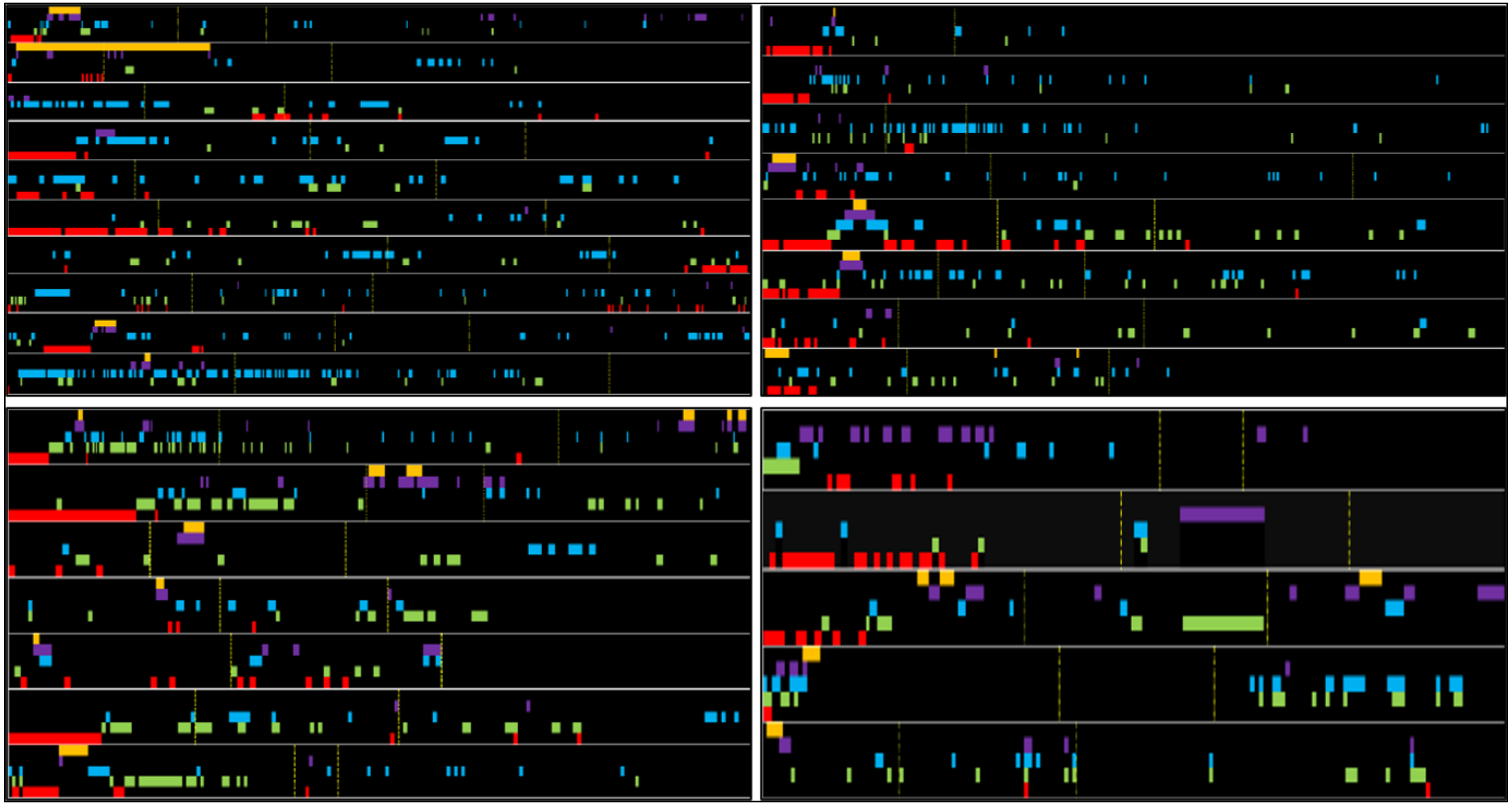


Figure 4.69 Comparative Perspectives between Four Designer Categories Interaction towards Mediators during Form Reasoning (top left-Junior, top right-Intermediate, bottom left-Senior, bottom right-Expert)

Designer Reflective Practice of VPAE3

As mentioned in section 4.4.5, VPAE3 conducted along with VPAE2 experiment. Thus, this section presents the findings of the data obtained from the analysis of the raw VPA data. The VPAE3 data were analysed using the theoretical framework of reflective practice analysis based on Valkenburg (2000). Reflective design practice analysis was carried out to explain the process of generating design ideas by designers directly through verbal recording activities. In this research, the objective of VPAE3 is to evaluate unintended use reasoning in design activities that may aid designers' interpretation in generating product design ideations. Reflective practice analysis will unravel how designers handle conceptual product design activities regarding UHBE towards washbasin design. These findings will be able to determine the reflective practices of designers and display their level of design thinking as proposed by Abidin' design practice level (2020). The results of the analysis will complement the RO2 and answer RQ2 as well.

In total, VPA protocol episodes were successfully collected from 30 designers from four different categories, which their verbal and design task were recorded using video and audio recordings. From there, a total of 30 VPA protocol data were collected and manually transcribed by research assistants for data analysis purposes. In addition, a total of 30 sketches (design tasks) were also successfully collected as a result of the VPAE3 experiment. All VPAE3 data (30 data in total) were evaluated through the theoretical framework of reflective practice analysis, but only four protocol results will be revealed for the purpose of presentation in this study. One protocol was present from each category based on the quality of descriptive analysis that meet the four theoretical components of reflective practice, which adapted from Valkenburg and Dorst (1998), such Naming, Framing, Moving, and Reflecting, which will be presented and discussed in detail, as explained in section 4.4.5. It includes the findings of (i) VPAE3 Junior Designer, (ii) VPAE3 Intermediate Designer, (iii) VPAE3 Senior Designer, and (iv) VPAE3 Expert Designer. In addition, to describe the pattern on how designers reflect on experiences, moving from broad theoretical perspectives to specific and giving detailed understandings during verbal and sketching activity, a presentation analyzing the reflective practice of designers using Andreasen's level of abstraction (abstract, semi-concrete, concrete). Each level of abstraction is represented by color coding (i) green: abstract level, (ii) orange: semi-concrete level, and (iii) red: concrete level.

To identify designer design activity, the activity coding method is adapted to the designer's reflective practice activity code in each utterance. As explained in section 4.4.5, the sub-activity of designer's reflective practice is identified based on the following activities; Identifying material (IM), Identifying component (IC), Framing problem (FP), Fixing goal (FG), Frame solution (FS), Sketching (S), Detail design concept (DDc), Generating Ideation (GI), Reflecting to phenomenon (RPh), Reflecting to attribute (RA), Reflecting to Problem (RP), Clarifying solution (CS), Reflecting to experience (REx). To code each designer's reflective practice, this research uses four color codes: (Blue, Yellow, Pink and Turquoise) which represent the four reflective practices by Valkenburg (2000). Blue (naming), Yellow (moving), Pink (reflecting), and Turquoise (framing). It aims to determine the designer's reflective practice according to the correct sequence flow. It is a systematic coding approach in explaining the pattern behaviour in designer's sketching activity. Each designer's reflective practice is matched with a sub-activity as follows: 1. Naming: Identifying material (IM), Identifying component (IC), 2. Framing: Framing problem (FP), Fixing goal (FG), Frame solution (FS), 3. Moving: Sketching (S), Detail design concept (DDc), Generating Ideation (GI), 4. Reflecting: Reflecting to phenomenon (RPh), Reflecting to attribute (RA), Reflecting, to Problem (RP), Clarifying solution (CS), Reflecting to experience (REx).

This section will present the results of the experimental session conducted with designers of VPAE3 session. As explained in the section, each transcript consists of time, the transcription of the Protocol, designers ‘Activity and designers ‘reflective practice. The green, orange and red colors respectively represent the abstraction level of the designers’ design activities, namely abstract, semi-concrete and concrete. While the designers’ reflective practive section represents the main activity consisting of four components: naming, framing, moving and reflecting. Each component has a sub-activity that describes the designers’ activities during the design task. The following are the findings from the VPAE3 session conducted with 30 respondents, where only four transcripts are presented and discussed based on Valkenburg theoretical.

Junior Designers' Reflective Practice

As explained in section 3.6, the respondents in the Junior designer’s category consist of Final Semester Degree in Industrial Design for at least 1 – 5 years of experience in product design program. Figure 4.70 indicate the transcription of the protocol by designer J8 who is a student of Degree in Industrial Design from UiTM Kedah Branch. The transcription of J8 depicts the entire conversation and reflection he had in session VPAE3, which was a design activity in resolving issues arising from the design of mainstream wash basin products based on the tasks given by the researcher. Designers J8 spent 16 minutes and 14 seconds for the experiment, which separately into three levels of abstraction: 3 minutes and 56 seconds spent on the abstract level, 6 minutes and 30 seconds spent on the semi-concrete level, while 8 minutes, 21 seconds spent on the concrete level.

J8 Subject: (Junior Designer)
Date of VPA Session: 21st June 2023

Time / Abstraction level	Transcription of the Protocol	Designer activity: Thematic Category	Designer Reflective practice			
			Naming	Framing	Moving	Reflecting
00:01	.......*observed phenomena*	Constructing information				RP
03:35	*So*...,	Constructing information		FP		
03:37	I have an idea...., like if we bathe *the baby* , we have to hold it, *so* if there is a place for him to sit, *so his safety* is *safer*.	Sketching			GI	
03:57	It's a place of pressure.... I think this sink *is add on*..., this is where *the baby* will sit, like he will be hanging...., Because normally when the child takes a bath, his legs will move..., *So better* we put it up..., a place to *support*... *At least* this chair is where he leans on...., Later when he takes a shower, he puts it.	Constructing information	IC			
04:40	*So* there is no such case..., when the person bathing *the baby* will miss, because is slippery, on his back.	Sketching		FS		
05:00	.........................*(sketching)*	Sketching			S	
05:14	*So* he will *prevent* this...., maybe he will....,	Sketching		FP		
06:08	................*(perspective view)*	Sketching			DDc	
06:23	This one is indirectly *this baby* he's going to be here..., he's going to sit here. This is the part of his body, this is the gap in his legs, he will put it in the chimney. *So* he won't slip and fall down until is weak.	Sketching		FG		
06:57	That's because the sink is slippery. After that, will be *lot of functions*, people do all the laundry. Slick.	Sketching			S	
07:10	.... *(sketching)*	Sketching			S	
08:01	Maybe in terms of use when in the sink..., So just add on..., the sink we will indeed use. Maybe we'll add more, right?.	Constructing information				CS
08:33	..............................*(detailing sketches)*	Sketching			DDc	
09:29	.............................*(design information)*	Sketching			DDc	
15:29	Like I have this concept, it's kind of supportive, *and comforting*. Because of this seat I recommend a buoy, the buoy is like rubber, there is a wind but not *a full* wind. But it's like a cushion where *the baby* sits. Baby will *stay* there, instead of us putting in the sink.	Constructing information	IM			
16:02	.... *(final touch design)*	Sketching			S	
16:14	That's all from me.	Sketching			S	
		Frequency of Effective Design Activity	**12%**	**24%**	**52%**	**12%**

Figure 4.70 Summary of Designers' Reflective Thinking and Interaction on Influence Mediators for J8

A verbal protocol analysis (VPA) session with a Junior designer (J8) as presented in Figure 4.70 focused on developing an enhanced wash basin concept for bathing babies that emphasized safety, functionality, and user comfort. The discussion was organized into naming, framing, moving, and reflection activities based on the three levels of abstraction in reflective practice. At the initial abstraction level (00:01 - 03:37), J8 observed existing baby bathing practices and identified key issues (RP). J8 noted that bathing babies in the wash basin could inadvertently cause them to slip easily (FP). This observation led to the initial idea of designing a support seat into the existing wash basin (03:37) to enhance safety and stability (GI).

Between minutes 03:57 and 08:32 (semi-concrete level), J8 began sketching the concept of an additional seat and proposed a hanging support structure to prevent the baby from slipping (IC, FS, S) (04:40). J8 highlighted that this feature would ensure a safer position for the baby and reduce the risk of accidental falls (FP, FS, FG) (06:23). Additionally, J8 pointed out that the surface of a sink is typically slippery (06:57) and that improvements to the design should consider various functional uses of the basin besides bathing the baby (CS). Moreover, during the semi-concrete level (06:22–08:00), J8 refined the conceptual features and structural integration of the baby seat (DDc) by proposing portable, easy-attach features for a standard basin (S) to create a versatile and user-friendly solution to the problem. Sketching activities during this phase focused on design details and usability improvements through illustrated perspective views. In the final phase of the concrete level (08:33–16:14), J8 enhanced the concept by introducing a soft inflatable cushion to increase comfort for the second user (DDc) (15:29). To realize the concept, J8 proposed a rubber-based material with an air cushion that serves as a safe and comfortable seating area for the baby (IM, S). The concept aims to boost user confidence, avoid discomfort during bathing, and improve the baby's safety level. Overall, the VPAE3 session for J8 demonstrated a problem-solving strategy focused on safety, ergonomics, modular design, and multi-use wash basin design features proposed to address product usage scenarios based on the UHBE attributes discussed.

Based on Figure 4.70, the frequency of effective reflective practice by J8 was also assessed. It shows that 52% of the time was spent on moving activities, 24% on framing activities, and 12% each on reflecting and naming activities. Through this percentage, it can be confirmed that J8's main activity focuses on moving. J8 started her design idea at minute 03:37 by sketching a draft idea for 20 seconds and continued the sketching activity at minute 05:00 using pencil medium at a semi-concrete level. At around minute 06:08, J8 sketched a perspective view to get a clearer picture of her concept design. The moving activity lasted until minute 08:00. At the concrete level, J8 used pen medium to confirm the product design concept, which was accompanied by some important information as concept information and reference. J8 completed the sketching activity at minute 16:14. Next, for the framing activity (24%), J8 proposed a solution by making a new portable product concept that would work better than UHBE as early as minute 03:35. This was an example of framing the design problem. The activity of framing the problem took place twice at the semi-concrete level because J8 reconsidered her concept design several times to obtain the maximum appropriate form. There was no framing activity at the concrete level. For the naming and reflecting activities, J8 allocated 12% each in the abstraction process.

The reflecting activity began at 00:01 with J8 reflecting on the phenomenon discussed for almost 4 minutes through the video source (mediator 1) provided, before considering the concept to be proposed. In addition, J8 reconsidered at a minute, around 08:01, by reflecting on the ergonomic source (mediator 2) before confirming her design concept. For the naming task, J8 came up with his design idea by talking about the parts of the wash basin that would support the portable wash basin during the abstract stage. She did this while referring to technical information (mediator 3) from time to time. Next, determining the type of material proposed was also well explained by J8 around minute 15:29 at the concrete level.

Overall, J8's design activity was greatly influenced by her intuitive process based on ergonomic information and video sources of how people use sinks to bathe their children at risk. J8 was also seen spending a lot of time referring to video sources to create ideas and interpret unintended use of wash basins through her creativity. Figure 4.71 illustrate J8 reflective practice based on design task given.

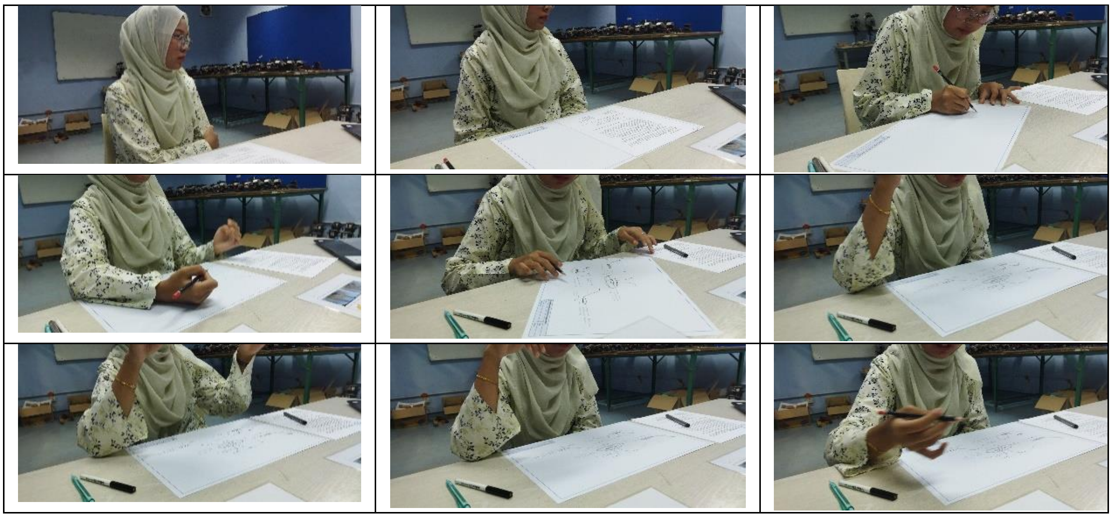


Figure 4.71 Part of J8’ Reflective Practice Activity based on Design task given

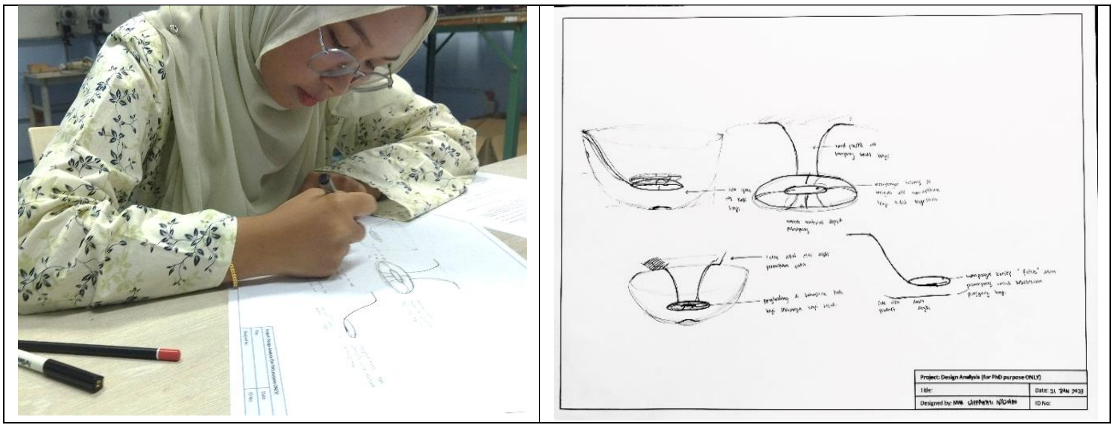


Figure 4.72 Design Sketching based on J8’ Interpretation on UHBE attributes towards Washbasin in VPAE3 Experiment

Based on the recorded design activities (see Figure 4.72), the J8s' design strategy patterns indicate that the design approach was predominantly hermeneutic, as it was driven by the interpretation of user behaviours, analysis of unintended use cases, and meaning making through design decisions. Hermeneutic features can be seen in J8's design process, which is centered on understanding and interpreting user interactions with wash basins, rather than solely solving a technical problem. At the abstract level (00:01 - 03:34), J8 analyzed video sources (mediator 1), focusing on how parents unintentionally adapt wash basins for baby bathing. This observational process allowed J8 to derive meaning from real-world usage scenarios, leading to the conceptualization of a new portable wash basin design (03:35). Throughout the semi-concrete level (03:57 - 08:34), J8 revisited ergonomic factors (mediator 2) and reassessed the effectiveness of the proposed solution, refining the design based on how users physically interact with wash basins. This interpretative cycle continued into the concrete level, where J8 further validated the design by ensuring its functional and spatial compatibility with existing wash basin structures. While the hermeneutic approach was dominant, the reflective approach (12%) also played a supporting role in the J8 design strategy. It can be seen when J8 frequently reflected on observed user behaviours, context of use, and product availability in daily life. By reassessing the ergonomic requirements, J8 ensured that the final design remained adaptable and human centered. To create a portable wash basin solution that aligns with real-world needs, J8 considered the broader context of user interactions, ensuring the solution remained intuitive. To conclude, J8's design activity was predominantly hermeneutic, shaped by analyzing user behaviours, interpreting unintended usage patterns, and redefining the wash basin's role. Reflection further supported the interpretative process, allowing J8 to refine the concept into a practical and human-factor design. As previously mentioned, the Junior category consisted of ten respondents who participated in the experiment, with each respondent's activity evaluated as outlined in J8. Figure 4.73 graphically illustrates the comparison of reflective practice episodes, revealing the abstraction levels of the ten Junior designers. The data for this category indicates that the designers primarily concentrate on concrete activities rather than abstract and semi-concrete levels throughout the VPAE3 period. Additionally, as presented in Figure 4.73, this study provides an overview of the analysis concerning the transition point patterns for abstraction levels, alongside reflective practice activities, highlighting the transition patterns among the ten Junior designers. To conclude, Junior designer spends more on abstract and semi-concrete level to understand, frame and integrated ideation into sketches. Figure 4.74 illustrates the transition points for the designers, comparing abstraction levels with reflective practice activities for the Junior category.

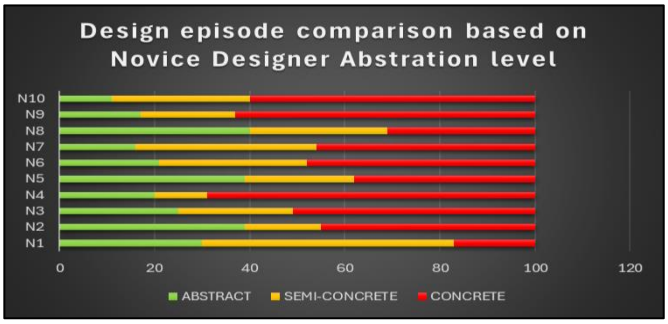


Figure 4.73 Comparison of Design Episode based on Junior Designers Abstraction Level

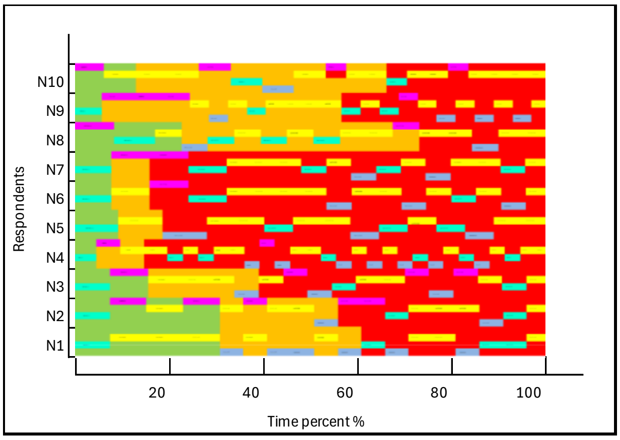


Figure 4.74 Illustration of Juniors' Transition Points (Abstraction vs reflective practice activities)

Intermediate Designers' Reflective Practice

As explained in section 3.6, the respondents in the Intermediate designer's category are individuals with working experience in the design industries or master students within for 6 – 9 years. Figure 4.75 (on the next pages) shows the transcription of the protocol by designer D6 who is a master's student in design technology at UiTM Kedah Branch and currently working at a design firm for 6 years of experience. The transcription of the protocol by D6 depicts the entire conversation and reflection he had in session VPAE3, which was a design activity in resolving issues that arose in the design of mainstream wash basin products based on the tasks assigned by the researchers. Designers D6 spent 23 minutes and 21 seconds for the experiment, which separately into three levels of abstraction: 4 minutes and 29 seconds spent on the abstract level, 6 minutes and 16 seconds spent on the semi-concrete level, while 13 minutes and 17 seconds spent on the concrete level.

D6 Subject: (Intermediate Designer)
Date of VPA Session: 21st June 2023

Time / Abstraction level	Transcription of the Protocol	Designer activity: Thematic Category	Designer Reflective practice			
			Naming	Framing	Moving	Reflecting
00:01	……………………(*observed phenomenon)*	Constructing information				RPh
01:21	I don't *prefer* this sink, but if you are in confinement you can't sit!	Constructing information		FP		
01:30	….So… This is in perspective ….	Sketching			S	
01:46	……………………(*sketching idea)*	Sketching			S	
01:48	I thought I was going to make him *a silicone*….. I don't want to make him a hard object….., maybe he can….	Sketching	IM			
01:59	I would also like to think about space …	Sketching		FS		
02:12	*so* it's like *silicone* that can *adjust* … the *stackable*…	Sketching	IM			

02:26	But I draw it overall.....	Sketching			S	
02:29	It's not a square shape, but...	Sketching			S	
02:40	Ok, due to the area he is watery, *slippery*, the bottom he is ok. Here it is..., *bottom* sink. *Slippery*, I want to go down he has maybe *silicone* or a pound of rubber...*Rubber*, below. Maybe that's the way it is, so it doesn't move..	Sketching	IM			
02:56	....	Sketching			S	
03:31	Another one, *based on my experience*, near the bath.... Like *a baby*... Wear *a towel*. But if most of them are like this, they don't have a place to put *towels*, right, and often far away. It's hard to pick up the baby. When it's *slippery*, then take the *towel* again. *Sometimes* no one wants to help...	Constructing information				Rex
03:52	*So* I think there should be a place to *put the* towel here..	Sketching	IC			
04:12	And then I don't feel like I'm going to be able to do that here,.... Worried about *the baby*'s head . Maybe he can come from underneath, like we stagnate the water...	Sketching				CS
04:30	..............................*(sketching)*	Sketching			S	
04:38	Then... Baby .. We're not going to lie to him, right? *So*... He's got to... like this. Got a little curved....	Sketching			S	
04:50	But here it is... Like *rubber*.... Aa yer...	Sketching	IM			
04:55	This is what happens when a baby is not *a newborn*. However, those who are older can use it....	Constructing information				CS
05:15	This is a sketch rather than a *bottom view...*	Sketching			S	
05:45	next may be able to place... soap parking...	Sketching	IC			
06:45	...this is from *side view*....	Sketching			S	
07:01	I'm going to have to make this quilt because I don't know *what the size* of the baby is. And as I *mentioned* earlier, it's not *just a newborn baby*, it's a two-year-old baby.	Constructing information				CS
07:23	And then it was like my parents, and I didn't *expect* to use this *portable washing basin* for so long. But this is if *the parents* don't *plan* to have another *baby*. Maybe he can turn this thing into something else..., maybe it could be a regular *basin*..., or a washing machine..., but that's *based on human behavior*. If they don't want to waste, they will start looking for what to use after this....	Constructing information				RA
08:35	This is *side view..*	Sketching			DDc	
08:56	If you want to get rid of the water, like I said before, you want to get rid of the water. You have to use constant water. That's right... That's why I don't want *to put the shoe* on top... It's from above..... he might be like *that Jakuzy*	Constructing information			S	
09:30	If the *faucet* is not like this, I don't want it to be like this, because it is dangerous. So if we do it near here, close in... But she's just a little girl. Maybe he's in this shape....	Constructing information		FG		
10:10	It's because of the *baby*... For example, we usually use our hands, right..... If we have a *faucet* that can move, *a long* hose...*in* and out... The *flexible* have a concept...	Sketching	IC			
10:45	..........................*(detailing sketches)*	Sketching			DDc	
10:52	Ok... But underneath there is a *drain hole*. But for example, if we want to place this baby in a higher place, like this we can put it below....	Constructing information	IC			
11:12	I think he needs to have some *support*. Maybe we can put *something...*	Sketching			S	
11:36	It's like *a clip*....., *so* we're going to open it up, it's going to be a place for *support*... And even if he does, he can *still* move.....	Constructing information	IC			
12:05	*So* it looks like there's a *clip*	Sketching			S	
12:40	To *stabilize him... If the baby is a newborn*... He's not very stubborn... If it's a little bigger, it's a bit of a stretch.....	Sketching			S	
12:54	But *the material* can *be mixed material... silicon* and *plastic*... This is a one-place *compartment*... This is called *foldable*.....	Constructing information				CS
14:48	*Material.... silicon* and *plastic...*	Constructing information	IM			
16:02	....	Sketching			S	
16:17	this... *Final design...*	Sketching			DDc	
19:59	................................*(final touch sketches)*	Sketching			S	
22:19	*So*, like I said... But it'*s foldable*. And his body is *silicon* but *it's a mix of plastic, his faucet is in* and *out*. It's inside..., not	Constructing information		FS		

	above. Here is a link to the *video clip*... On the Side. There is a rubber underneath... At the bottom of the stairs so that he doesn't *move. The drain hole* is a *rubber* like that round, right. So that he doesn't *slippery.* Then there's a towel detector on the side, and *a part compartment....*					
23:21	...and that's it....	Sketching			S	
		Frequency of Effective Design Activity	**25%**	**10%**	**47%**	**18%**

Figure 4.75 Summary of Designers' Reflective Thinking and Interaction on Influence Mediators for D6

At the beginning of the abstract level (00:01 to 02:12), D6 observed the current wash basin design (RPh) while identifying key usability issues. Initially, D6 opposed the use of wash basins for bathing babies. However, D6 raised concerns about user safety, especially for mothers' post-childbirth, as they are advised against sitting or squatting while bathing their infants (FP). D6 then began sketching a portable design concept based on silicone material (S, IM) (01:48 to 02:12), highlighting flexibility and adjustability through stackable features (FS). Between minutes 03:31 and 03:51, D6 recalled a personal experience, mentioning that during preparations for bathing a baby, there was a lack of towel facilities near the basin, making it difficult for mothers to manage (Rex, IC). As a solution, D6 proposed an integrated towel holder (04:11) through sketches. Furthermore, D6 expressed concerns regarding the faucet position, suggesting that water flow should originate from the bottom instead of the top (04:30) to lower the risk of injury (CS).

Moving to the semi-concrete level (04:30 - 10:44), D6 refined the structural components of the wash basin and began developing a proposed design aimed at newborns and young children (S, CS). At minute 05:45, D6 advanced the concept by suggesting a soap holder be included in the portable wash basin design. D6 also recommended that the product concept should be reusable if it becomes unnecessary, adhering to sustainable design principles (CS, RA). Additionally, D6 introduced features such as drain hole placement and a flexible faucet system to enhance the functionality of the concept (IC, DDc, S). At the concrete level (10:45 - 23:21), D6 concentrated on the design's stability and safety by incorporating a "clip-on" support structure feature (11:36) and a rubberized base to prevent slipping (S, CS). D6 recommended using a combination of silicone and plastic materials (14:48) to improve durability and flexibility in the design's form and structure (IM). At the conclusion of the concrete phase, D6 presented the final design for the portable wash basin, incorporating baby bathing features, a foldable concept, an in-out faucet system, rubberized drain holes, and integrated compartments. The basin was designed to be compact, stable, and multifunctional, addressing user safety and space efficiency in response to the characteristics of UHBE (S, DDc, FS). The sketching and reflecting activity of the S4 VPA session ended at 23:21. Overall, D6's VPAE3 session reflected a problem-solving strategy, merging personal experience, ergonomic considerations, and modular design elements to develop a versatile and user-friendly new product concept. Figure 4.75 also shows how often effective reflective practice happened for D6. It shows that 47% of the time was spent on moving activities, 25% on naming activities, 18% on reflecting activities, and only 10% on framing activities. Based on this percentage, D6's main activity was moving. D6 started her design idea at 01:30 by sketching a perspective view draft for 18 seconds and continuing at minutes 02:26 and 02:56 at an abstract level using a pencil. At the semi-concrete level, D6 is moving to a detailed design at 08:35 by providing a comprehensive perspective view to show the improvement of the features concept. Throughout the concrete level, D6 focuses on enhancing her design by adding detailing to the component proposed, highlighting the information about the idea, and validating the design using a technical pen.

For naming activity, D6 has been naming the material proposal of the design concept as earlier in her design activity (01:48; 02:12; 02:40) and drawing up the component of the new basin concept. Moving to the semi-concrete level, D6 continues to discuss material determination to enhance the component of the design throughout the semi-concrete level until the concrete level (04:50; 05:45; 10:10; 10:52; 11:36; 14:48). For reflecting activity, D6 focuses on abstract and semi-concrete levels. Reflecting activities involve observing the UHBE phenomenon, reflecting on her experience, reflecting on the attribute, and confirming her idea solution towards the end of the concrete level (14:47). The least activity done by D6 is framing (10%). At the abstract level, D6 shows the activity of framing the design problem and proposing solutions that are considered appropriate to overcome the issues discussed. Overall, D6's design activity was greatly influenced by her intuitive process based on the experience on how people use a wash basin to bathe their child. Figure 4.76 illustrated D6' Reflective practice activity based on design task given.

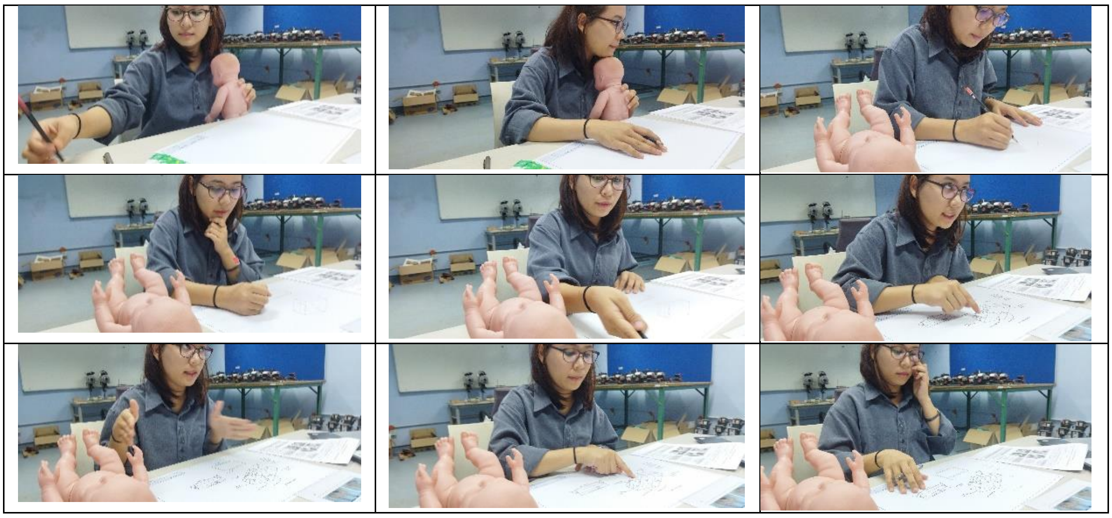


Figure 4.76 Part of D6’ Reflective Practice Activity based on Design task given

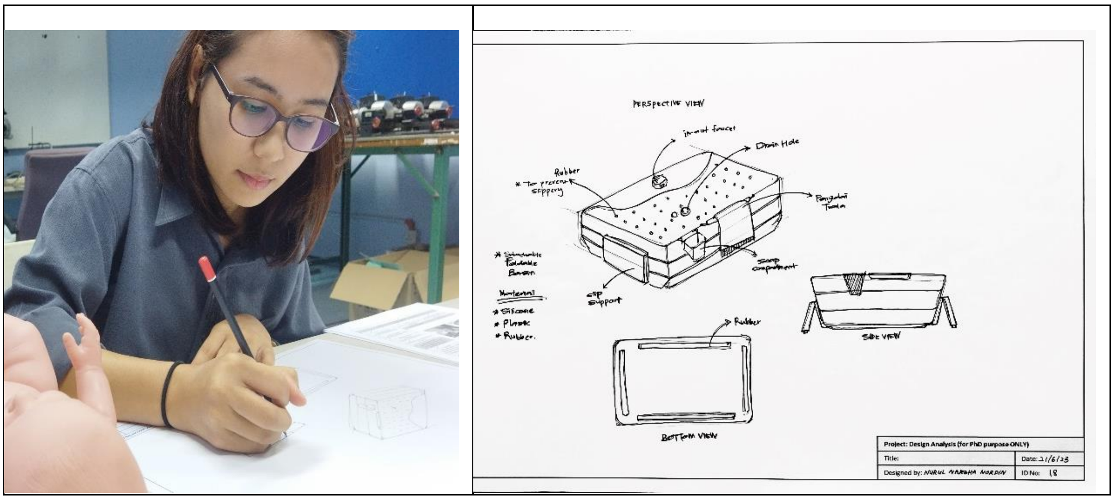


Figure 4.77 Design Sketching based on D6’ Interpretation on UHBE Attributes towards Washbasin in VPAE3 Experiment

Based on the design activities recorded on D6 (see Figure 4.77), the designer primarily engaged in moving, followed by naming, reflecting, and framing. These patterns suggest that D6's design approach aligns most closely with the reflective approach and the hermeneutic approach, with elements of the synthesis-analysis approach. The characteristics of reflective approach by D6 can be seen when her design process was heavily influenced by personal experiences and observations. Throughout the abstract and semi-concrete levels, D6 engaged in reflecting on the UHBE phenomenon, personal experiences, and user behaviours to generate insights that shaped the design concept. The reflection process helped refine ergonomic aspects, including faucet positioning, material selection, and safety enhancements. Towards the concrete level, reflection played a role in validating the design concept, ensuring that it met both functional and user-centered needs. Furthermore, D6 shows the characteristics of hermeneutic approach when his design practice followed an interpretative process, where meaning was derived from user interactions, behaviours, and contextual challenges. Rather than following a strictly technical approach, D6's design evolved as a response to observed usability issues. The designer interpreted the struggles of parents handling slippery conditions while bathing their children, leading to intuitive design decisions such as adding a towel holder, using rubberized materials for stability, and ensuring modular functionality for long-term usability. However, there is a little synthesis-analysis approach shown by D6's when incorporated elements of synthesis-analysis, as the designer first analyzed the usability challenges and then synthesized a solution by integrating material selection, ergonomic adjustments, and structural refinements throughout the semi-concrete and concrete levels. The naming activity further supports this approach, as D6 systematically labelled components and materials to enhance the design.

To summarize, D6's design approach was predominantly reflective and interpretative, with a strong focus on user experience and intuitive decision-making. The hermeneutic and synthesis-analysis approaches further shaped the design, ensuring that the final concept was adaptable, user-friendly, and contextually relevant. As previously mentioned, the intermediate category consisted of eight respondents who participated in the experiment, with each respondent's activity evaluated as outlined in D6. Figure 4.78 graphically illustrates the comparison of reflective practice episodes, revealing the abstraction levels of the eight intermediate designers. The data for this category indicates that the designers primarily concentrate on concrete activities rather than abstract and semi-concrete levels throughout the VPAE3 period, same as Junior category. Additionally, as presented in Figure 4.78, this study provides an overview of the analysis concerning the transition point patterns for abstraction levels, alongside reflective practice activities, highlighting the transition patterns among the eight intermediate designers. To conclude, intermediate designer spend more on semi-concrete level to understand, to frame and integrated ideation into sketches. Figure 4.79 illustrates the transition points for the designers, comparing abstraction levels with reflective practice activities for the intermediate category.

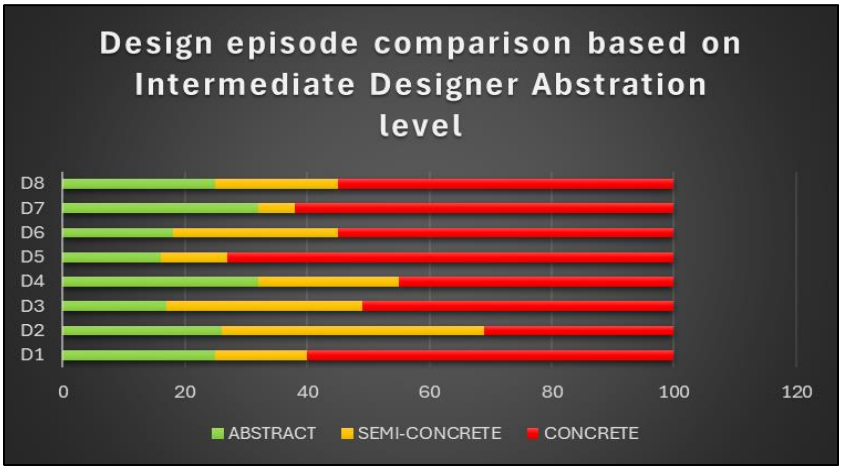


Figure 4.78 Comparison of Design Episode based on Intermediate Designers Abstraction Level

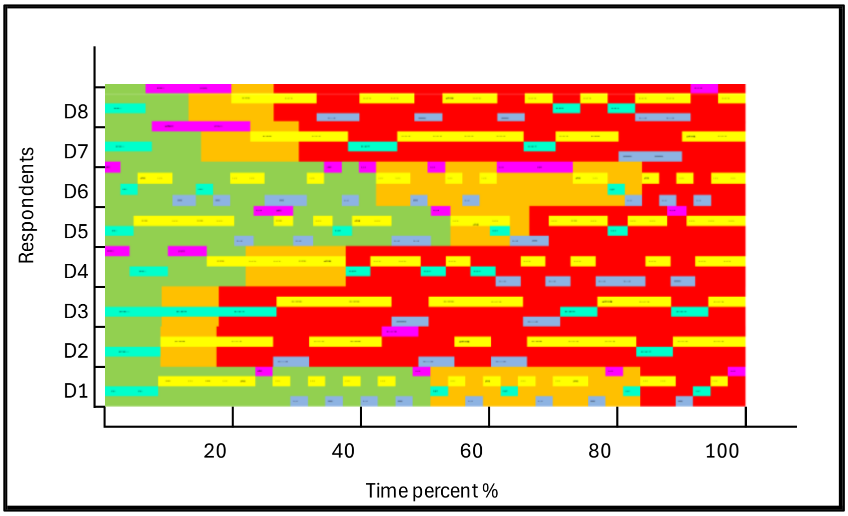


Figure 4.79 Illustration of Intermediates' Transition Points of Abstraction Level vs Reflective Practice Activities

Senior Designers' Reflective Practice

As explained in section 3.6, the Senior designer's category respondents consist of individuals with working experience in the design industries for 10 – 19 years. Figure 4.80 shows the transcription of the protocol by designer S4 who is a student designer and sanitaryware modeller at Roca Industries Sdn. Bhd. The transcription of the protocol by S4 depicts the entire conversation and reflection he had in session VPAE3, which was a design activity in resolving issues that arose in the design of mainstream wash basin products based on the tasks given by the researcher. Designers S4 has spent 39 minutes and 10 seconds for the experiment, which separately into three levels of abstraction: 11 minutes and 14 seconds spent on the abstract level, 17 minutes and 5 seconds spent on the semi-concrete level, while 11 minutes and 31 seconds spent on the concrete level.

S4 Subject: (Senior Designer)
Date of VPA Session: 23rd June 2023

Time / Abstraction level	Transcription of the Protocol	Designer activity: Thematic Category	Designer Reflective practice			
			Naming	Framing	Moving	Reflecting
00:01	*Based on* this second video, it is *more appropriate*, because the basin is wide and wide, *compared* to us using the existing *wash basin*. Because this is in the hospital, it seems that the space for the user to move around is easier.	Constructing information				RPh
01:09	*And then* to turn the baby upside down, it's easy *to compare* it to the first one.	Constructing information				RPh
01:19	Because if I look at the two videos, the *closet* of the person bathing the baby is indeed standing...	Constructing information				RPh
01:31	… *referring technical information*). Ok, Aaa…., *(referring artifact).* Ok…. *Based on previous video*.	Constructing information				REx
02:17	………..*Artifact interaction*	Constructing information				RPh
03:01	The first video of her bathing in the *wash basin*. But even though the *wash basin* is large, it looks small. This one he didn't use the *wash basin* completely. The second video is likely to be a specialist from a hospital that gave birth to a child. It is possible that *the design* she made is indeed suitable for bathing newborn babies. And the *design* shown is the shape of a square, a square. And you can see in the video that the *nurse* bathes the baby very comfortably, and she can change the baby's position without needing a lot of movement. If we *compare* it to the second video, it requires a lot of movement. *End up,* the person who takes a wet bath. The second video is more organized and easier *to handle* the baby. Baby pounds are very calm with the situation.	Constructing information				RPh
04:19	But when I look at this picture of the plaque, he has *this wash basin* that I think is the kind that is located underneath. It's *a portable* one, or at least it*'s because of the rounded design. For me, if it's* a round design or a tile design, I don't think there's a problem for him to use it. The most important thing is that *the wash basin* space is enough for him to move, for him to take care of the baby. Because if we want to bathe the baby I see here, he has two people, two situations. First, we put him on his back, to wash in front. Second, we must reverse it. If the *design* lacks *space* like we saw in the first video, it's a bit *of a struggle* to do the washing in the back. So, for me, in terms of *design,* it's not the wrong shape to be round or square, but it needs enough space to bathe it.	Constructing information			GI	
05:47	But the round space or compartment he does not need to have anything *taped* on him to avoid disturbing situations. But if the *tap* we see here, it is a *flat surface*, that area will indeed interfere with the process of bathing the baby. Like here, he has indeed eaten *the space* of this area.	Constructing information			GI	
06:10	……..*Artifact interaction*	Constructing information				RPh
06:17	If you look at the second video, he does not have *a* flat *surface* to place the *water tap*, and this *design* is suitable for us to move freely. And reduce our risk of injuring the newborn *baby*. It's normal for newborn babies to be soft, right, sensitive, right.	Constructing information	IC			

06:38	When I was a kid, I used to take a shower with my baby. Yes, I have experience, but I use the *portable* one. And he can wear which *extender* has. Put the *baby* down. I was kind of afraid to put *the baby* because it was soft, *so* I put the baby and I bathed him....	Constructing information			REx
07:00	But in situations like outside, if the designer makes a *wash basin,* it is recommended to design a *flat tab*, and he has enough space. I don't think the *baby* in Asia is as big as *the baby* in Europe or in the US. *So* he has to do a study on *how* many kilos we have a baby in Malaysia, how big *is the size*, so that we can equrate *the size* for a suitable wash basin near any situation such as near RnR, *shopping malls,* because now we already have, most shopping malls that have recently had a lot of places for *baby rooms* right.....	Constructing information			RPh
08:02	Aaaa. She has a place that is not deep, the place to bathe the baby is not deep and she did buy a sink. The sink that was allusions, had an aluminium place where he put it. For boys, because I always go to wash my child, but for *toddlers*. Toddlers are very suitable, but for small *babies* like this. If we want to bathe him there, I don't think it's suitable, but most people use it to wash, *change his diapers*.... aaaa, that's fine.... That's my opinion......	Constructing information			RP
09:14	................ermm	Constructing information			
10:02	For me, I *prefer* to make a round shape. Because *based on* my experience, the time of work, making *a round wash basin* is not as difficult as the shape of a square. There are a lot of technical areas that we have to make, to *develop* them. Because we play with *ceramic materials*, right. *This ceramic material* is very *sensitive,* which has an *angle* to it. So, I *prefer* to make it round....	Sketching		S	
10:36	The most important thing here is *the space, the space* between here and here that we have to *measure*. That is, it's bigger than the *usual wash basin* looks like, and the depth, aaaa, the depth is enough.			GI	
11:15	We call it *shallow* in its depth	Sketching		S	
11:19	On the other hand, he doesn't get out of his *tabletop because he wants to avoid any injury* that happens. If that *happens*, he'll be the same as he has a *tabletop*....	Sketching	FP		
11:31	Erm, my goal for making the basin in this is to help my mother's hand that enters. He has enough *space* for him to accommodate. If we want to make a *square,* we need bigger dimensions. For him to move, that's *based on* my opinion.	Sketching		S	
12:04	And from a technical point of view to make, I think to make *a wash basin* using this *ceramic material*. This round shape is easier to develop than *a square*. That's why I'm going to have to wash these dishes. *So,* there are indeed many *technical measures* that we *are countering*. And you have to do it two or three times. Adjustment, for us to get him has criteria... Do you want to *pass the criteria*......	Sketching			CS
13:01	Because he is wide, I don't think he needs to be wide, he is a cube for us to turn the baby around and he doesn't need aaa....., a lot of movement. That is, whether we must move or bow, or switch to change the baby's position....	Sketching	FP		
13:41	*Top view......*	Sketching		S	
14:21	And then there's the wall, and we're going to have to do something like this. Eermmm, because I want to *counter measure* the time of the manufacturing process. *Most* of the time we make *a structure* to *support* him to have *an oval shape* during *firing, so that he doesn't distort* or *warp* during firing. At the time*,* however, he was on the same *level* as *the Democrats. He won't come out, if he comes out a few pounds*.	Sketching	FG		
15:16	................*(rendering sketches)*			S	

16:09	Again, if we make this *oval shape* using *materials* that are not as much as *squares, it* is *based on theory*. We don't know how many slips he uses, the process of making him have that *support structure*, he has that *case*, everything, it's *based on* the cost of everything. That's my *concern*....	Sketching			S	
17:04	................*(rendering sketches)*	Sketching			S	
18:08	Another one I think is the use of water, if it *is oval shaped*, the water we want to use is not as much as *square shape. So, there is no waste of water to stagnate the water. In my opinion, if you use ceramic material,* for the long term, *the durability* is higher because it does not corrode. If we buy *portable plastic*, it is moldy, we have to throw it away. But if the *ceramic* on is dirty, we wash it, it's gone. Because we want to bathe for babies, babies are *sensitive*. Anything in the sink. It is likely to have *an effect* on the baby. So the finished product has the *material* we must *take note of....*	Constructing information		FS		
20:19	That's my opinion. But there has to be an *overflow.*	Sketching			S	
20:36	Below is *an accessory.* I'm not mistaken; I do have *old* oval *designs*. In the catalogue there is. There is indeed an oval *design*. But use *marble*. It looks like *a high-end product*. And there are also things that I have seen that have not been done. But this one is because he has *exclusive*. So here he *is sharp...*, *joining* him *sharp....*, but he has the *bowl* located. It is very unsuitable for us to use. For me, he is risky for us to use. Because he has *sharp edges* here, right?	Sketching	IM			
22:02	That's why I *prefer the curve*, but he has a bone in the *level* near the tabletop.	Sketching			S	
23:15	If he comes out, it's just a little bit because *of the curving design factor*. Whatever you want to *do* with it, it comes in the *washbasin*. He will *fix* it in the *cabinet* or *tabletop* that is available, he has the right height. If the height is not correct, most average Asians are not that tall. But he has to *have the right length,* so he doesn't hurt his back. I have used a low *wash* basin. I had to submit. When we submit, the burden will put pressure on our backs... (painting)	Constructing information				REx
25:15	(Watch the video). Okay, he's wearing *a tall* faucet.	Constructing information		FS		
28:20	..................*(detailing sketches)*	Sketching			DDc	
28:21	For *his water tap*, I *prefer* the one as it is now. It's the same thing. This one is *flexible,* it has a *spring*, it can pull, and it has a *button*... We can press, so that the water can come out. The purpose is if the mother or anyone wants to use it, she has two *options* to fill up with water, she can bathe as usual. Or the second *option*. He opened the water, he could just pull the *tap* and he took a shower. *So* if you use the second technique, it's easier and save water out of *the flow* like that. Without having to drain the water, it is more economical... *So* he can solve the child quickly.	Sketching				RA
29:59	Because if you *tap* something like *a spring*, this is *his button*. This one is more..., when we don't want to wear it, we can push it to the side, or he can pull the hose. He can take a bath. If he doesn't want to, he can put it there. *The faucet* I created makes it easy.	Sketching			DDc	
33:32	*So,* what we say is *enough space*. If we hold him, he has at least one hand he can get into this. You have to get your hands dirty. Because some people have big hands.... small arms. So, we can assume that he has *an end product everage...*, including *everage baby*. We can somewhat, that's for a bit *of space*	Sketching				CS
35:32	So *far* this is all I can think of. To find out the depth of *the bowl wash basin*, you need to do a *study*. When we put the volume of water, and when we put the baby, there is enough volume of water. And when we put *the baby* there, how much space do we have for this area. Because you want to know how shallow *the design* is , it's *subjective.* He doesn't have an *accurate measurement* of how we're going to do it. *So,* it is possible that there will be	Sketching			DDc	

	some *design development.* He has that *curve* for us to put that hand, for the baby's feet to influence. I don't think there is an *accurate method* to *measure* this. *So,* we have to make some *design improvements* from the design we have. When we do that prototype, we have to see if we have to *test it* first. Maybe he's less *shallow*, *curve* him, maybe sharper, we have to *shallow* a little. *So,* we have to change it again, maybe our third design will get *the accurate* design......					
39:10	Ok...., I think it's done...	Sketching			S	
		Frequency of Effective Design Activity	**5%**	**13%**	**43%**	**39%**

Figure 4.80 Summary of Designers' Reflective Thinking and Interaction on Influence Mediators for S4

At the beginning of the abstract level (00:01 - 01:31), S4 analysed a video demonstration (mediator 1) of a baby bathing procedure and compared two different basin designs (RPh). Based on the recording, S4 concluded that the hospital basin was wider and provided a more efficient user experience than the conventional basin (RPh). In addition, S4 reflected on the inadequacy of the baby's position and the different limitations of movement in each design (RPh). Between minutes 03:01 - 06:17, S4 examined artifacts (mediators 4, 5) and design elements (mediators 2, 3) that highlighted the differences between the rectangular and round basins. Although both were considered to be functional, sufficient space for movement was emphasized as a critical factor for usability (RPh). S4 also emphasized that the flat surface near the drain hole area also hindered movement and increased the risk of injury to the baby (IC, GI). Also, in the abstract level (06:38 - 11:14), S4 reflected on his personal experience in bathing babies and emphasized ergonomic considerations (Rex, RPh). S4 suggested that the size of babies in Asia is generally smaller than babies in Europe or America, so optimizing the size based on regional anthropometric data is important (RP). In addition, S4 also responded to concerns about the shallow wash basins commonly found in public facilities and the unsuitability of such designs for bathing newborn babies (RPh). At the end of the abstract level (10:02 - 15:16), S4 began to draft a product concept sketch with a tendency towards a round basin design because it is more practical to produce from ceramic material compared to a rectangular design (which is more technically complex) (S, GI).

Meanwhile, for the semi-concrete level (11:15 - 28:19), S4 emphasized 3 main aspects of wash basin design considerations based on the design problems expressed. Among them (1) suggested that the wash basin should be at the same level as the tabletop to reduce the risk of injury to the baby while using it (FP); (2) the aspect of material efficiency, cost, and water saving based on the oval shape (more sustainable) compared to the rectangular basin (FS); and (3) ceramic material is preferred over plastic due to durability and hygiene factors (CS, Rex, S). During the semi-concrete period, S4 showed a perspective view of the proposed product concept (IM, S).

In the concrete level (28:21 - 39:10), S4 detailed technical improvements to the sketch (DDc), including the design of an adjustable water pipe with a flexible hose to increase water efficiency and user convenience (CS). In addition, S4 also considered ergonomic features through hand position and baby position for the purpose of 1st User comfort. In the last minute of the concrete level, S4 emphasized that this new product concept proposal needs further improvement to determine the most optimal depth and curvature for a wash basin with baby bath features. The emphasis on form is shown with the intention of emphasizing the proposed shape, along with important information on the sketch for reference purposes (DDc). Overall, this session demonstrates a structured approach to design evaluation and improvement, with S4 combining observational analysis, material considerations, and ergonomic evaluation to propose a better and more effective wash basin design. The sketching and reflecting activity of the S4 VPA session ended at 39:10.

Referring to the frequency of effective reflective practice (refer Figure 4.80) recorded for S4, it shows that 43% of the time was spent in moving activities, 39% for reflecting activities, 13% framing and only 5% naming. Based on this percentage, S4's main activity was moving (43%). In this activity, S4 discussed the issues discussed by delving into the attributes of unintended use, understanding user interactions using the wash basin, making evaluations and considerations of existing technical and ergonomic solutions for wash basins as initial idea generation. During the abstract stage, S4's movement focused on discussing existing products by making basic comparisons of conventional wash basin shapes. At the semi-concrete stage, S4 began to plan technical, ergonomic and material suitability solution strategies through continuous sketching activities. The development of S4's thinking moved to the concrete stage by focusing on validating the design idea in more detail. For the reflecting activity, S4 spent 39% in total. During the abstract stage, the contemplation activity included reflection on the phenomenon, observing video demonstration (mediator 1), interacting with artefacts and artificial objects (mediators 4 and 5) four and five times respectively.

In addition, S4 reflected on his own experience and provided design solution suggestions through technical, ergonomic and material aspects. Towards the semi-concrete stage, S4 framed the existing problems a lot while providing solutions through idea sketches. Next, for the concrete stage until the end of the VPAE session, S4 showed reflection on the UHBE attributes and improved the design concept in detail based on user needs and problem solving. While for the framing activity (13%), overall S4 only spent time framing the problem and determining design suggestions at the abstract and semi-concrete stages. The remaining 5% of the design activity period was spent on naming by identifying the basic components of the wash basin and the suitability of the material at the abstract and semi-concrete stages. Overall, S4's design activity was greatly influenced by his own experience of using a wash basin to bathe his child (refer to Figure 4.81 on the next pages).

Figure 4.81 Part of S4' Reflective Practice Activity based on Design task given

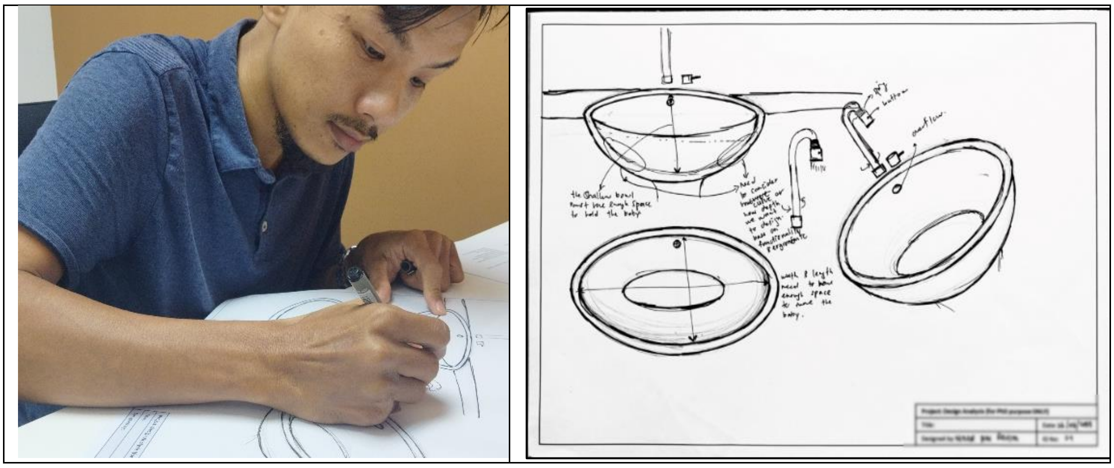


Figure 4.82 Design Sketching based on S4' Interpretation on UHBE Attributes towards Washbasin in VPAE3 Experiment

Based on the design activity recorded for S4 (see Figure 4.81 and Figure 4.82), designers employ a structured approach to establish design standards, technical requirements, and ergonomic considerations. This activity indicates that S4's design process aligns with a normative approach, emphasizing industry best practices, ergonomic principles, and adherence to established design guidelines. This conclusion is drawn from S4's focus on standardization, usability optimization, and material selection to adhere to best practices in wash basin design. At an abstract level, S4 reviews conventional wash basin designs by comparing their forms and usability in various settings. At a semi-concrete level, S4 develops the technical framework using perspective sketches and ergonomic features that ensure adequate space for babies to lie down, that the equipment is safe to handle, and that the water supply functions properly. Moving to the concrete level, S4 refines the design based on anthropometric data, material durability, and installation feasibility. These characteristics reflect industry practitioners' commitment to practical standards and established practices.

However, S4 also adopts a reflective and analysis-synthesis approach. The normative approach is most common, but reflection is an important part of figuring out how the user will experience the design and what its limitations are. This makes sure that the final design meets functional and ergonomic standards. S4 uses an analysis-synthesis strategy, where the analysis phase looks at how useful the wash basin is, and the synthesis phase makes structured technical improvements based on that information. S4 systematically examined the usability of conventional wash basins and synthesized new design elements to enhance compliance with safety and ergonomic guidelines. In conclusion, S4's design activities were primarily normative, emphasizing industry standards, usability optimization, and material selection. S4 made sure that the wash basin design followed useful, safe, and standard design rules by using structured problem analysis, ergonomic assessment, and technical refinement.

As previously mentioned, the senior category consisted of seven respondents who participated in the experiment, with each respondent's activity evaluated as outlined in S4. Figure 4.83 graphically illustrates the comparison of reflective practice episodes, revealing the abstraction levels of the seven senior designers. The data for this category indicates that the designers balance on abstract, semi-concrete and concrete activities throughout the VPAE3 session, slightly different for categories Junior and intermediate. Additionally, as presented in Figure 4.83, this study provides an overview of the analysis concerning the transition point patterns for abstraction levels, alongside reflective practice activities, highlighting the transition patterns among the seven senior designers. To conclude, senior designer spends more balances on abstract, semi-concrete and concrete level to understand, to frame and integrated ideation into sketches. Figure 4.84 illustrates the transition points for the designers, comparing abstraction levels with reflective practice activities for the senior category.

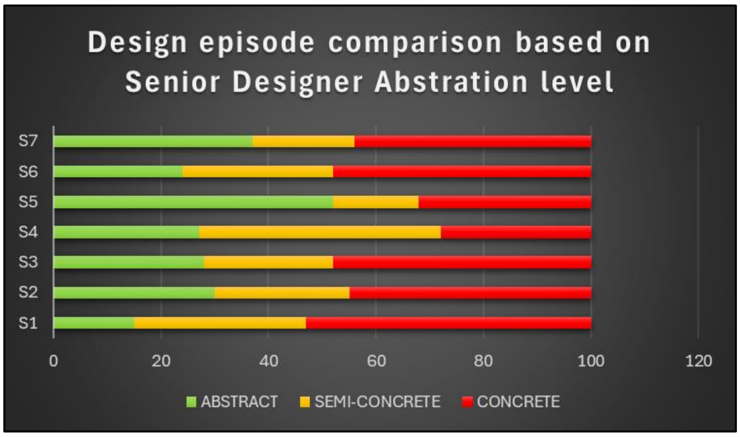


Figure 4.83 Comparison of Design Episode based on Senior Designers Abstraction Level

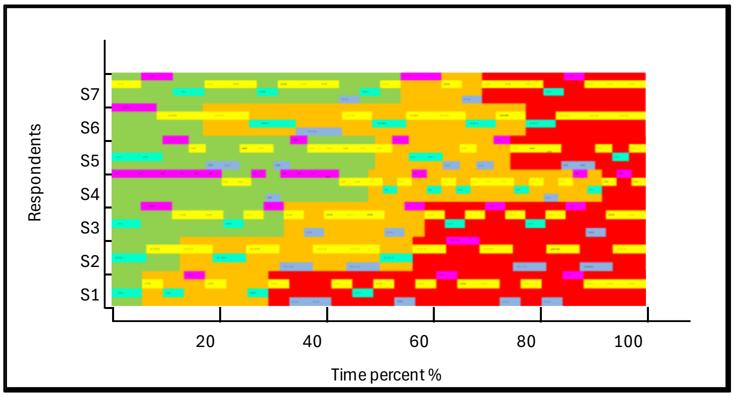


Figure 4.84 Illustration of Seniors' Transition Points (Abstraction vs Mediators Interaction)

Expert Designers' Reflective Practice

As explained in section 3.6, the Expert designer's category respondents consist of individuals with working experience in the design industries for 20 years and above. Figure 4.85 shows the transcription of the protocol by designer E3 who is a student of sanitaryware product design at Goucera Sdn. Bhd. The transcription of the protocol by E3 describes the entire conversation and reflection during the VPAE3 session, which is a design activity in resolving issues that arose in the design of mainstream wash basin products based on the tasks given by the researchers. Designers E3 has spent 17 minutes and 2 seconds for the experiment, which separately into three levels of abstraction: 6 minutes and 29 seconds spent on the abstract level, 5 minutes and 35 seconds spent on the semi-concrete level, while 6 minutes and 28 seconds spent on the concrete level.

E3 Subject: (Expert Designer)
Date of VPA Session: 3rd August 2023

Time / Abstraction level	Transcription of the Protocol	Designer activity: Thematic Category	Designer Reflective practice			
			Naming	Framing	Moving	Reflecting
00:01	………Observed phenomena	Constructing information				RPh
00:13	……*Artifact interaction*	Constructing information		FP		
02:26	Well today I'm going to make a little observation about the *wash basin* used as a baby bath.	Constructing information				RPh
02:39	So I'm here, I can tell you if we look out there, there are types of *wash basins* of the top *and* stand *types*. *Rectangle*. It's normal to have one with *a pedestal*, *without a pedestal*.	Constructing information		FP		
02:57	Then the *shape* is *oval*, *there is a semi-round* pound. If it is round, it is usually *rectangle*. And the *top* is usually on top, Ok, *rectangle*…	Sketching			GI	
03:30	In terms of *safety*, criteria, if I am a designer, number one is important to me from *functionality. My functionality* is more *ergonomic*. How is the baby's position appropriate, the suitability of the baby's position in the *wash basin* .	Sketching		FG		
03:46	……………Artifact interaction	Sketching			GI	
03:52	Maybe we can add *something* that can make *it open*. If we look at the *design of the ceramic basin*, sometimes we are not sure of the *safety*, *chipping* or *cracking*, or that can cause injury to the baby.	Sketching			S	
04:12	If possible, we *can add* others for example we make *seats*.	Sketching		FS		
04:20	Then we look at the *material*, we will *decide* later.	Constructing information	IM			
04:30	Then in terms of manufacturing, I prefer to think about *costing* in terms of making machines. If we want to *supply* to the community, we have to calculate *the cost* because there may be some who are less capable. So I prefer *the cost of production* to include the capital for us to produce *basins*. Even though we know in terms of production, they will follow *the volume* of production. So it will determine the reason why in the latest ceramics, I can say that the *price* for *electricity* for *natural gas* is getting higher. In my experience, we allocate approximately 1 million per month for *natural gas*. So cost for *production* has taken into account.	Sketching				Rex
05:30	And also *production capilibity* according to about *production capability*. This means that in the process of making ceramics, I like to see the *firing process*. Where is the process for making *this sanitary* product , I like that it uses *a long tunnel kiln* and has certain wagons. And it has a *cycle* in about 40 minutes in each carriage. *The overall length of the kiln* is about 100m, so *we take into account* the cycle in *the* kiln.	Sketching				REx

06:18	So I think to make *a shape*, I prefer it for *this baby* to be more *ergonomic*, more of a wider one..	Sketching			**DDc**	
06:22	I like the *more square* one, like *a lab* with taps. *The outlet* must be in *the center,* and *the overflow* is in this section. Okay, *overflowing*.	Sketching			**DDc**	
06:30	……………………(*sketching)*	Sketching			**S**	
07:17	Then in terms of he has this *water tap*, today's *water tap* he has cold water hot water. So from the *functionality* that we can make is that we will *design something*.	Constructing information	**IC**			
07:52	We can sketch one thing that we call it, I'm just arguing... ok.	Sketching			**S**	
08:08	Then then in terms of he has this *tap*, this *water tap* he has a long *square* he likes to say, which is like *a kitchen*, he is *a spectacle*.	Sketching	**IC**			
09:52	……………*(perspective view)*	Sketching			**S**	
10:48	Ergonomically, height also needs to be taken into account. Usually for an ordinary adult in 800mm is reasonable. To allow them to do their daily work *so far from top,* we mention *reasonable*.	Sketching				
11:22	We can add it *to the list* if there is *any additional material*.	Sketching	**IM**			
11:25	……………………*(detail design)*	Constructing information			**DDc**	
11:28	*Safety*, in addition, means he can *insert in*. That means he can be varied, if he doesn't want to, if he has one he can put *add in this water tap*. If there can be *hot and cold*, because now there are children who prefer hot baths, rainy season, hot weather.	Sketching				**RA**
12:02	………………………*(final touch sketches)*	Sketching			**S**	
12:13	We also have to see where to install this, houses, hospitals, *shopping malls, water parks* and *etc*. Sometimes we also have to take into account where this product can be used, sometimes we can't *just be specific* at *home* . So there two *functions* . Sometimes children want to defecate, use this thing, not just bathing.	Sketching				**CS**
12:45	*The outlet* if it follows *the dimensions* that he gives the *Malaysia Standard* is set in 100mm, to 80mm, more or less for *this* outlet.	Constructing information	**IC**			
12:57	If he is only about 10-15mm he has this *overflow*. *Overflow*, because if he is on the wall he will overflow back here, get it, I think that's all, *simple*, I think more *spontaneous* things like this.	Sketching				**RP**
13:12	If in *real life*, if we *are manufacturing*, he always *talks about it*. Maybe how much does it cost us to sell, if it costs us 100 ringits, we want to sell 200 ringits, maybe we want to *target*, our target greetings..., mothers who have just given birth. Sometimes you want to spend a lot of money, so that's taken into account. In addition, *safety* is also very, very important. Sometimes if you look at the shape that has *flow*, it's safe, but because maybe it also has a special standard, *so* we have to take that into account. Because sometimes he has the type that *wall hung* has. Sometimes he's just like this. *So* take it into account. I think in terms of shape we don't need to change, because he has enough depth, maybe he has the *depth*, he has, and in terms of his breadth.	Constructing information		**FS**		
14:14	*The depth* here is in 200mm, but it doesn't reach here, usually in 50mm approximately... Tolaj 50, about 155mm that's how he has depth. Of course, there are a lot of things that are going on here, but I don't think there is a way to do that , so I think it's a good idea. And for the type without *a pedestal* he is on the *counter*. It's like a sleeping bill, ok he's on top, this one is usually like *a lab*, these labs are more suitable, so I think maybe there is *a material that* we can use maybe for, but he has *water resistance*. So it's waterproof, *rubber type...*, then it *functions* can *move in out.* He can remove it, then for other *functions*.	Constructing information			**DDC**	
15:24	Sometimes it's R&R, the hospital has room to change diapers, sometimes it has a *seat* to put it, it wears like *the*	Constructing information				**RA**

	PU, to be soft. But there are many functions. So I prefer to think about it. *Basic design*, then in terms of *production* if we *produce*, this is easier, from this square is easy, they will lie down and *firing*. In a carriage. But sometimes he will *bend down*, that's why the process also needs to be taken into account...*We have* 10 units, 8 *rejects. So that's why* we want to achieve productivity. How much does he want, so that also needs to be taken into account... He wants to minimize his flaws. Sometimes, *this is* the kind of thing that makes a lot of sense. Sometimes a lot of *bending*, a lot of *cracking*... A lot of breaks. That one is very, very berlaku.so if this child's bath, if it breaks, he can get hurt, he is sharper, because he is thick. Ok					
17:02	I think it's a little simple, yes. Meet the requirement....	Sketching			S	
		Frequency of Effective Design Activity	**16%**	**16%**	**42%**	**26%**

Figure 4.85 Summary of Designers' Reflective Thinking and Interaction on Influence Mediators for E3

Based on the transcription, E3 spent most of the time at both the abstract and concrete levels of analysis. At the abstract level, E3 began by observing the phenomenon (RPh) through Mediator 1 and then interacted with Mediators 4 and 5 for approximately 2 minutes and 25 seconds. During this period, E3 was observed framing the assigned problem (FP) through body gestures. The think-aloud session started at 02:26, where E3 identified various types of washbasins available in the market, including top-mount and pedestal models (RPh). Additionally, E3 highlighted commonly used shapes such as rectangular, oval, and semi-circular, responding to Mediator 4 to determine a suitable design based on personal perspective (GI). During this phase, the early draft of sketches indicated that E3 suggested a square shape as the most significant design form (FG). Subsequently, between 03:30 - 04:12, while moving a sketching (S), E3 emphasized the importance of product safety and functionality, prioritizing ergonomic aspects, particularly the proper positioning of the baby within the existing washbasin (GI). E3 expressed concerns regarding the risks associated with ceramic materials, especially the potential for cracks or chipping, which could pose safety hazards to the first user and second user. However, as a solution, E3 proposed the addition of a built-in seat within the basin (FS) to enhance support and comfort for the baby by using an appropriate material (IM). In the final minutes of the abstract level (04:30 - 06:29), E3 reflecting to concerns regarding cost efficiency and production feasibility. E3 acknowledged that the unintended use of washbasins might result from financial constraints among consumers (REx). Therefore, E3 emphasized the need to develop a cost-effective and affordable design, addressing UHBE attributes. At this abstract level, E3 primarily recorded observations and provided a simple perspective draft sketch of the proposed washbasin shape (DDc).

At the semi-concrete level (06:30 - 11:24), E3 move to consider design aspects (S), including ergonomic shape and water tap design (IC). E3 suggested a square-shaped washbasin with a centred drain hole and overflow, ensuring optimal functionality and efficient drainage. Additionally, E3 recommended the integration of hot and cold water taps to meet the needs of users who prioritize temperature control when bathing their babies. At 10:48 - 11:24, E3 expressed opinions regarding additional materials (IM), height ergonomics, and installation versatility, suggesting an optimal washbasin height of 800mm to ensure comfort for adult users (S, GI). At the concrete level (11:25 - 17:02), E3 asserted that the proposed design was based on the unintended use of washbasins (RA, DDc). Therefore, E3 also proposed alternative installation locations beyond residential settings, such as hospitals, shopping malls, and water parks, emphasizing the importance of a flexible and multi-functional design (CS).

Several key design elements were reinforced through E3's sketches (S, IC) around 12:02. Between 12:45 - 15:23, E3 focused on Malaysian standards, particularly standard dimensions and additional safety features (RP). E3 also suggested soft, water-resistant materials such as rubber to enhance safety and provide modular functionality for greater adaptability (FS). Based on the progression of E3's ideation sketches, the concrete level demonstrated E3's highest level of design assertion, with emphasized shapes highlighted through repeated bold sketch lines (DDc). E3 proposed a new product concept incorporating maximum ergonomic features, which was considered essential to achieving the intended product function based on the discussed phenomenon (RA). The interview concluded with reflections on production challenges and safety considerations (15:24 - 17:02). E3 also addressed manufacturing defects in ceramic production, such as bending, cracking, and breakage, which could compromise product quality, durability, and safety. Special attention was given to mitigating injury risks caused by sharp ceramic fragments (S). Overall, the VPAE3 session with E3 provided a comprehensive evaluation of the washbasin design, integrating ergonomic, functional, safety, and production considerations to strengthen future product development. The sketching and reflecting activity of the VPA session of Designer E3 ended at 17:02.

According to the frequency of effective reflective practice recorded for E3, the results indicate 16% for both naming and framing activities, 42% for moving, and 26% for reflecting. Based on this percentage, the primary activity performed by E3 was moving (42%). During this activity, E3 analysed the issues discussed by understanding user interactions with the wash basin, making assessments and evaluations of the technical solutions present in the existing product through design sketches. At the abstract level, E3's movement focused on discussions about existing products, whereas at the semi-concrete level, E3 began to delve deeper into user issues and plan technical, ergonomic, and material suitability strategies. E3's thought process progressed to the concrete level, where the primary focus was on generating more detailed and specific design ideas. For the reflecting activity, 26% of the total session was dedicated to this process. At the abstract level, reflection activities involved assessing the phenomenon, observing video demonstrations (Mediator 1), and interacting with artifacts (Mediator 4) and an artificial doll (Mediator 5). Additionally, E3 also reflected on user experiences and proposed design solutions based on ergonomic aspects and the productivity of the existing wash basin. Moving into the semi-concrete level, no reflecting activity was recorded for E3. However, at the concrete level until the end of the VPAE session, E3 demonstrated reflection on UHBE attributes and refined the design concept in detail based on user needs and identified problem resolutions. The remaining design activity time for E3 was allocated to naming and framing, each accounting for 16%. During the VPAE session, the naming process occurred when E3 identified differences in the types and materials of washbasins available in the market.

At the semi-concrete level, E3 focused on naming design components, additional functions, and suitable materials to create a safer and more comfortable washbasin for User 1 and User 2. In the framing activity, E3 concentrated on considering design issues at the abstract level and spent a short amount of time at the concrete level to formulate design concept proposals. Throughout the session, two instances of problem identification were discussed, one solution proposal was presented, and one solution verification was conducted to ensure that all considerations were carefully recorded and considered. Indirectly, the repetitive problem considerations helped E3 understand the real context of unintended use, as discussed during the VPAE1 session, ultimately leading to the creation of a new product experience. Figure 4.86 illustrate the VPAE3 session of the E3 expert designer from camera 3.

Figure 4.86 Part of E3' Reflective Practice based on Design task given

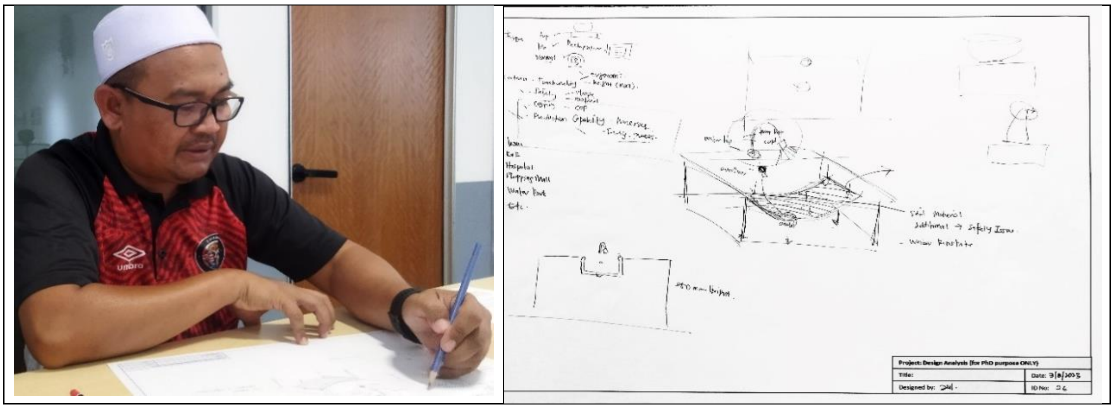


Figure 4.87 Design Sketching based on E3' Interpretation on UHBE Attributes towards Washbasin in VPAE3 Experiment

We examined E3's design activities (see Figure 4.86 and Figure 4.87) and found that the respondent utilized both a problem-solving approach and a reflective approach in his conceptual design work. The problem-solving approach is evident in E3's focus on analyzing user interactions, evaluating each technical solution, and iteratively refining the design. This approach is structured, involving problem identification, research, ideation, and solution validation activities. For E3, the problem-solving process encompasses (1) assessing how users engage with the product, identifying design issues, and evaluating technical solutions; (2) enhancing the design over time through structured problem-solving sketches and strategies; and (3) adhering to a model of identifying problems, evaluating them, and developing structured solutions. Regarding the reflective approach, E3 dedicates the design session to reflection by analyzing user experiences, evaluating existing products, and refining the wash basin design based on ergonomic considerations. On an abstract level, E3 engages in discussions about current products, noting differences in wash basin shapes available in the market, types of materials, and their primary components (naming and framing). On a semi-concrete level, E3 deepens the analysis of user issues and begins to formulate technical, ergonomic, and material strategies. At the concrete level, E3 focuses on generating detailed designs that reflect the attributes of UHBE while refining the final design concept. E3 employs a reflective approach that includes three aspects: (1) examining user experiences through video demonstrations and interaction artifacts; (2) contemplating ideas at both abstract and concrete levels to enhance clarity and usability; and (3) considering recurring issues. In conclusion, the design approach utilized by E3 combines problem-solving and reflective methods. E3 aims to ensure that the final wash basin design is user-centered, ergonomic, and technically feasible. The structured processes of naming, framing, transferring, and reflecting enable E3 to develop product solutions with careful consideration, safety, and effectiveness.

As previously mentioned, the expert category consisted of five respondents who participated in the experiment, with each respondent's activity evaluated as outlined in E3. Figure 4.88 graphically illustrates the comparison of reflective practice episodes, revealing the abstraction levels of the five expert designers. The data for this category indicates that the designers concentrate on abstract and semi-concrete level throughout the VPAE3 session, totally different from three categories discussed earlier. Additionally, as presented in Figure 4.88, this study provides an overview of the analysis concerning the transition point patterns for abstraction levels, alongside reflective practice activities, highlighting the transition patterns among the five expert designers. To conclude, expert designer spends more on abstract level to understand, to frame and integrated ideation into sketches. Figure 4.89 illustrates the transition points for the designers, comparing abstraction levels with reflective practice activities for the expert category.

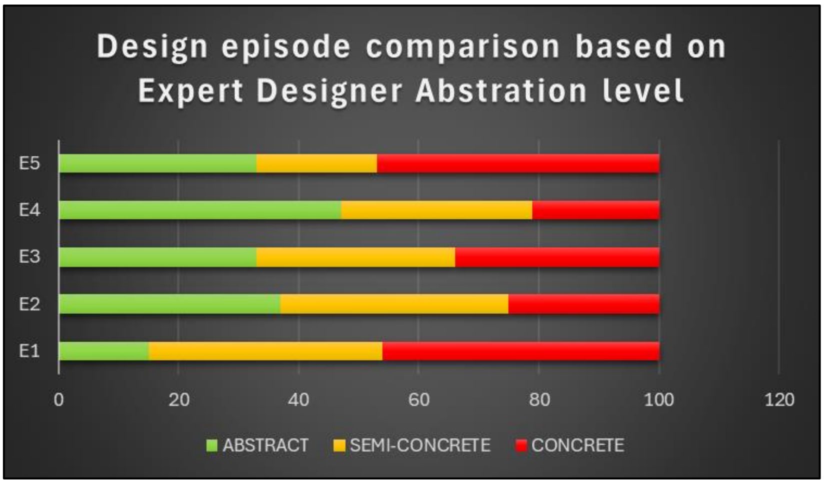


Figure 4.88 Design Episode Comparison Based on Individual Performance of Expert Designers' Abstraction Level. The Performance Measure by Percentage of Each Level

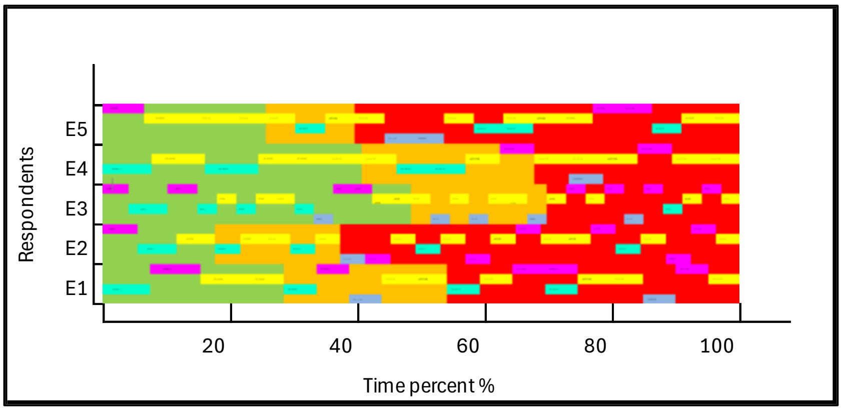


Figure 4.89 Illustration of Experts' Transition Points (Abstraction Vs Mediators Interaction)

Summary of Designers' Reflective Practice

This research has accomplished its second purpose by examining designers' reflective practices in the VPAE3 experiment, specifically assessing their responses and interpretations of unanticipated human behaviour throughout conceptual design activities within the design protocol experiment. This study utilises sketching activities to elucidate designers' creative processes, while Visual Protocol Analysis (VPA) is applied as an observational tool to evaluate each designer's conduct. In the observation phase, designers are required to create sketches of conceptual concepts, utilising their comprehension, analysis, and reflection pertaining to the subject of research (PBA pictures). The data collected from these observations are subsequently evaluated with Schön's (1983) theoretical framework of reflective practices, in conjunction with the mechanisms of reflective practice suggested by Valkenburg and Dorst (1998). The analysis findings are delineated according to Hassen and Andreasen’s (2002) stages of abstraction: (1) abstract level; (2) semi-concrete level; and (3) concrete level.

The researcher found that analysing design activities and designers' behavioural patterns, in relation to the four mechanisms of reflective practice, provides valuable insights into their thought processes during conceptual ideation. The study demonstrates that the designers comprehend the foundation of the main conceptual framework, which centres on unintended human behaviour interactions with popular items. To differentiate the designer’s approach in design practice, Junior designer spend more on abstract and semi-concrete level, while intermediate designer spend semi-concrete and concrete level to understand, to frame and integrated ideation into sketches. Meanwhile senior designer spends balances on abstract, semi-concrete and concrete level, while expert designer spends more on abstract level to understand, to frame and integrated ideation into sketches. The designers can express their insights regarding the attributes of UHBE interactions. The researcher also discovered that the designers have adequate skills to perform critical analyses that reveal the 'incongruities' in the behavioural interactions depicted in PBA photos, considering how these interactions may significantly contribute to increasing product value, supported by mediator resources.

Furthermore, the designers adeptly formulated particular 'criteria' elements from their verbal articulations. The designer has suggested specific criteria for incorporating the UHBE attributes into both new product concepts and existing products. These criteria include: (i) square form, (ii) elliptical form, (iii) a replication of the 'fetus' form, (iv) a soft finish, (v) a tall form, (vi) functionality for hot/cold water, (vii) a flexible faucet, (viii) curved edges, (ix) easy cleaning, (x) compartments, and (xi) hard materials. Based on these elements, the researcher has identified three key components: (i) functionality, (ii) form, and (iii) material and finish, as illustrated in Figure 4.90 on the next pages. This set of criteria will serve as a guideline for the design format analysis test in the subsequent section. However, the designers' capacity to realise the performance outcomes varies significantly, influenced by differing levels of expertise among the designers and the nature of the tasks assigned.

Upon doing a critical analysis of the study, the researcher found that designers may develop a framework for the design task, pinpointing key issues that connect the design process with the design task in certain situations. Conventional design techniques frequently neglect these components (Schön, 1983). The researcher noted that designers identify design issues through diverse sketch representations of scenarios, functioning as an experimental modality; this corresponds with Schön's notion of "frame experiments." Moreover, it was observed that designers deliberately delineate the design problem, expressing the pertinent elements they confront and contemplating the results within this context, or "operating within this framework." In the sketching activity, the researcher noticed that designers create their worldviews through personal experiences, aided by mediators and the practice of "moving test experiments," which encompass both action and reflection. This method aligns with Schön's (1983) foundational structure of reflective practice activities. This study provides a broader viewpoint on identifying unintended behaviours and integrating human involvement into the product concept development process. The researcher asserts that design practitioners, educators, and students must critically analyse all tiny factors that affect human interaction and behaviour, including unintended actions. By employing this methodology, designers will improve their capacity to harmonise human values and experiences, hence facilitating the development of unique design solutions.

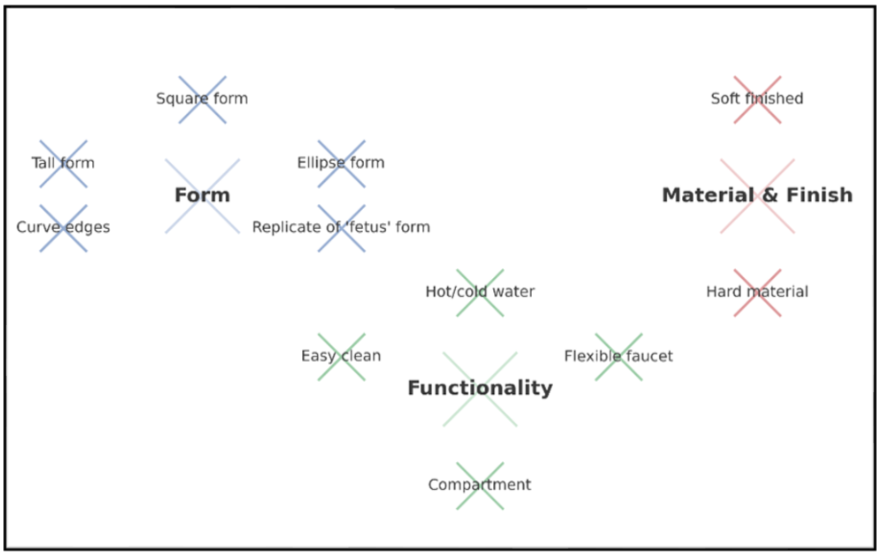


Figure 4.90 Design Criteria Pattern for New Product Concept Incorporating UHBE Attributes Based on Designers Proposed for Subject of Research (New Product Concept of Wash Basin Design)

4.6 Design Syntactic Analysis: An Experiment of Design Entity

As explained in Chapters Two and Three, the DSA was conducted with the aim of investigating and evaluating the understanding of UHBE in mainstream products based on the criteria established by designers. It was also implemented to test the capability of the UHBE conceptual framework in terms of usability and applicability in transforming unintended situations into intended purposes through design tasks carried out by designers during the VPAE1, VPAE2, and VPAE3 episodes (designers' responses in the VPA study and reflective practice analysis). Technically, the design syntactic analysis experiment aims to answer the third research question: "How does understanding unintended human behaviours lead to meaningful conceptual design, inclusive design solutions, and maximizing the value of products?" In summary, it examines how the attributes of UHBE in mainstream products can be implemented and utilised by designers to generate more innovative conceptual ideas that meet users' needs. Nevertheless, the primary concern is to determine empirical evidence that helps to understand the significance of the study and supports the findings of the VPA study and reflective practice analysis. In this research, the researcher aims to verify whether the phenomenon of UHBE in mainstream products is feasible by conducting a DSA experiment on sample idea sketches from representatives of each designer group in this study. Therefore, based on the DRM by Blessing and Chakrabarti (2009), the usability and applicability of UHBE in everyday products will be investigated by master's students in Design Technology using the design syntactic analysis framework on five conceptual design ideas (from the VPAE3 episode) of four level of designers. Figure 4.91 shows the stages of implementing the DSA in this research.

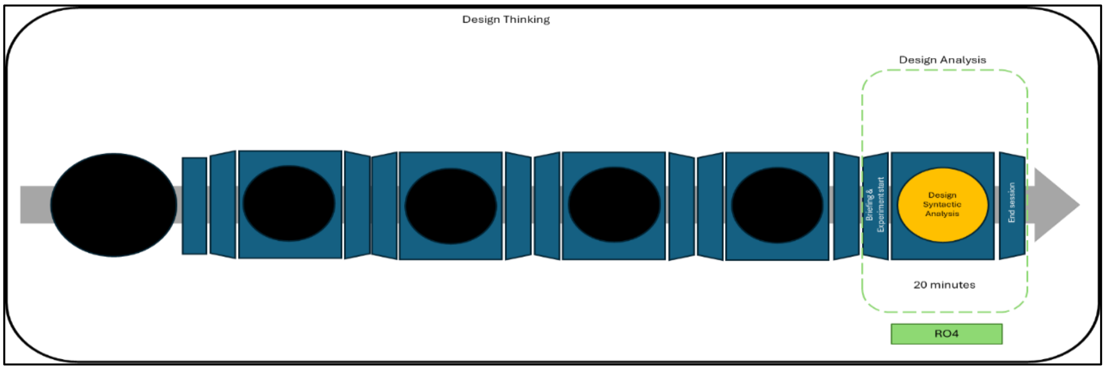


Figure 4.91 Fragmentations of Design Syntactic Analysis begin after Preliminary Fieldwork Study, and Photo-based Research Analysis, Verbal Protocol Analysis Episode

In Chapters Two and Three, the researcher critically discussed the theoretical framework of design syntactic analysis, including the background issues of form analysis, the motivation for framework development, contributions, and discussions based on previous literature. Warell (2001) emphasised that there are at least four form entity levels to describe form entities, communicative functions, characteristic form elements, and the superimposed aesthetic organ. These four levels can be identified based on the following hierarchy: (1) The Superior Gestalt – represents the highest hierarchical (global) level in product form analysis (external shape), (2) Characteristic Shapes – refer to prominent form elements that are integral to the product's function and aesthetic appeal (internal shape), (3) Significant Curve – identified as a component distributed throughout the product (product component), (4) The Fifth Element – refers to unique, often subtle design features that serve as brand identifiers or convey specific symbolic meanings (brand symbolism). In summary, the Design Syntactic Analysis (DSA) experiment on designers' conceptual designs examines the consistency of form, functionality, and design format, which can be summarized as follows:

(1) Form functionality – addresses the notion that every visible surface of a product serves a function (whether structural, ergonomic, semantic, or aesthetic).
(2) Form syntax – describes how the product form is organised, both at the broader organ level (e.g., the overall shape of a chair) and at the detailed material-physical level (e.g., stitching, edges, or surface texture).
(3) Design format – relates to a broader design philosophy at the brand or company level, where the consistent use of form elements conveys a recognisable identity across different products (Warell & Nåbo, 2000).

In simpler terms, this experiment was conducted to achieve the following objectives: (i) identify and analyse the functional content of the product concept, (ii) identify the consistency of form entities and design opportunism, and (iii) analyse the design format of the conceptual product. The implementation of this DSA experiment can help designers enhance their design thinking parameters while testing the feasibility of the new product concept through the expanded potential of UHBE in this research.

4.6.1 Material, Tools, and Devices

In the DSA experiment, several equipment, materials, and technologies were required for testing the design entities. The following is the list of requirements used in the DSA, as described in Table 4.27.

Table 4.27
List of Material, Tools, and Devices used in DSA Experiment

Material / Tool / Device	Roles in research activities
	Akaso Brave 7 Akaso brave 7 was selected as the main equipment in this study to visually record the entire process of designer sketches and conversations. During the procedure, the main camera was placed on the left side of the designer to get a full perspective of the VPA procedure especially during the sketching activity.
	Remax Voice Recorder Remax voice recorder was used to record the entire process with the designer. During the study, the voice recorder is placed near the designer to ensure that there is no noise of the external environment this can interfere with the conversation during the procedure. Sound recording for a long time with built-in Mic and external high-power speaker, built-in Lithium battery, can record continuously for 13 hours.
	Tripod A tripod is a portable three-legged frame or stand used as a platform for supporting the weight and maintaining the stability of video recorder.
	Pencil A pencil used for artistic sketching and drawing.
	Sharpie Marker A permanent marker or indelible marker is a type of marker pen that is used to create permanent or semi-permanent writing on an object.
	Sharpie Marker A permanent marker or indelible marker is a type of marker pen that is used to create permanent or semi-permanent writing on an object.
	Sharpie Marker A permanent marker or indelible marker is a type of marker pen that is used to create permanent or semi-permanent writing on an object.

As previously explained, four categories of designers were involved in the VPA study. However, for the DSA experiment, the researcher selected five representative design sketches (comprising one from each designer group) to be examined according to the established procedure. The following are sample representations of the five design sketches from each designer group that will be used in the DSA experiment. Figure 4.92 presents a sample of design sketches from the VPAE3 episode. During the experiment series, the respondents were also provided with an attachment from the PBA, which includes the four attributes of UHBE that were used in the VPAE1 experiment, as an additional reference (see Figure 4.92 on the next pages).

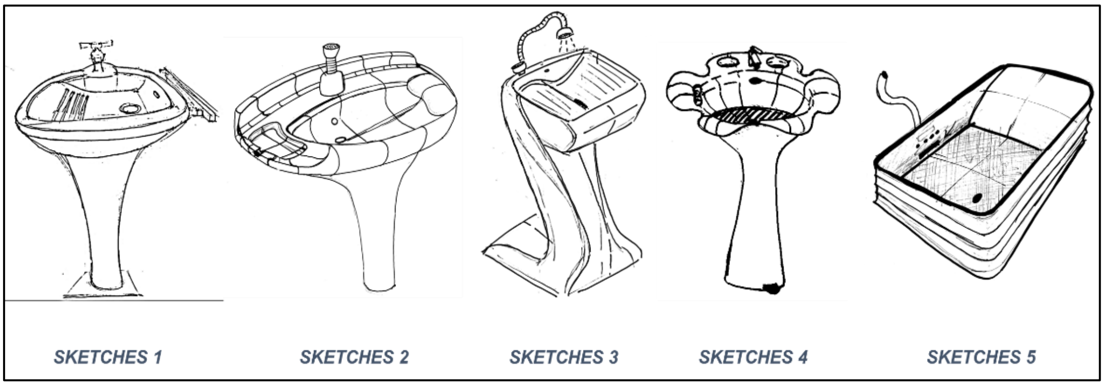


Figure 4.92 Selected Designers’ Sketches from VPAE3 Episode (From Left Sketches 1, Sketches 2, Sketches 3, Sketches 4, And Sketches 5)

4.6.2 Method of Sampling

As detailed in Chapter Three on study sampling, the DSA experiment employed snowball sampling as the sampling method, similar to the sample size requirements for the survey study and the VPA study. This method is particularly relevant for hidden populations that are difficult to reach (Noy, 2008; Breweton & Millward, 2001). Technically, snowball sampling involves using a small group of initial informants to nominate, through their social networks, other participants who meet the eligibility criteria and can potentially contribute to the specific study (McDormett, 2023). In this experiment, eight respondents, comprising postgraduate product design students, participated.

4.6.3 Data Collection and Process

In the design syntactic analysis experiment, the usability and applicability of UHBE in daily products will be examined using the design syntactic analysis framework. Technically, the conceptual design ideas produced by the designers, based on their understanding during the VPA study, will be analysed. The key element is to objectively determine and describe the components of visual form composition, such as shapes and their arrangements. Therefore, this process requires an extensive and systematic design syntactic analysis procedure, as illustrated in Figure 4.93. The purpose is to prevent respondents from any distractions during the analysis session and to ensure that the researcher has a clear understanding of the overall analysis process while maintaining the correct direction. Similar to the VPA study, the researcher must also ensure that the location and environment of the session are comfortable for the respondents. Consequently, the researcher intentionally conducted the analysis sessions in specific areas recommended by the respondents themselves, based on their personal preferences (e.g., private offices, living rooms, or meeting rooms). In this study, a total of eight postgraduate design students were asked to analyse four conceptual sketches (printed on A3-sized sheets in grayscale mode) that were generated from the VPA study. For reference, four polar images (printed on A4-sized sheets in grayscale mode) were also provided.

At the initial stage of the analysis session (see Figure 4.94), the experimental site was prepared by arranging the required equipment and materials (e.g., Camera 1 and writing tools). Once the experimental setup was complete, the researcher provided a briefing to the respondents about the experiment they would be participating in (e.g., the objectives of the experiment and instructions). In addition, respondents were asked to complete a personal descriptive form provided by the researcher, similar to the procedure in the VPA study, and for the same research purpose.

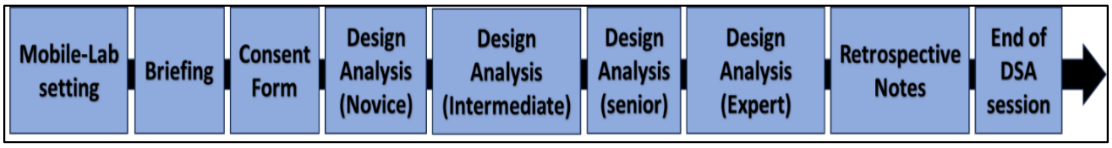


Figure 4.93 The Flowchart of the Experiment in Design Syntactic Analysis


Figure 4.94 Simulation During DSA Session

The design syntactic analysis experiment officially commenced when the respondents began analysing each conceptual sketch. However, since the four sketches were not generated based on a specific product brand, only three levels of form entities were analysed by the respondents using a set of different coloured pens, as follows:

(1) red pen to indicate the superior form level (external shape)
(2) blue pen to indicate the intermediate form level (form characteristics)
(3) green pen to indicate the lower form level (product components)

At the same time, the entire analysis session was visually recorded using Camera 1 as supporting evidence. Figure 4.94 illustrates the positioning of the respondents and the researcher during the actual DSA experiment, as suggested by Anwar (2016). The DSA experiment officially ended once all the procedures completed by the respondents. The outcomes of the DSA consist of two empirical evidence sources obtained from each session: (1) video recordings; and (2) sketch analyses, which will be used for further analysis in next section.

4.6.4 Design Syntactic Analysis Procedure

The purpose of DSA is to identify the relationship between designers' conceptual sketches and the UHBE phenomena in daily products, thereby creating opportunities for improving existing products. It aims to determine any changes or enhancements within conceptual ideas that have the potential to provide valuable design solutions or contribute to the development of better products. This analysis also involves examining the technical elements of design that are proposed or applied in the conceptual sketches, which are developed based on the designers' perceptions, analysis, and thinking during the VPAE3 episode. Therefore, DSA focuses on evaluating the designers' conceptual sketches according to their respective experience levels to assess the differences in the concepts presented. This approach helps identify form entities and potentials related to visual composition, functionality, and design format as outlined in syntactic elements.

As stated in Chapter Three, data collection for the DSA experiment relies on two primary sources: video recordings and sketch analyses. Hence, key information regarding designers' interactions during sketch analysis is recorded throughout the experiment. The raw video data from this experiment is processed using the VSDC Video Editor software to enhance video quality for research purposes. This step prepares the necessary tools for analysing the three levels of form entities using three sets of colored pens by the respondents. Additionally, the final video output will serve as a reference for further analysis. Figure 4.95 illustrates the raw video data editing process using VSDC (version 2024). Based on the processed raw data, the sketches produced by the respondents are critically synthesised according to the defined design elements. As a result, three sets of transcription analyses are generated from five conceptual sketches, which include: (1) transcription of direct functionality and design intent, (2) transcription of form entity analysis, and (3) transcription of single-family product design format analysis.

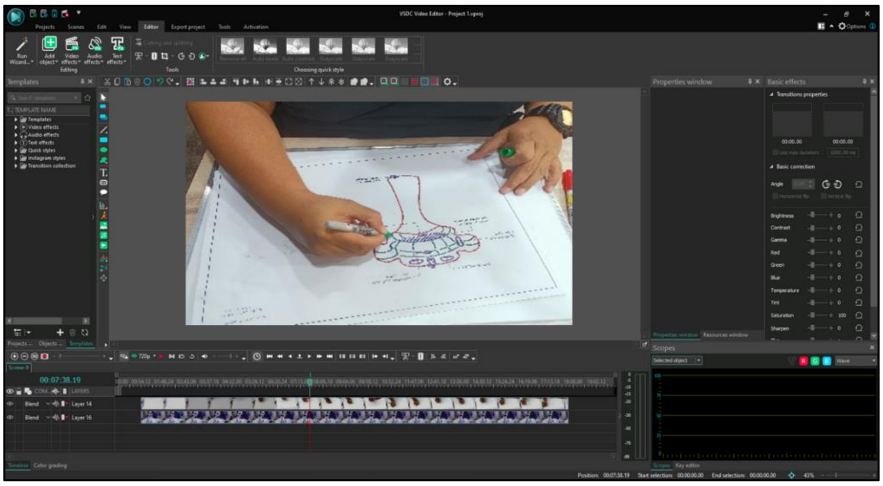


Figure 4.95 Screenshot of DSA Video Editing using VSDC Video Editor for Sketches 4

Form Entity Analysis

In this experiment, the form entity analysis transcription provides crucial information about the form entity elements produced by respondents based on the five conceptual product ideations selected from the VPAE3 study. In this analysis set, the form entity elements were evaluated, tracked, and distinguished by the respondents according to their respective levels (based on the assigned colour codes). All respondents were given a detailed explanation of how the evaluation process was conducted. To avoid bias, the transcription process for form entity analysis was assisted by research assistants who were master's students. Figure 4.97 illustrates a sample of the form entity-level analysis transcription of the designers' sketch ideations. The transcription preparation process was carried out systematically, starting with;

(i) Scanning the five sketches from each respondent using MS Paint software. A total of 40 transcriptions were generated in this experiment. The purpose of the transcription was to digitize and preserve all sketch analyses for further examination and inclusion in the appendix.

(ii) All sketches were digitally traced using three colours representing the levels of form entities (organ levels): red (superior form), green (intermediate form), and blue (detailed form), as suggested by Warell (2001) and described in Chapter Three. The lines were retraced according to the respondents' analysis. The digitisation of sketches was performed using MS Paint software (see Figure 4.96).

(iii) After the tracing process was complete, a schematic table was drawn up to illustrate the transcription of the form entity analysis. As stated in section 4.4.2, a total of eight respondents were involved in the DSA experiment, which means a total of eight sketches were analysed (by design) as shown at the top of the schematic table. Figure 4.97 shows an example of the transcription of the form entity analysis results based on two main aspects.

(iv) Based on (iii), the transcriptions of form entity were tabulated in colour Red, Green and Blue (refer to Figure 4.97; section purple). The analysis of the form component is built based on visual characteristics (wash basin) according to three levels of form structure as stated in (ii). In this section, the main component and sub-component of the ideation as proposed by the designer in the VPAE3 episode were listed for consistency analysis of the form component (structure). The component and sub-component, including basin, pedestal, inner basin, drain hole, overflow hole, etc.

(v) The analysis of form structure comprises two elements, (i) consistency, and (ii) opportunistic element, which will be analysed by the respondent in order to determine the level of consistency of the form entity (for each design concept) (refer to Figure 4.97: section yellow and pink).

(vi) The analysis process was conducted using frequency distribution based on the results of the analysis from all eight respondents.

(vii) The consistency of the form entity for each conceptual sketch proposed from the VPAE3 experiment was determined by the most frequent data evaluated by the respondents.

(viii) The form entity procedure was repeated until all five sketch ideations were completed.

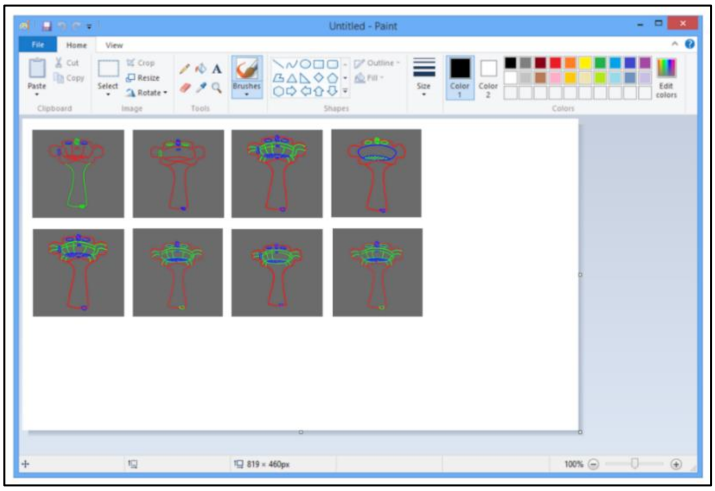


Figure 4.96 Sample of Trace Process Using MS Paint for Sketches 4

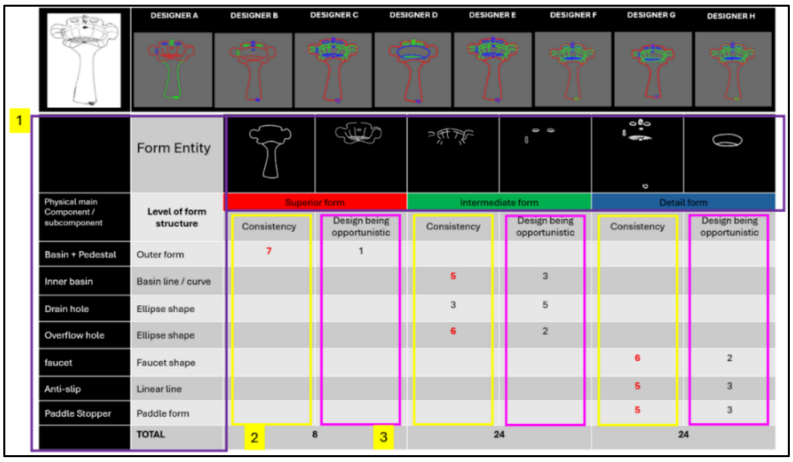


Figure 4.97 Sample of Form Entities Level Analysis Transcription for Sketches 4

In this study, form consistency and design being opportunistic show elements of consistency between the structure of the establishment of the appropriate form entity among the set of analyses by the eight respondents involved. In addition, the element of design being opportunity shows the element of the form entity that is embodied, offering innovative features in the design and recognition of new concept ideas. Warell (2001) emphasised that there are at least four form entity levels (superior gestalt/external shape, characteristic shapes/internal shape, significant curve/detail product component, and the fifth element/brand symbolism) used to describe form entities, communicative functions, characteristic form elements, and the superimposed aesthetic organ. However, the fifth element (brand symbolism) will be considered specifically for the design format analysis, which will be discussed in the following section.

Analysis Form Functionality

As explained in Chapters Two and Three, the analysis of form functionality based on Warell (2001) consists of two comprehensive mechanisms, namely: (i) Direct Functional Identification: A systematic class-by-class observation of structural, ancillary, ergonomic, semantic, and syntactic functions, each documented with visual evidence, and (ii) Design Intent Analysis: An investigation into the rationale behind each feature, structured in tabular form. In section 3.5.6, direct functional identification involves observing the product to identify functions from distinct classifications. The analysed item can be the product itself or an image, sketch, or cad model, depending on availability and size. The procedure follows the basic of three steps as follows:

1. Select the initial function class for analysis, such as structural, ergonomic, syntactic, etc. The objective is to examine all function classes; however, to mitigate complexity, each class is studied individually. This streamlines the analysis by constraining the search to a single function class at any given time.
2. Solutions are sought for the entire product or a subsystem, focusing on particular structural functionalities. The specified functions are documented, for instance, on an image of the product for future reference.
3. The subsequent function class is chosen, and the product is sought for functions in an analogous fashion. The identified functions are documented, and the process is reiterated for each relevant function class. Figure 4.98 shows an example of direct functional identification, which was adapted from Warell (2001).

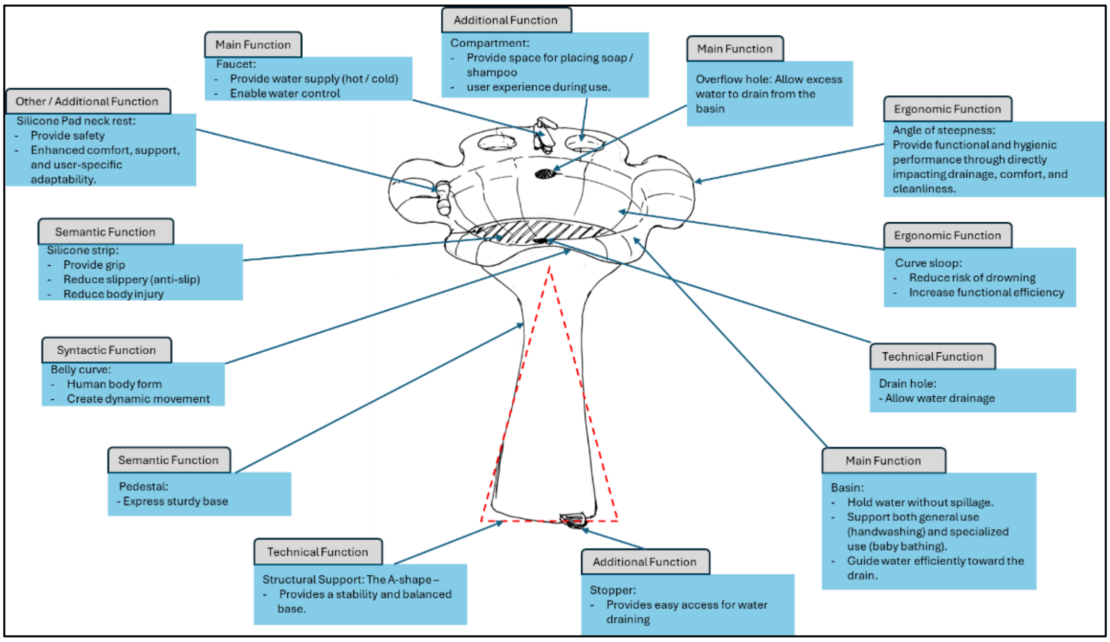


Figure 4.98 Sample of Direct Functional Identification for Sketches 4

Although direct functional identification provides a rapid method for gaining a functional understanding of the product, design intent analysis offers a more comprehensive insight into the design and its functional components. The technique can be systematized into a manual form-based instrument. Unlike direct functional identification, the product is examined segment by segment (or subsystem by subsystem) following the outlined approach (see Figure 4.98) As mentioned in Chapter Two, design intent analysis refers to an investigation into the rationale behind each feature, structured in tabular form:

1. Column A: "Why is this solution or feature present?"
2. Column B: Articulation of design intent.
3. Column C: Transformation to a simple verb–noun function statement.
4. Columns D–I: Classification of each function into a predefined category (Warell, 2001)

The following are the five steps of analysis for design intent, as proposed by Warell (2001), to evaluate the functional content and its classification of the product.

1. The analysis begins at the principal product level and thereafter progresses to the subsystem levels. The design intent is determined by asking, "Why is the solution/feature/mean present?" (Column A)
2. By articulating the goal (cause for existence) of the specific solution, the design intent is conveyed (Column B).

3. The goal is now articulated as a functional statement by posing the question, "What does the solution/feature/mean accomplish?" The function must be articulated concisely (Column C), ideally employing a single verb and noun in conjunction, in alignment with recognised function analysis methodologies (e.g. Landquist, 1994; Hubka et al., 1988; Jakobsen, K., 1990; Wikström, 2000). The identified functions utilising the direct function identification approach can be utilised as input in this phase.
4. In columns D-I, the function statement is then categorised according to the function classes (see Figure 4.99). Each function statement can be assigned to a one function class exclusively. Each subsystem may possess a singular primary function. (D-I)
5. The process from steps 1 to 5 will be repeated for each subsystem of the product until a satisfactory analysis is achieved.

Both functional evaluation methods, technical and aesthetic, are implemented through the establishment of a form-functionality classification as proposed by Warell (2001) but are flexible according to the needs and characteristics of the product to be evaluated.

CoL	A	B	C	D	E	F	G	H	I
	Question: "Why is the solution / feature / mean present?"	Purpose / Reason / Cause (design intent) "in order to..."	Function statement (verb + noun notation) "What does the solution / feature do?"	Main	Technical / Structural	Additional / Other	Ergonomic	Syntactic	Semantic
1	Why is a wash basin intergrated with baby bathe need?	...enable bathing baby from convensional basin in general bathroom	Support bathe feature	x					
	Basin bowl								
2	Why is there an opening in the top of wash basin body?	...provide a space cleaning, washing, and baby bathing.	Hold water			x			
3	Why is the cross section of the wash basin elliptical in shape?	...provide a versatile space for washing hands, face, or bathing a baby in a safe, stable, and hygienic manner.	Increase water flow efficient				x		
4		...create a visual composition in balance with other form solution	Refer form element (human gesture, dynamic movement)					x	
5		...facilitate using by occupying ample space when using	Fit / suit bathing activity				x		
6		...strengthen the visual impressing of the basin body	Express strenghtness						x
7	Why is the wash basin body made of ceramic?	...increase the durability of the appearance	Describe visual aging						x
8	Why is there a cutout concave curve surface of the wash basin body facing the basin	...guide water efficiently toward the drain.	Fasilitate water direction				x		
9	Why angle of steepness determint the effision of basin?	...provide water affordance into the drain hole.	Enable water flow				x		
	Faucet								

Figure 4.99 Sample Transcription of Design Intent Analysis

Analysis Design Format

Design format is a representation of form and design philosophy that encompasses style, identity, visual language, and stakeholder specifications to shape brand and market perception. According to Karjalainen & Snelders (2010), design format analysis is a qualitative method that can be flexibly applied to various design contexts. It is crucial for ensuring visual identity consistency of products and is closely related to aesthetics and brand image communication. Warell & Nåbo (2000) emphasised that design format acts as a template that determines form elements and their arrangement within a design language that differentiates a company's products from competitors. To analyse the design format, Warell (2001) proposed two categories of evaluation that can be applied to the type of product produced. The first evaluation is conducted on individual products, while the second method is performed in groups, commonly referred to as a 'family group.' In this experiment, the researcher established that the conceptual ideation evaluation by designers would be assessed using both methods to examine the strength of the proposed design ideas and to identify design characteristics that fulfil the UHBE context based on the criteria set by the designers during the VPAE3 episode. Among the criteria proposed by the designers for embedding UHBE attributes into existing products are: (i) square form, (ii) ellipse form, (iii) replication of 'fetus' form, (iv) soft finish, (v) tall form, (vi) hot/cold water, (vii) flexible faucet, (viii) curved edges, (ix) easy cleaning, (x) compartments, and (xi) hard material. In this experiment, the design format process for the conceptual ideation by designers is structured based on the format suggested by Warell (2001). Figure 4.100 presents a sample analysis of the design format for Conceptual Idea 1, analysed individually based on the main components of the study product (wash basin).

As previously explained, design format analysis is carried out to achieve a deeper understanding of the appearance of the product through the study of the form content and composition in a single product, product family or product series. It is the first step in creating a descriptive design format by examining the styling characteristics of the product, including visual form and composition of the solution. The following is the basic procedure for the steps of visual material distribution based on the structure of the components as described by Warell (2001) (refer Figure 4.100).

1. Major physical components (or subsystems) - Identify the total number of major components of a product design. In this case, a wash basin can be broken down into

4 major components, namely the basin, drain hole (strainer), overflow hole and faucet. All major physical components of the product are recorded in writing or with sketches.

2. Styling Features - Identify the styling features of the product form displayed, such as form elements, material treatments, colours, graphics, surfaces, confluences of shapes, curves, symmetry, shape relationships, composition and principles of balance, etc. These styling features represent the ingredients of the product design format. The identified styling features are recorded in writing or with sketches.
3. Scoring Format - For each physical part (or subsystem) of the product, the styling features are illustrated with coloured line sketches (red) that highlight the use of styling principles in each part consistently. The design format is assessed using a 2-point (black circle) and 1-point (empty circle) scale score for each consistent styling feature and the uncertain styling feature (based on the respondent's total ratings).
4. The procedure is repeated for each physical component or subsystem until all relationships are considered.
5. The scores in the format matrix column indicate the level of each styling feature (product part shape solution) that represents the element of consistency or "design being opportunistic", that is, the extent to which the product design format is "strong". The total score indicates the number of elements that the respondent has identified in this product design format analysis assessment.

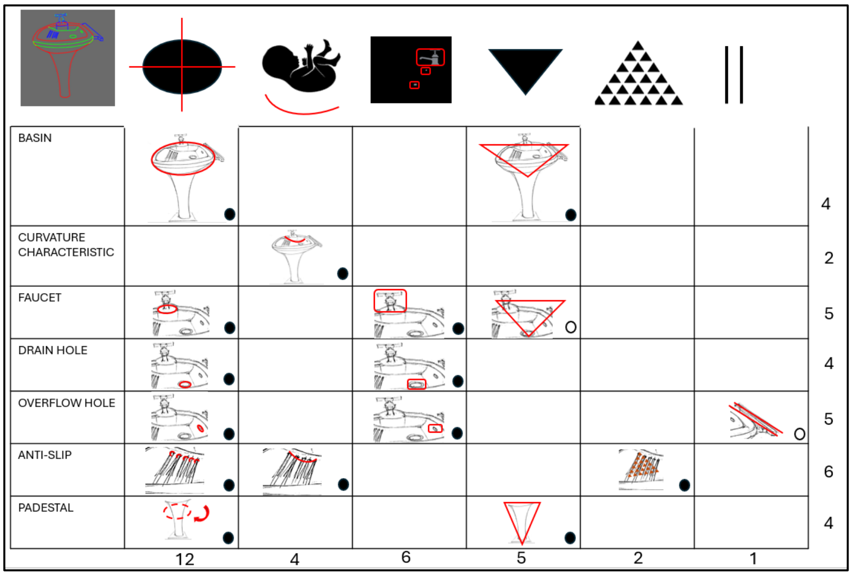


Figure 4.100 Sample of Individual Design Format Based on Designer's Design Criteria for New Conceptual Product Design (Sketches 1)

Figure 4.101 representation of a formatted design for a family series based on the DSA approach by Warell (2001), which focuses on mapping the relationship between form and function elements in the product design process. In this figure, five design concepts of washbasin (with baby bath features) were evaluated against eleven key design criteria determined by the designer, such as square form, ellipse form, fetus form, soft finish, tall form, hot/cold water, flexible faucet, curved edges, easy clean, compartment, and rigid material. The evaluation of each concept was done using a syntactic scoring system where a black circle indicates full fulfilment of the criteria (2 marks), while an empty circle indicates partial fulfilment (1 mark). The total score for each concept is displayed at the right end of the matrix, reflecting the extent to which the design meets the specified requirements. At the bottom, the numbers indicate the relative importance of each criterion based on the designer's preferences. This representation serves as a systematic visual analytical tool to support the process of evaluating, selecting, and reasoning about form in product design based on the syntactic relationship between form and function.

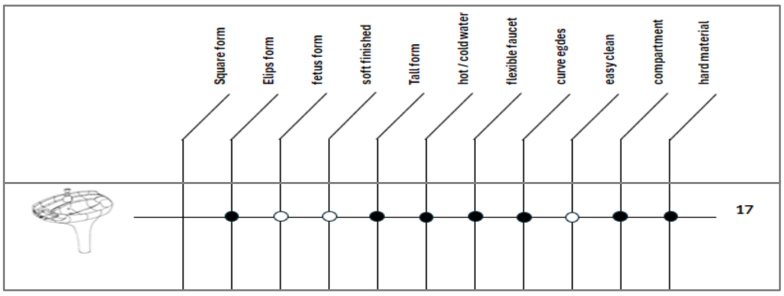


Figure 4.101 Sample of Family Design Format Based on Designer’s Design Criteria for New Conceptual Product Design (Family Series)

4.6.5 The Reliability and Validity of DSA Data Analysis

In the process of validating and evaluating research results in design science, many controversial issues arise, including the validation of approaches, hypotheses, the 'accuracy' of theories and models, the applicability of methods, among others. This situation is considered an obstacle to recognising design research methodology in the field of science [Buur, 1990; Jakobsen, 1995]. Since then, Andreasen (1994) suggested the following characteristics to ensure that research design is 'scientific' namely, (i) having a theory base (a system of logically related bits of knowledge valid for a domain), (ii.) being based on scientific methods for definitions, object identification, demarcations, for the creation of concepts, for modelling, and for proofs, and (iii) being based on considerations about validity and uncertainty.

The triangulation considerations can illustrate that research in the field of design science is considered scientific and 'valid'. Therefore, as explained in the previous section that the effort to obtain validity and reliability in design syntax analysis is through triangulation analysis. It is a holistic approach where data is being analysed through various sources. Creswell (2009) agrees that this method is the most popular among design science researchers to ensure internal validity and data verification. Reliability and validity of design syntax analysis is obtained through the approach of triangulating data from various sources including data from the third phase (VPAE3 experiment) of the research to ensure that all information or interpretations are also considered without compromise. The following are the data sources used for design syntax analysis, namely (1) VPAE3 transcription, DSA transcription; (2) DSA video data; and (4) DSA sketches analysis.

4.6.6 The Result and Discussion: The Applicability of Unintended Human Behaviour elements into design strategy through Design Syntactic Analysis

As outlined in Chapter One, the third research objective for this study is to develop an unintended behavioural design framework that integrates unintended attributes into the design development process and strategies. In other words, this research seeks to provide a comprehensive design model that integrates unintended behavioural design components into design activities and the design thinking strategy for creating new product designs while enhancing the value of existing products. Therefore, a design entity analysis is conducted to ensure that the component of the UBD model is comprehensive and applicable to the current design process and strategy. Using the design syntactic analysis (DSA) proposed by Warell (2001), this research provided a comprehensive design model that supports a more systematic design development process, to formulate, to clarify, and to evaluate the structural, functional, and visual aesthetic aspects of a new or existing concept product before making a design decision. Based on the need, this sub-section will demonstrate how the data findings from the study (VIA, PBA, VPAE1, VPAE2, VPAE3) can be tested and applied to product design activities by designers. This experiment will also answer the third research question: " How does understanding unintended human behaviours lead to meaningful conceptual design, inclusive design solutions, and maximizing the value of products?"

Referring to Chapters Two and Three, the three elements of DSA are identified as form functionality, form syntax, and design format (Warell, 2001). Chapter Four elaborates on the DSA experiment concerning designers' conceptual designs, which tests consistency within form, functionality, and design format. This process can be articulated as follows:

(1) Form functionality addresses the idea that every visible surface in a product serves a function (whether structural, ergonomic, semantic, or aesthetic.)

(2) Form syntactic describes how product form is organised, both at the broader organ level (e.g., the overall shape of a chair) and at the detailed material-physical level (e.g., stitching, edges, or texture of a material).

(3) Design format relates to a broader design philosophy at the brand or company level, where the consistent use of form elements conveys a recognisable identity across different products (Warell & Nåbo, 2000).

Through DSA, the experiment can (i) identify and analyse the functional content of the product concept, (ii) evaluate the consistency of the form entity and design being opportunistic, and (iii) analyse the format of the product concept. This analysis aims to assist designers in recognising the consistency of designs generated through UHBE research, enhance design thinking parameters, and assess the feasibility of the UBD model by expanding the potential of UHBE in design research. The following section presents the design analysis conducted by a group of designers from the VPAE3 experiment. However, this presentation includes only five conceptual design analyses out of the 30 conceptual designs collected for comparative analysis.

For the first analysis, the functionality content of product concept will detail the important components that offer functionality based on the subjective perspective of the designer and user experience. Each component refers to the role of form elements or visual signals (signs) in supporting the function of product use. The analysis that will be used in this section refers to the proposal by Warell (2001) including direct identification and design intent analysis (see Chapter Two). Although Warell proposed one of the tools for the purpose of evaluating the functionality of form, this study takes a holistic approach to both methods to obtain a more holistic understanding of UBD design model.

For the second part is the form entity analysis, it describes the approach used in the development and evaluation of product form design. It provides a systematic framework through iterative stages in the process of creation, reflection, analysis and improvement of form with an emphasis on the assessment of syntactic, semantic and ergonomic aspects of form elements. It supports the creation of product forms that are visually coherent and meaningful in terms of their function. Syntactic form analysis is used as a tool to improve the quality and effectiveness of form design at the operational stage of product development through key aspects in design such as visual coherence and gestalt principles, Functional clarity of form elements, Product semantics and user perception, Ergonomic integration, Manufacturing, and cost considerations.

For the third part is the design format. Its depiction of the form, content, and design philosophy that (i) includes elements of the style, identity, and visual language of the product, or (ii) outlines the specifications and requirements established by stakeholders, elucidating how the product's form influences the perception of the brand, product category, and market viewpoint. It is crucial for maintaining visual identity consistency across a product series or among different goods within a brand. This feature is frequently linked to the aesthetic and communicative dimensions of brand image. The design format functions as a template intended to assist the designer in establishing the product identity. Warell & Nåbo (2000) contend that the design "format" or "design concept template" serves as a metaphor that encapsulates the company's stylistic philosophy, dictating the particular form elements to be utilised and their arrangement inside the design formulation, referred to as design "form language." It includes the subtle format in every nuanced element, structural composition, curvature, design motif, or interface that can distinctly distinguish the manufacturer's products from those of competitors. In this study, the design format will be referred to designers' design criteria pattern for new product concept incorporating UHBE attributes, as depicted in Figure 4.101.

The complete implementation of syntax in form, functionality, and design format establishes a robust theoretical and practical basis for merging aesthetic appeal, ergonomic efficiency, and technological performance in industrial design. The examination of five selected sketches derived from the VPAE3 study, evaluated by eight respondents utilising the framework of design syntactic analysis, as follows:(i)

Sketch 1; (ii) Sketch 2; (iii) Sketch 3; (iv) Sketch 4; and (v) Sketch 5. Subsequently, each sketch, examined by eight respondents, was processed to critically synthesise the analytical elements produced by these respondents.

To present and discuss the results of the design syntactic analysis, five sets of analytical transcriptions (data findings) were prepared for each sketch analysis, as follows: (i) transcription of direct functional identification; (ii) transcription of design intent analysis; (iii) analysis of form entities; (iv) design format analysis for individual products; and (v) design format analysis for product families. Consequently, the subsequent sub-chapter will provide a detailed elaboration and discussion of the results from the design syntactic analysis of each sketch.

Analysis Form Functionality Content: Design Intent and Direct Functionality

As mentioned in Chapter Three, form functionality content analysis help designer to identify and assess the functional content of products. The analysis encompasses all functional dimensions of the product, including internal functions (structural, transforming, and secondary functions) and interactive functions (ergonomic, syntactic, and semantic functions). The method for identifying product functions comprises two complementing approaches that mutually reinforce each other and can be employed either independently or in conjunction. The methodologies are grounded in direct functional identification and the analysis of design intent, respectively. Figure 4.102 indicate form functionality analysis through design intent analysis.

As stated before, the subject of research is a standard wash basin for basic use. This section will present the results of design intent analysis based on wash basin integrated with baby bathe features for five design idea sketches. The analysis is formed based on questions such as "Why is the solution/characteristic/mean present?", there are twenty-three questions developed in Column A. To begin an analysis, a general question has been asked: “Why is a wash basin integrated with baby bathe need?”. Then, based on the whole-product level of wash basin design, there are five questions has been asked, as follow: (1) “Why is there an opening in the top of wash basin body? ”; (2) “Why is the cross section of the wash basin elliptical in shape?”; (3) “Why is the wash basin body made of ceramic?”; (4) “Why is there a cutout concave curve surface of the wash basin body facing the basin lid?”; and (5) "Why angle of steepness determine the efficient of basin?".

Moreover, based on the subsystem levels of wash basin design, there are five section of questions has been asked towards (1) Faucet: (i) "Why is faucet need?"; (ii) "Why is faucet placed in the middle of bowl?"; (iii) "Why is the faucet body made of steel?"; and (iv) "Why faucet include telescopic function?". Second subsystem is (2) Drain hole: (i) "Why is drain hole need?". The third subsystem (3) Overflow hole: (i) "Why is overflow hole need?". Fourth, (4) Pedestal Stand: (i) "Why pedestal stand need?"; (ii) "Why stopper need?"; and (iii) "Why pedestal structural form is shape accordingly? (V/A/L-shape)". the last subsystem, (5) Accessory: (i) "Why is additional compartment need?"; (ii) "Why portable pillow need?"; (iii) "Why towel rail need?"; and (iv) "Why silicone strip / barrier needs?".

Later, by posing an answer towards the purpose / reason / cause such as “in order to…”, Column B answering those questions in Column A and stating the purpose of the solution which includes justifying the design intent of each element. Then, by posing a question such as “What does the solution/feature do?”, Column C transformed the purpose statement in Column B into a function statement. When column A, B and C has been filled, the function statement of wash basin design ideation were identified, marked and classified according to the function classes as presented in Column D to I. Finally, the transcription of design intent analysis of wash basin integrated with bathe baby design ideation in Sketches 1 to 5 were simplified and adapted into the transcription of direct functional identification each, where the solution selected (functionality) for the wash basin design ideation were labelled and recorded as an image for further references.

Col.	A	B	C	D	E	F	G	H	I
	Question: "Why is the solution / feature / mean present?"	Purpose / Reason / Cause (design intent) "in order to..."	Function statement (verb + noun notation) "What does the solution / feature do?"	Main	Technical / Structural	Additional / Other	Ergonomic	Syntactic	Semantic
1	Why is a wash basin intergrated with baby bathe need?	...enable bathing baby from convensional basin in general bathroom	Support bathe feature	x					
	Basin bowl								
2	Why is there an opening in the top of wash basin body?	...provide a space cleaning, washing, and baby bathing.	Hold water			x			
3	Why is the cross section of the wash basin elliptical in shape?	...provide a versatile space for washing hands, face, or bathing a baby in a safe, stable, and hygienic manner.	Increase water flow efficient				x		
4		...create a visual composition in balance with other form solution	Refer form element (human gesture, dynamic movement)					x	
5		...facilitate using by occupying ample space when using	Fit / suit bathing activity				x		
6		...strengthen the visual impressing of the basin body	Express strenghtness						x
7	Why is the wash basin body made of ceramic?	...increase the durability of the appearance	Describe visual aging						x
8	Why is there a cutout concave curve surface of the wash basin body facing the basin	...guide water efficiently toward the drain.	Fasilitate water direction				x		
9	Why angle of steepness determint the effision of basin?	...provide water affordance into the drain hole.	Enable water flow				x		
	Faucet								
10	Why is faucet need?	...enable water to supply from water tank into pipe	Connect water (hot / cold)	x					
11	Why is faucet placed in the middle of	...enable water to flow from water tank inti basin	Support water supply		x				
12	Why is the faucet body made of steel?	...increase the durability of the appearance	Describe visual aging			x			
13	Why faucet include telescopic function?	...provide flexibility, convenience, and user experience during use.	Enable water coverage				x		
	Drainhole								
14	Why is drainhole need?	...enable water drainage	Transmit water to the sewer hole	x					
	Overflow								
15	Why is overflow hole need?	...prevent water from spilling over if the basin fills beyond its intended capacity.	Restrain excess water in basin	x					
	Padestal Stand								
16	Why padestal stand need?	...provided stability and balance of the basin	Support / hold basin		x				
17	Why stopper need?	...provides easy access for water draining	Control drain water			x			
18	Why padestal structural form is shape accordingly? (V/A/L-shape)	...provided stability and balance of the basin	Connect part					x	
19		...strengthen the visual impressing of the basin body	Express sturdy base						x
	Accessory								
20	Why is additional compartment need?	...provide room for soap placement	Suit soap / others			x			
21	Why portable pillow need?	...provide safety and comfort and user-specific adaptability	Communicate head			x			
22	Why towel rail need?	...provide space of towel hang	Hang towel			x			
23	Why silicone strip / barrier need?	...provide safety and comfort and user-specific adaptability	Describe anti-slippery						x

Figure 4.102 The Design Intent Analysis of the Sketches: Wash Basin with Baby Bathe Features

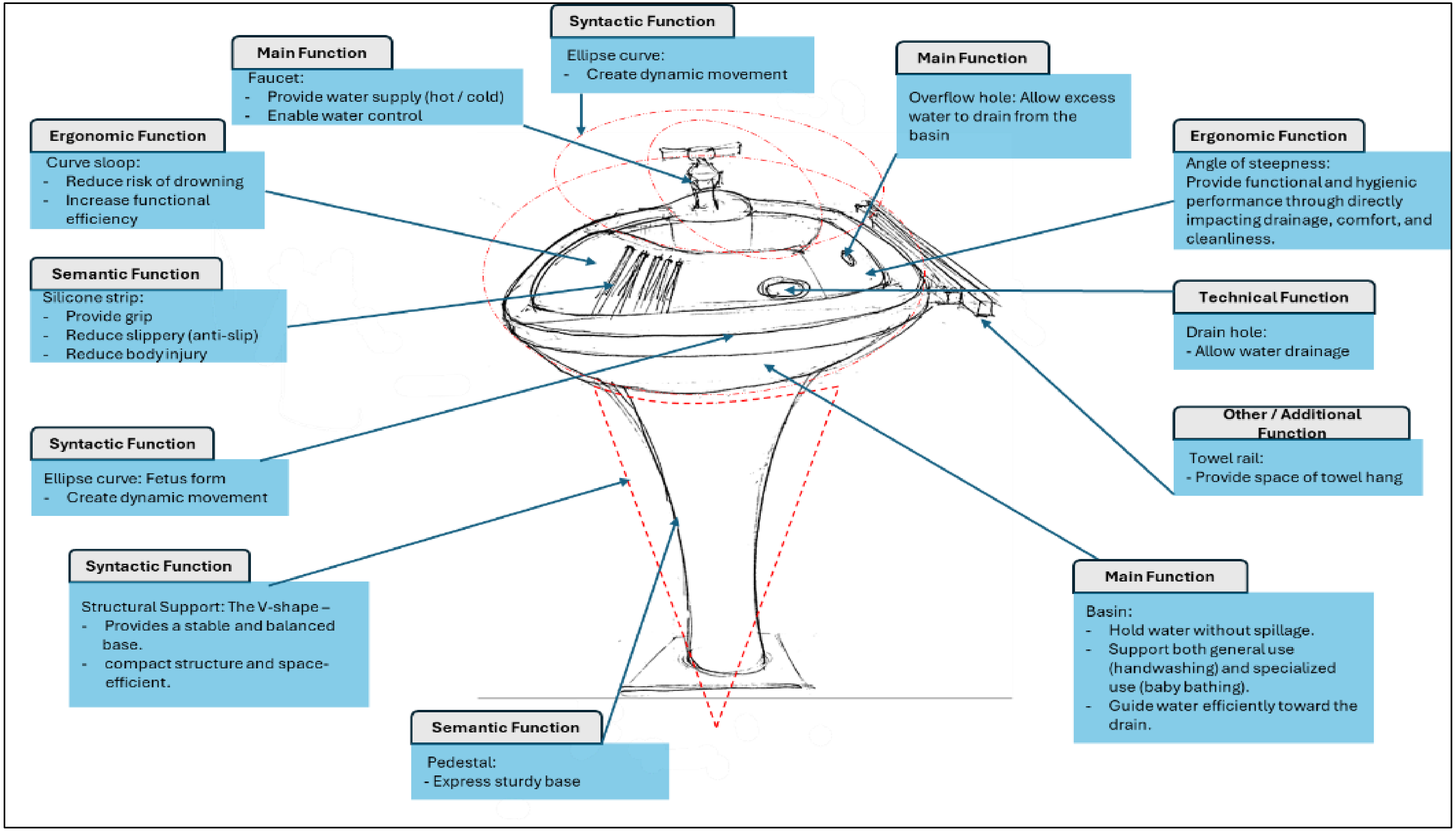


Figure 4.103 Direct Functionality Identification Sketches 1

Figure 4.103 illustrates the transcription of the direct function introduction in Sketch 1, generated from the analysis of design intent. Three main functions are implemented: (1) the wash basin design for additional use in bathing babies, (2) the faucet adapter for more ergonomic access to the water source, and (3) adjustment of the drain hole position to improve baby safety. A technical function is also included: an overflow hole to allow excess water to drain from the basin. Three syntactic functional elements create a visually balanced composition: (1) the ellipse curve in the main body cross-section, (2) the V-shape in the pedestal cross-section, and (3) the ellipse curve in the adaptation design resembling foetal form. Two semantic functional elements enhance form expression: (1) the V-shape in the pedestal adapter cross-section representing the study base, and (2) parallel straight lines on the silicone strip for grip, reducing slipperiness and injury. Two ergonomic functional elements are applied: (1) the sloop curve in the adaptive design to reduce drowning risk, and (2) the main body angle, improving hygiene through better drainage, comfort, and cleanliness. Finally, one inventive functional element is implemented: a towel rail to facilitate baby bathing activities. This transcription demonstrates how multiple functional layers including technical, syntactic, semantic, ergonomic, and inventive elements interact to produce a safe, practical, and expressive product design. Each element contributes to usability, safety, and visual coherence, reflecting thoughtful integration of form and function in the baby wash basin design.

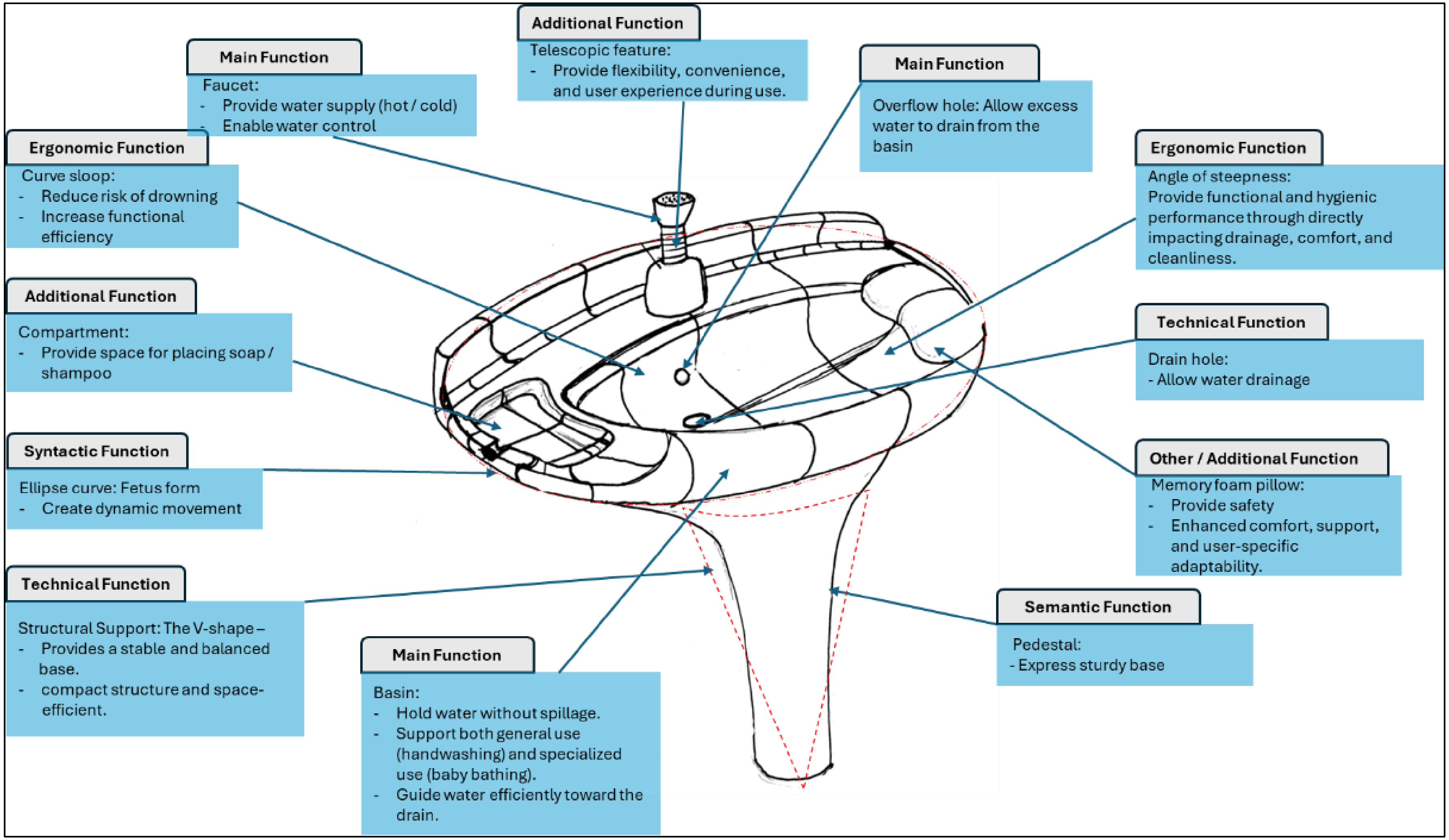


Figure 4.104 Direct Functionality Identification Sketches 2

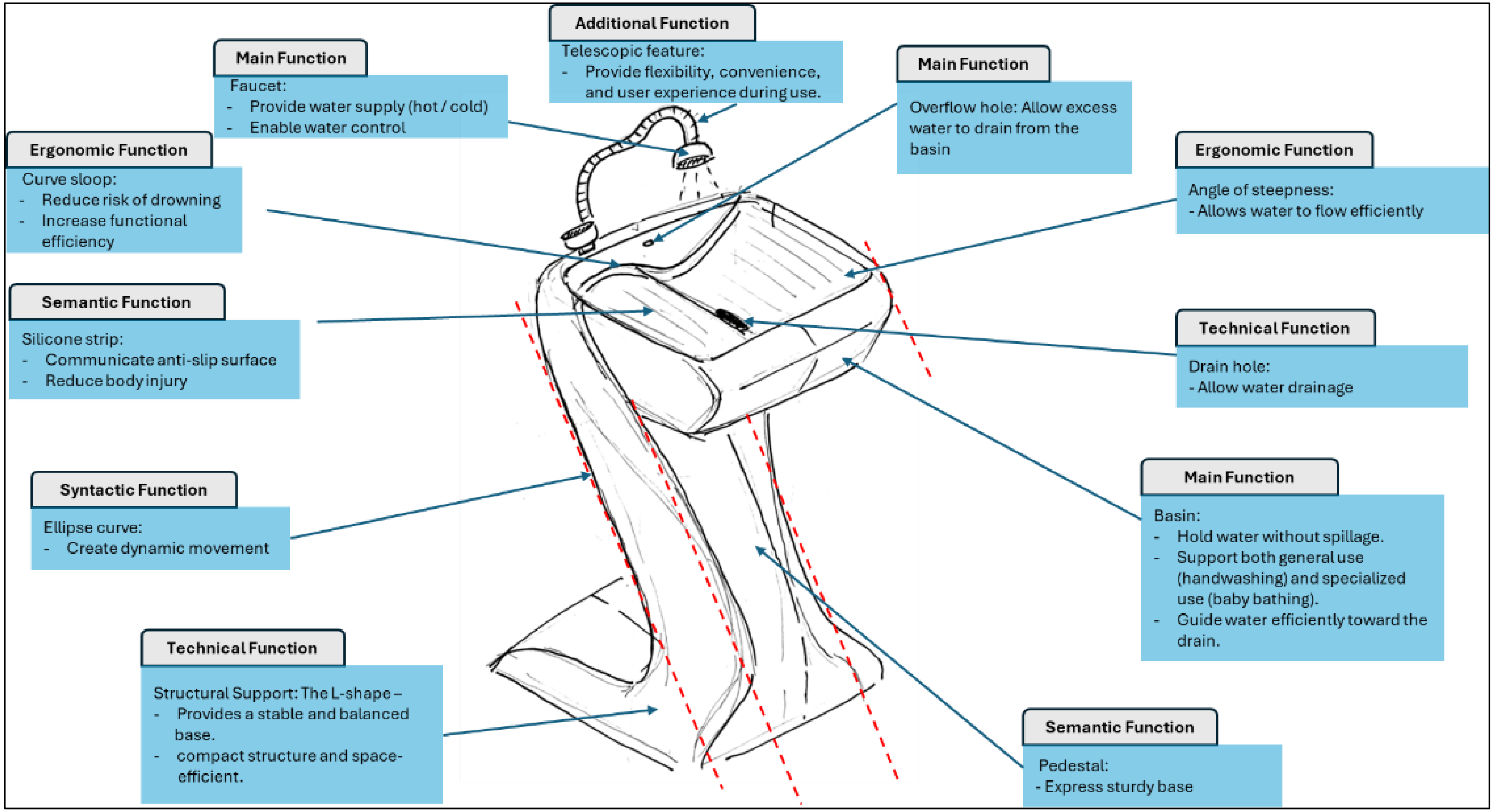


Figure 4.105 Direct Functionality Identification Sketches 3

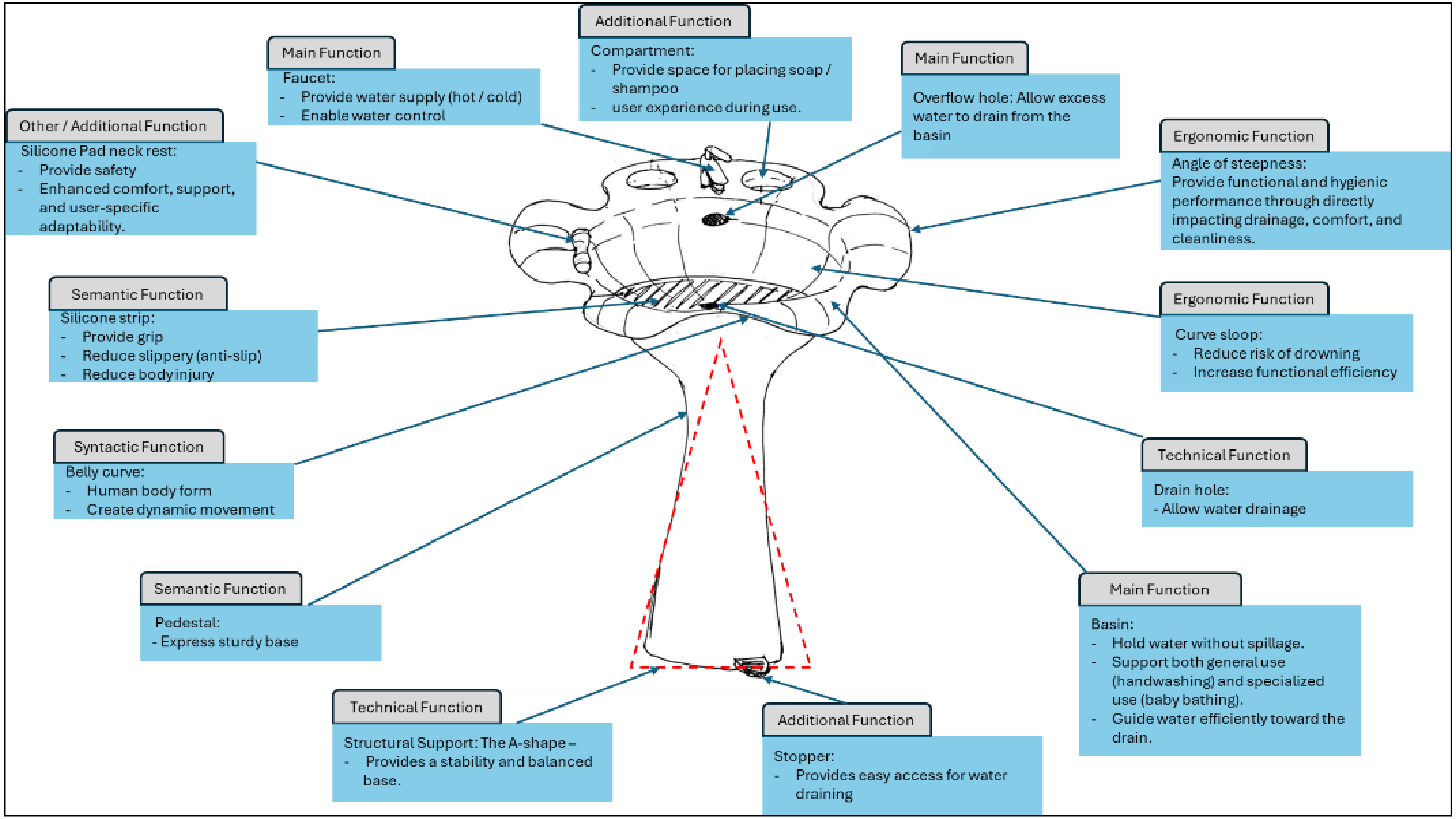


Figure 4.106 Direct Functionality Identification Sketches 4

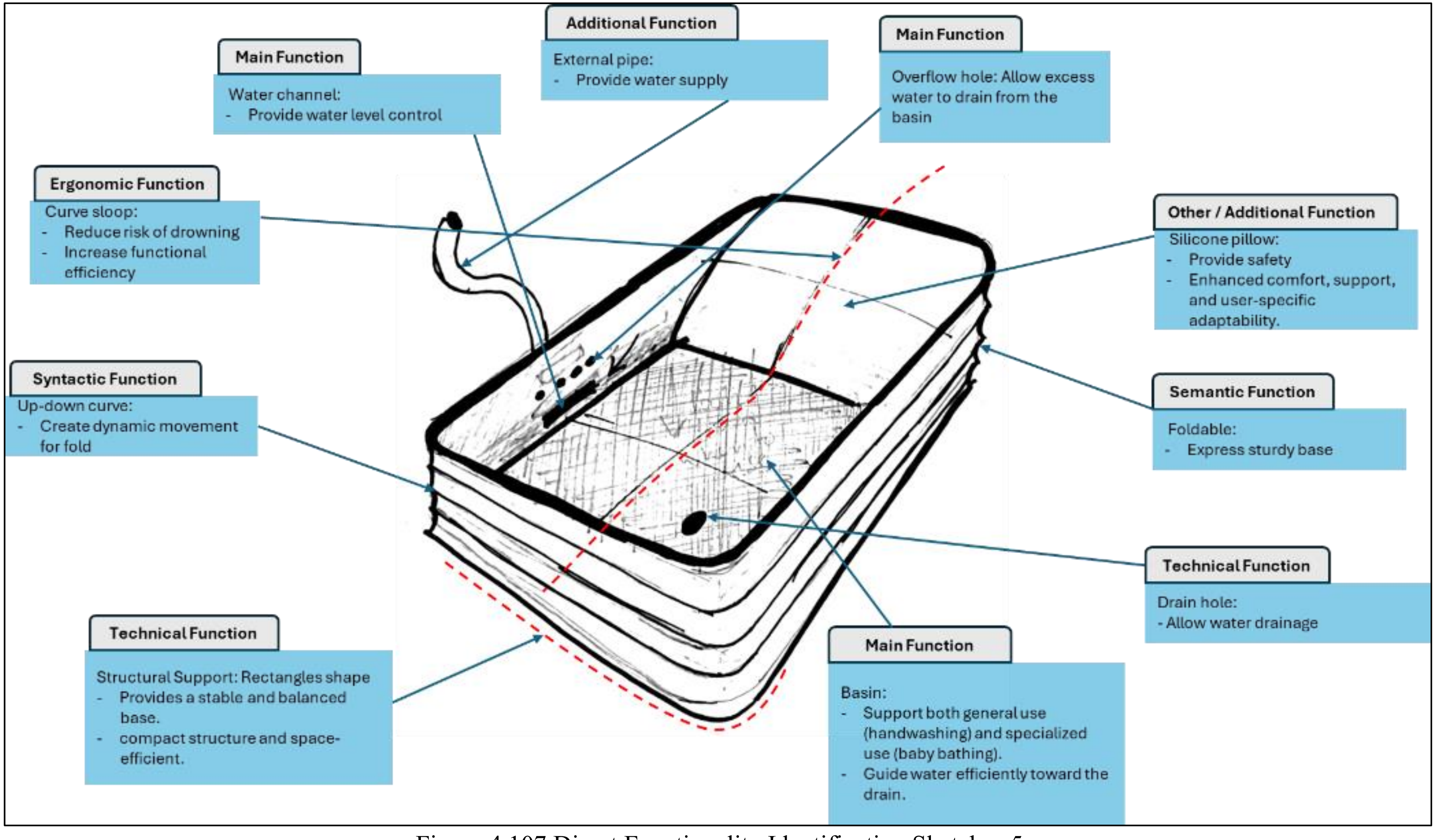


Figure 4.107 Direct Functionality Identification Sketches 5

Figure 4.104 to 4.107 illustrates the transcription of the direct function introduction in Sketch 2, 3, 4, and 5. Through overall transcription, there are other element that different from sketches 1 such as (1) telescopic faucet adapter for more ergonomic access to water sources, (2) adjustment of the drain hole position to improve safety aspects for babies, (3) shape of the curve sloop in the adaptive design, which reduces the risk of drowning; (4) the angle of steepness in the main body shape, which improves hygienic performance through directly impacting drainage, comfort and cleanliness, (5) memory foam pillow, increasing the safety and comfort aspects of the baby's head, (6) compartment, a space for filling other tools such as toiletries and others, (7) square form of basin, the design of the wash basin for additional use for bathing babies according to the curve of the baby's body, (8) telescopic faucet adapter for more ergonomic access to the water source, (9) the structural of pedestal in L-shape, (10) straight line, which is a silicone strip for anti-slip and reduce body injury features, (11) pedestal form express study base. In addition, there are two ergonomic functional elements implemented, (12) rounded form of basin with aesthetic curve based on flower form, the design of the wash basin for additional use for bathing babies in accordance with the use of bathing babies, (13) the structural of pedestal in A-shape, provide stability balance, (14) stopper, water control and easy access, (15) silicone pad neck rest, provide safety, comfort, support form, and user specific adaptability, (16) square form of basin with aesthetic curve based, and portable concept of baby bathtub, the design of the wash basin as an additional use for bathing babies according to the use of bathing babies, (17) water channel, facilitating the reception of water from external sources of faucet, and (18) overflow hole, adjusting the position of the disposal of excess water.

Analysis Form Syntactic: Design being Opportunities

As mentioned in Chapter Three, form syntactic is understood as a constitutive model describing the structure and configuration of forms at both the organ level (form entities) and the material-physical level (form elements) which delineates four hierarchical levels of form entities (Warell, 2001; Warell & Nåbo, 2002). These levels reveal how aesthetic organ structures, communicative functions, and form-element characteristics interrelate. The four hierarchical levels of form entities are (1) The Superior Gestalt represents the highest hierarchical level (global) in product form analysis. (external shape), (2) Characteristic shapes pertain to prominent form elements that are integral to the product's function and aesthetic appeal. (internal shape), (3) A significant curve is identified as a component distributed throughout the product (product component), and (4) The Fifth Element refers to unique, often subtle, design features that serve as brand identifiers or convey specific symbolic meanings. However, in the form syntactic analysis section, the fifth element will not be analyzed due to no specific brand involved in this analysis. At every level of form structure, the form entity of conceptual sketches ideation is evaluated through (i) consistency, and (ii) design being opportunistic. The consistency of form entity of design concept is evaluated using frequency distribution, based on evaluation by eight respondents who are undergraduate design students, as depicted in Figure 4.108. In this analysis, respondents assessed the form structure of each sketch using red, green and blue pens to represent superior form (red), intermediate form (green) and detail form (blue) (see Figure 4.109). Later, Figures 4.110, 4.111, 4.112, 4.113, 4.114 show the results of the analysis performed on the five sketches.

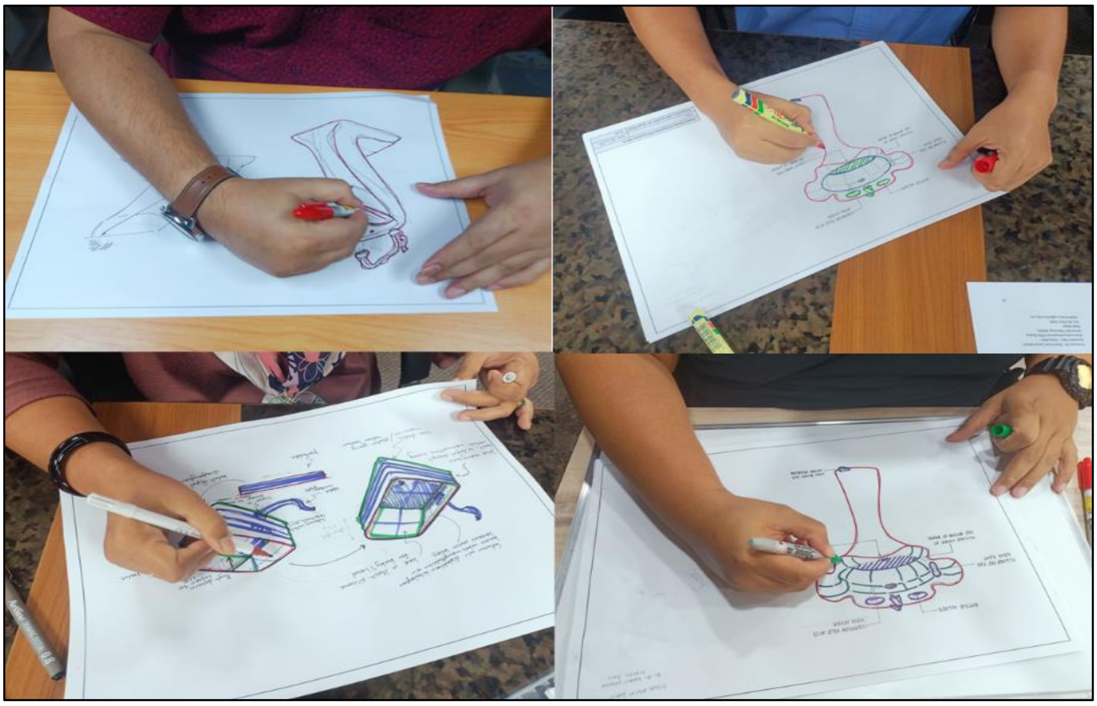


Figure 4.108 Respondent Involved in Design Syntactic Analysis

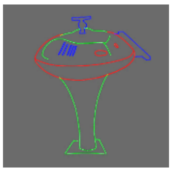
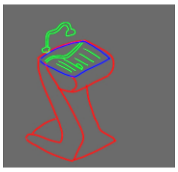
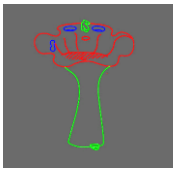
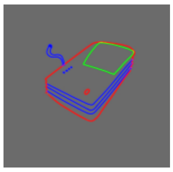
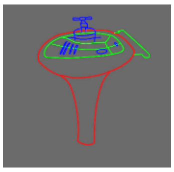
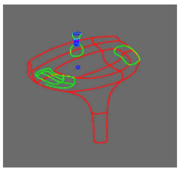
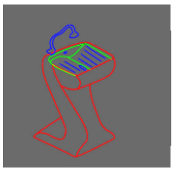
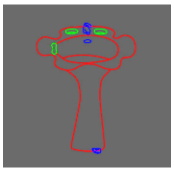
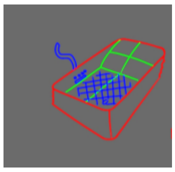
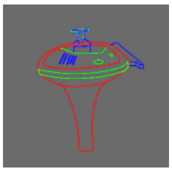
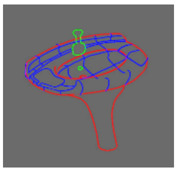
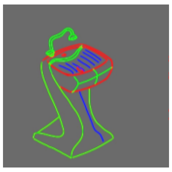
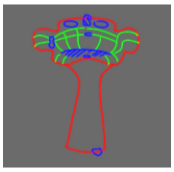
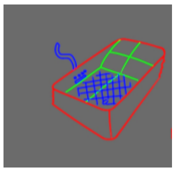
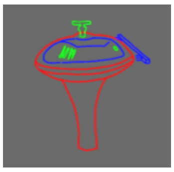
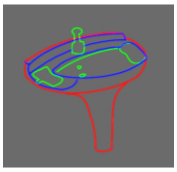
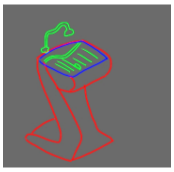
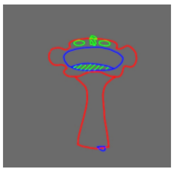
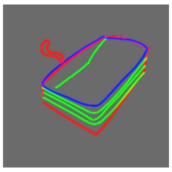
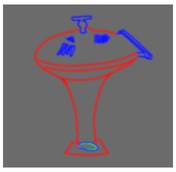
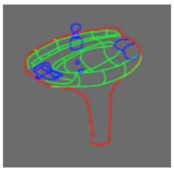
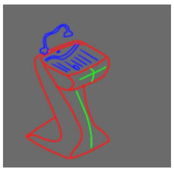
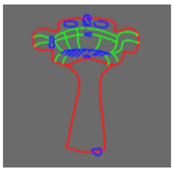
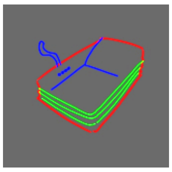
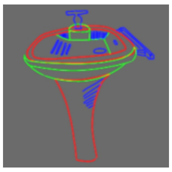
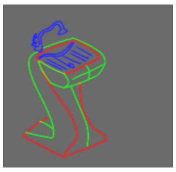
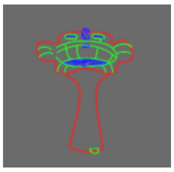
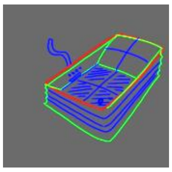
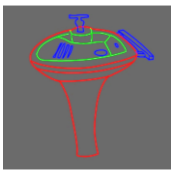
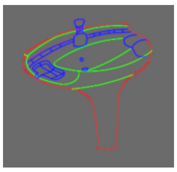
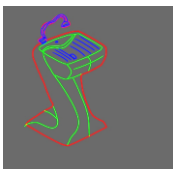
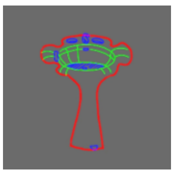
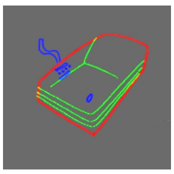
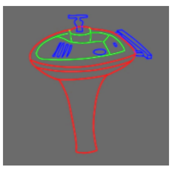
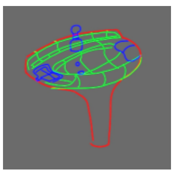
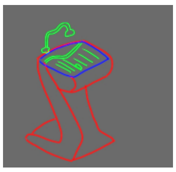
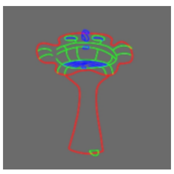
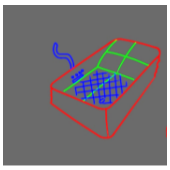
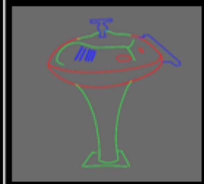
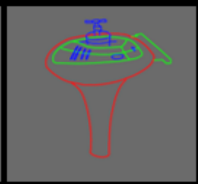
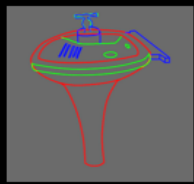
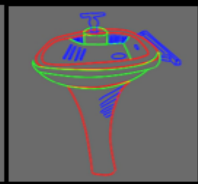
FORM ENTITY / STUDENTS	Design 1	Design 2	Design 3	Design 4	Design 5
STUDENT A					
STUDENT B					
STUDENT C					
STUDENT D					
STUDENT E					
STUDENT F					
STUDENT G					
STUDENT H					

Figure 4.109 Design Syntactic Analysis of Sketches 1,2,3,4 And 5, As Indicated by 8 Respondents

	DESIGNER A	DESIGNER B	DESIGNER C	DESIGNER D	DESIGNER E	DESIGNER F	DESIGNER G	DESIGNER H
								

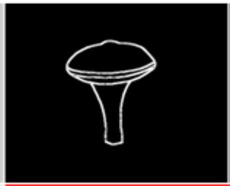
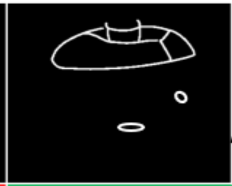
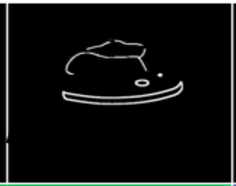
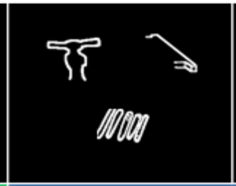
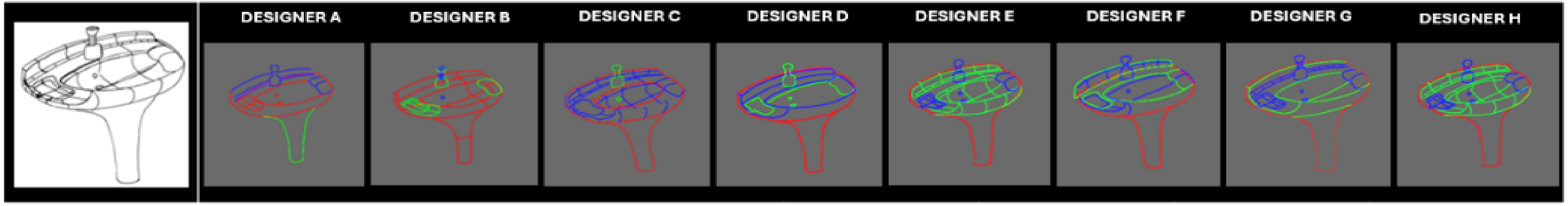
	Form Entity						
Physical main Component / subcomponent	**Level of form structure**	Superior form		Intermediate form		Detail form	
		Consistency	Design being opportunistic	Consistency	Design being opportunistic	Consistency	Design being opportunistic
Basin + Pedestal	Outer form	7	1				
Inner basin	Basin line / curve			5	3		
Drain hole	Ellipse shape			3	5		
Overflow hole	Ellipse shape			3	5		
faucet	Faucet shape					7	1
Towel rail	Rail line					7	1
Anti-slip	Linear line					7	1
	TOTAL	8		24		24	

Figure 4.110 The Form Entity Level of Sketches 1

In the conceptual design of sketches 1 (refer to Figure 4.110), overall consistency value for the superior form indicates that the designed external structure, which includes the basin and pedestal, is rated high (7), while only one evaluation of this design is considered opportunistic, highlighting the innovative features presented in sketches 1. Meanwhile, for the intermediate form level, including the inner basin, drain hole, and overflow hole, the consistency and design of the opportunistic internal form structure are balanced. While the details of the form show the highest consistency value, which shows that entity form elements such as faucets, towel rails and anti-slip features are strong. Meanwhile, the conceptual design of sketches 2 to 5 (Figure 4.111 – 4.114), consistency value for the superior form indicates that all external structure is mostly rated high (except sketches 3). Moreover, for the intermediate form level (inner basin, drain hole, and overflow hole), detail form (faucet, soap placement and memory foam material use), and consistency of form entity (internal form structure and product component) are moderate to high. All sketches reflect strong form entity based on analysis conducted. Overall, the syntactic form of the designers' conceptual sketches, demonstrate high consistency form structure based on the evaluation by the respondents. Through this lens, the syntactic form analysis reveal aesthetic organ structures, communicative functions, and form-element (Warell, 2001), is reliable and applicable to test form and functionality of new product concept.



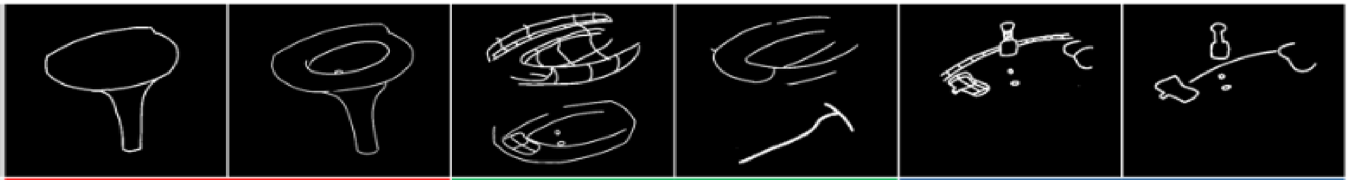
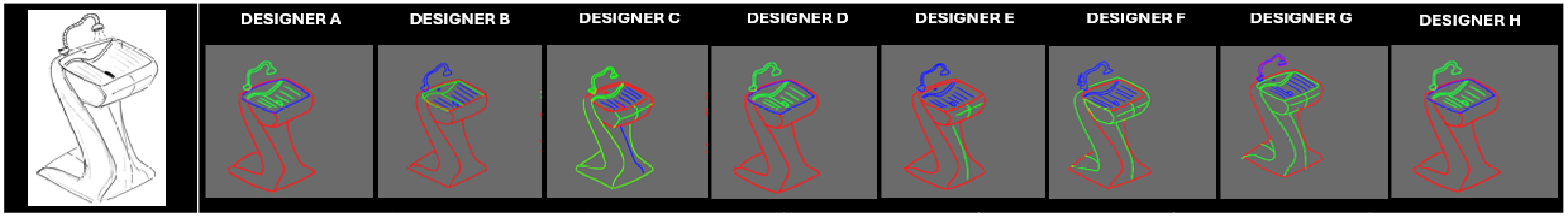
	Form Entity						
Physical main Component / subcomponent	**Level of form structure**	Superior product gestalt		Higher order form element		Lower order form element	
		Consistency	Design being opportunistic	Consistency	Design being opportunistic	Consistency	Design being opportunistic
Basin + Pedestal	Outer form	7	1				
Inner basin	Basin line / curve			5	3		
Drain hole	Rounded shape			5	2		
Overflow hole	Rounded shape			5	3		
faucet	Faucet shape					6	2
Soap						5	3
Memory foam						5	3
	TOTAL	8		23		8	

Figure 4.111 The Form Entity Level of Sketches 2



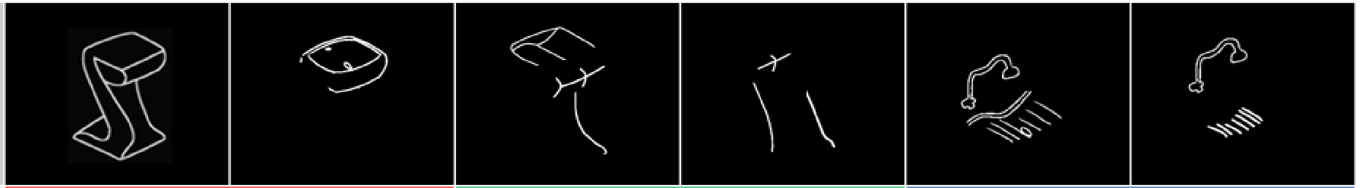
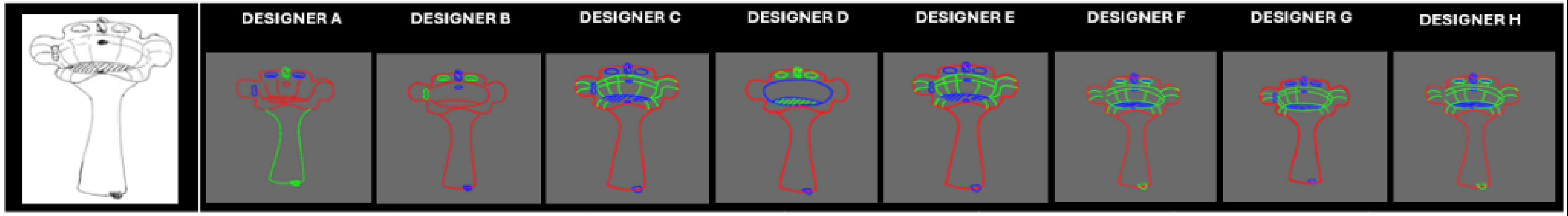
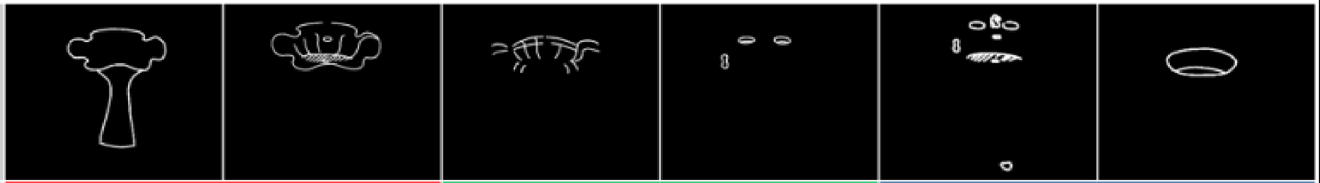
	Form Entity						
Physical main Component / subcomponent	**Level of form structure**	Superior form		Intermediate form		Detail form	
		Consistency	Design being opportunistic	Consistency	Design being opportunistic	Consistency	Design being opportunistic
Basin + Pedestal	Outer form	**6**	2				
Inner basin	Basin line / curve			4	4		
Drain hole	Ellipse shape			3	5		
Overflow hole	Ellipse shape			3	5		
faucet	Faucet shape					4	4
Anti-slip	Linear line					4	4
	TOTAL	**8**		**24**		**16**	

Figure 4.112 The Form Entity Level of Sketches 3

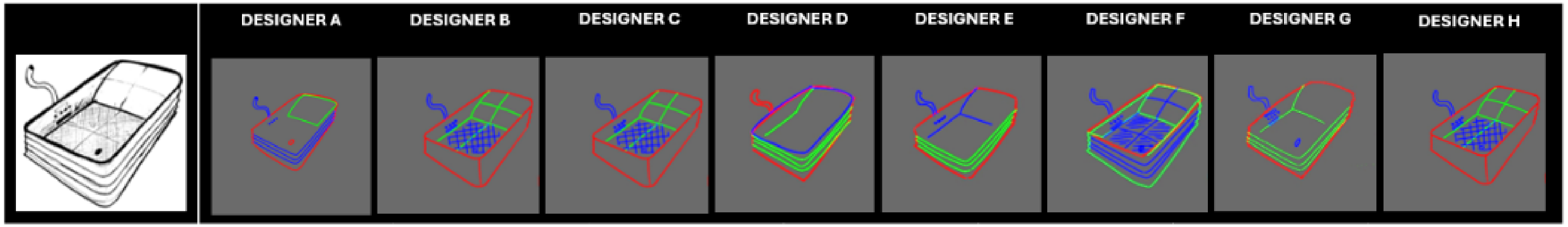


Form Entity

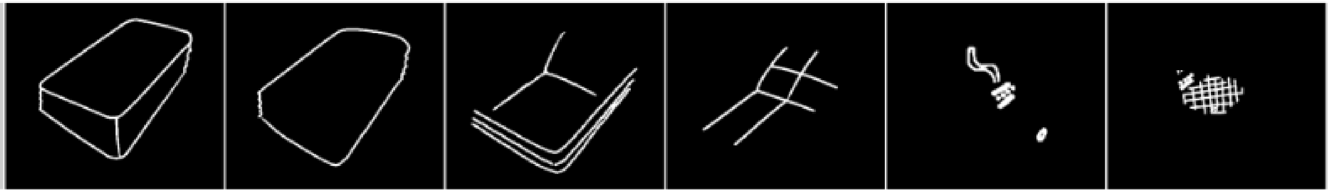


Physical main Component / subcomponent	Level of form structure	Superior form		Intermediate form		Detail form	
		Consistency	Design being opportunistic	Consistency	Design being opportunistic	Consistency	Design being opportunistic
Basin + Pedestal	Outer form	7	1				
Inner basin	Basin line / curve			5	3		
Drain hole	Ellipse shape			3	5		
Overflow hole	Ellipse shape			6	2		
faucet	Faucet shape					6	2
Anti-slip	Linear line					5	3
Paddle Stopper	Paddle form					5	3
	TOTAL	**8**		**24**		**24**	

Figure 4.113 The Form Entity Level of Sketches 4



Form Entity



Physical main Component / subcomponent	Level of form structure	Superior form		Intermediate form		Detail form	
		Consistency	Design being opportunistic	Consistency	Design being opportunistic	Consistency	Design being opportunistic
Basin + Pedestal	Outer form	7	1				
Fold line	Foldable line			5	3		
Drain hole	Rounded shape			5	1		
Overflow hole	Square shape			7	1		
External pipe	Pipeline					7	1
Anti-slippery	Mesh line					4	4
	TOTAL	**8**		**17**		**12**	

Figure 4.114 The Form Entity Level of Sketches 5

Design Format Analysis: Individual and Family Product

According to the procedure proposed by Warell (2001), the most effective method for analysing the design format of a single product entails the distribution or decomposition of the design component structure into various visual materials, which include (i) primary physical components, (ii) form elements, (iii) form entities, and (iv) gestalt. Based on Warell's (2001) procedure for distributing visual materials related to the component structure and styling features, the design format for individual designs. As detailed in the previous section, designers have established specific 'criteria' for the implementation of designs informed by UHBE interaction. These criteria encompass (i) square form, (ii) elliptical form, (iii) a replication of the 'foetus' form, (iv) a soft finish, (v) a tall form, (vi) functionality for hot/cold water, (vii) a flexible faucet, (viii) curved edges, (ix) easy clean, (x) compartments, and (xi) hard materials.

Figure 4.115 on the next pages illustrates the scoring scheme analysed for sketches, utilising the criteria suggested by the designer and based on the Warell (2001) procedure for assessing the integrity of the design format for new conceptual designs on an individual basis. The scoring process involves determining which components of the design meet the established criteria within the design format. The scoring format for each physical part (or subsystem) of the product is depicted through coloured line sketches (red), which consistently highlight the application of styling principles in each component. The design format is evaluated using a 2-point score (represented by a black circle) for consistent styling features and a 1-point score (represented by an empty circle) for uncertain styling features. In Sketch 1, the findings indicate that the resulting design components, including the basin, faucet, drain hole, overflow hole, curvature characteristics, anti-slip features, and pedestal, meet all the specified criteria. However, some components or design details demonstrate lesser compliance with the established design format, as indicated by a 1-point score.

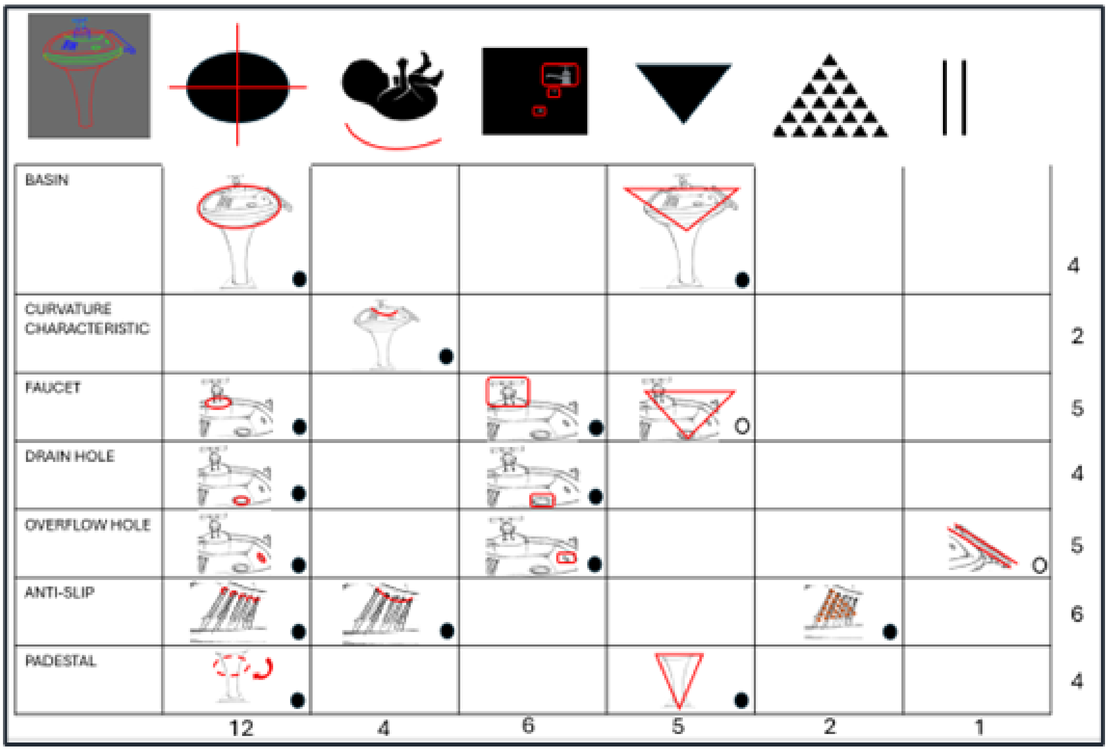


Figure 4.115 Design Format for Sketches 1 Based on Single Product Analysis

Meanwhile, Figure 4.116 represents a design format for a family product series, as proposed by Warell (2001). This format focuses on mapping the relationship between form and function elements in conceptual product design. Referring to Figure 4.116, five design sketches for a washbasin with integrated baby bath features were evaluated against eleven key design criteria established by the designer, as previously mentioned. Each concept was assessed using a syntactic scoring system, in which a black circle denotes full fulfilment of the criteria (2 marks), while an empty circle signifies partial fulfilment (1 mark). The total score for each concept is displayed at the right end of the matrix, indicating the extent to which the design meets the specified requirements. At the bottom of the design format, there are marks indicating the relative importance of each criterion according to the designer's preferences. This representation serves as a systematic visual analytical tool to facilitate the evaluation, selection, and reasoning about form in product design, based on the syntactic relationship between form and function. According to the results, Sketch 1 achieved the highest score, with a total of 19 evaluation points across the 11 criteria outlined in the UHBE product design format, particularly for the washbasin integrated with baby bath features. It was followed by Sketch 2 (17 marks), Sketch 3 (15 marks), Sketch 4 (14 marks), and Sketch 5 (9 marks).

The evaluation concentrated on the highest criteria met in each sketch, specifically examining the elements of soft finish and durable material. The fetus form, tall form, and flexible faucet design were the elements that received the second highest scores. Conversely, the sketches lacked elements of square form and hot/cold water features, which were deemed inappropriate. However, this evaluation could vary if it were conducted on 30 conceptual designs produced by 30 designers in the VPAE3 experiment. The following presents the results of the design format analysis from the family product group.

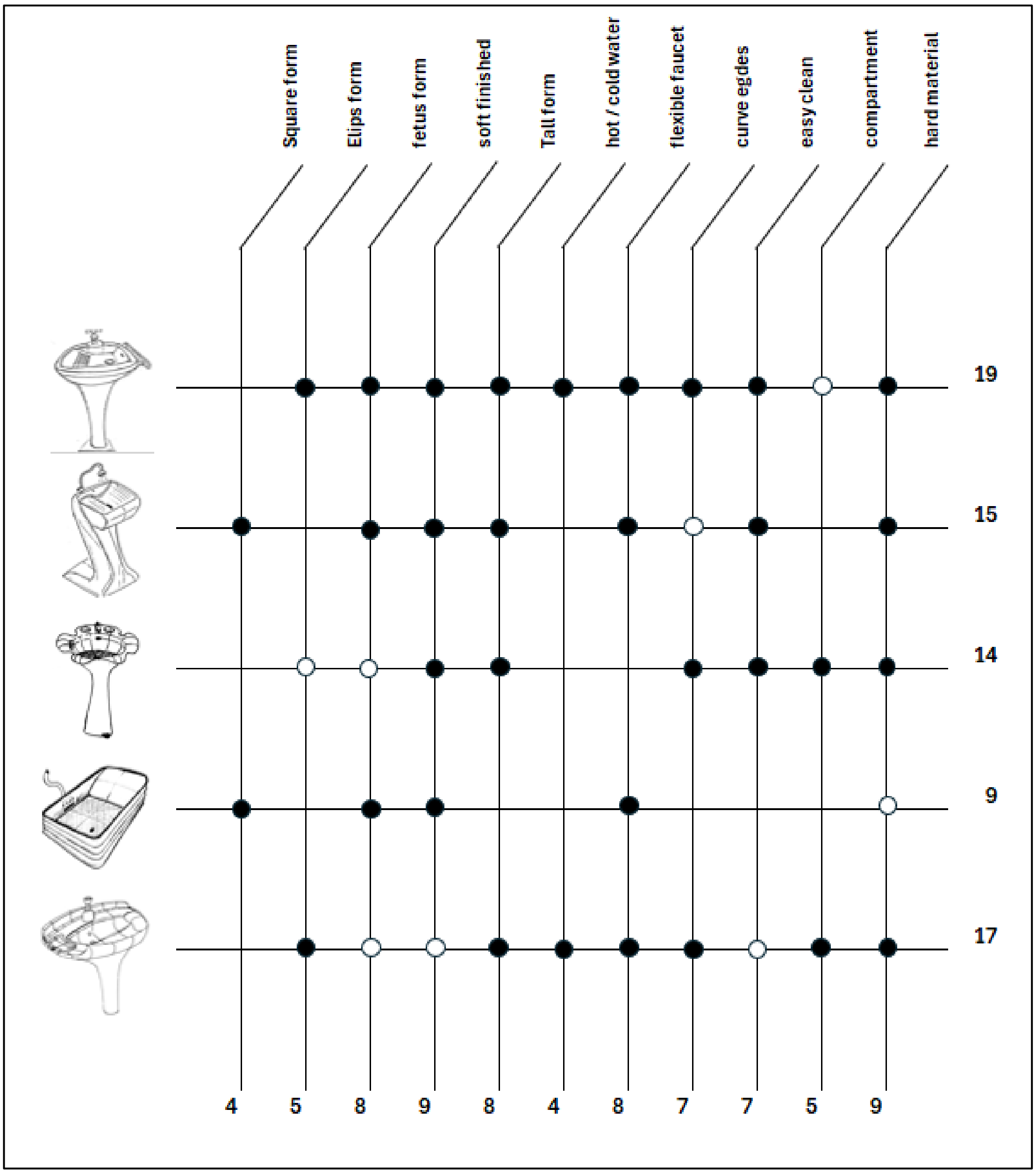


Figure 4.116 Design Format Based on Designer Design Criteria for New Conceptual Product Design

The Summary of Design Syntactic Analysis

Reflective practice and critical thinking in design are believed to yield novel interpretations and create opportunities for innovative solutions during the sketching process undertaken by designers (Schön, 1983). This study identifies five conceptual ideations addressing "new functionality" within a single product, selected from designers with varying levels of experience: (i) Sketch One; (ii) Sketch Two; (iii) Sketch Three; (iv) Sketch Four; and (v) Sketch Five. The study has achieved its third research objective by conducting a design syntactic analysis to assess the relevance and applicability of the unintended-behaviour design model in facilitating idea generation and innovative design initiatives. Furthermore, the research has established the applicability and utility of proposed design framework for designers product development strategic through three propositions: (i) identifying and analysing the functional content of the product concept; (ii) examining the consistency of form entities and designs that are opportunistic; and (iii) analysing the format of the product design concept based on designers' criteria. In addressing the second proposition, the researcher determined that each tier of form entities within the selected conceptual design ideation displays consistent characteristics, with commonalities evident among the structural foundations of these entities.

In the context of the study, the aspects of consistency among the structural installations of form entities were substantiated through the most pertinent elements identified by respondents in the analysis sets. Research focusing on design intent analysis and direct functional identification has clarified the functional aspects inherent in all selected conceptual design ideations in response to the first proposition. According to Warell (2001), design intent analysis and direct functional identification encompass all functional dimensions of the conceptual design ideation under examination, which include internal functions (such as structural, transforming, and supplementary functions) as well as interactive functions (including ergonomic, syntactic, and semantic functions). Furthermore, regarding the second premise, the research indicated that every tier of form entities within the chosen conceptual design ideation comprises design elements that present opportunities; this is the primary factor driving modifications in sketching structure and fostering innovation in design.

On the other hand, the design opportunities identified within the structural elements of form entities were justified by the notion that certain aspects underwent partial conversion or alteration during the drawing process, particularly in comparison to the existing washbasin. The term "design being opportunistic" signifies a transformation in design that is realised through the recognition and encouragement of contemplation regarding the illustrated concepts. By contrasting each level of form entities with the current product, the researcher identified elements of change that contribute to the enhancement of aesthetic value and innovation. The alignment with Scrivener, Ball, and Tseng (2000) suggests that these modifications act as catalysts in design, driving product innovation. Consequently, this study carefully examines the sketches to classify functions across various categories.

4.7 Summary of Chapter Four

Chapter Four of this research focuses on the segment: data collection activities, analysis procedure, and the results of the research findings based on the research methodologies set. For the data collection and analysis segment, data collection activities lasted for 5 semesters of study, included 4 phases of activities, involved 70 respondents from users population, 30 participants of designers, and 8 student Master student. The four phases involved were (1) Visual Inventory study (VIA); (2) Photo-based study (PBA); (3) Verbal protocol analysis (VPA); and (4) Design syntactic analysis (DSA). The first data collection activities, VIA survey study, which is the driver for RO1, was carried out to answer RQ1 through a survey study involving target user groups to collect initial information to identify the main attributes of the unintended behaviour of using mainstream products outside the original context. Using the innovativeness behaviour Model of Hirschman (1988) and Leslie's " two information layer" framework (2012), the photos were analysed to identify unintended interaction attributes that represent theoretical foundations, as well as to determine the representative research subjects for next phase of the study. The VIA data were coded using statistical quantitative analysis (SPSS).

Second phase of data collection was conducted to answer the RQ2 and achieve the RO2. Photo-based research analysis (PBA) conducted through a survey study was used to assess the perceptions of the designer group (four levels of design experience) towards the phenomenon of unintended use of the product and to unravel the differences in user-designer perceptions in assessing unintended behaviour. The survey was used the Pauwels' integrated framework for visual research (2010). Through this method, it helps to show whether the photos can be trusted as research materials (visual elicitation stimuli) for the next phase, namely the VPA experiment. The PBA data was coded into information categories for statistical analysis using SPSS software (version 28).

Further, through the third phase of the study, the VPA study was carried out to qualitatively core study that also to answer the RQ2 and achieve the RO2. Design activities were observed through the VPA experimental setting, in which the data were obtained through three experimental episode sessions (VPAE1, VPAE2, VPAE3). After going through all three episodes, data processing was carried out with the VPA data (i) coded into information categories for qualitative analysis using an open-coding format, (ii) analysing the interactive towards mediator, and (iii) critically analysing the designers' design activities using the reflective practice model proposed by Valkenburg & Dorst (1998).

Closing the last phase of the study, a detailed design syntactic analysis (DSA) experiment on selected sketches was conducted. This fourth phase study was carried out to answer the third research question. Through several stages of data processing for the syntactic experiment, each sketch was analysed based on the theoretical framework of design syntactic analysis introduced by Warell (2001). This phase also intends to verify the applicability of the research framework as a body of knowledge in design science research. The reliability and validity of design syntax analysis is obtained through the approach of triangulating data from various sources as mentioned in the previous section.

Based on pragmatism indicators, the data collection and analysis process in this chapter is carried out according to the approach recommended by Prochner (2022) through the quality indicators framework which emphasizes the quality of methodology in RTD research based on five main categories of quality indicators (i) Traceability, (ii) Interconnectivity, (iii) Applicability, (iv) Impartiality, and (v) Reasonableness. This mechanism helps researchers plan, report, and evaluate the entire research process more systematically. Figure 4.117 illustrates the summary of research flow fragmentation for Chapter Four.

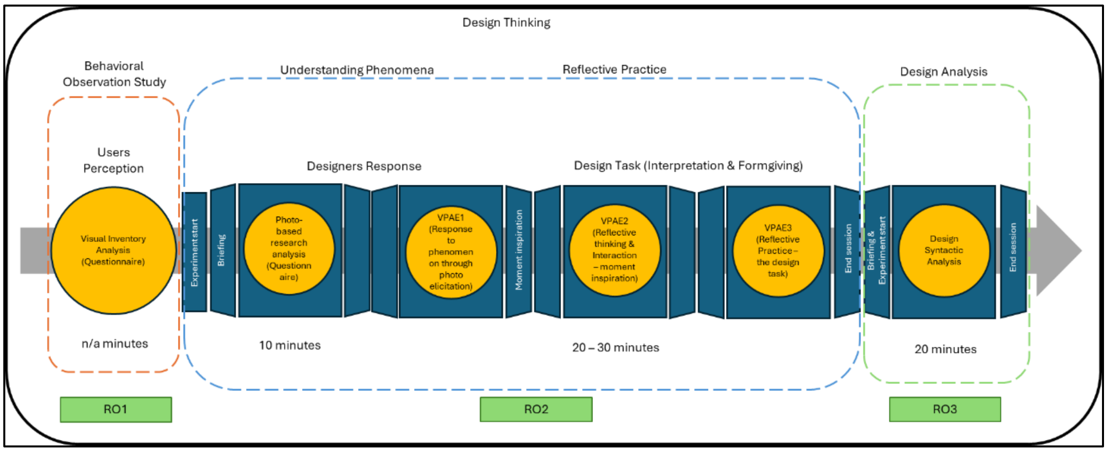


Figure 4.117 The Summary of Research Fragmentations Strategy

The last segment of the Chapter Four presents a comprehensive synthesis of the empirical findings, validating the central contention that the scientific investigation of UHBE interaction that furnishes a robust foundation for advancing design thinking parameters and guiding artefact evolution (Hassan et al., 2022; 2024). The synthesis integrates results from four complementary analytical approaches, VIA, PBA, VPA, and DSA. Firstly, the VIA leveraging visual-based survey methods, confirmed the existence of the UHBE phenomenon, identified its main characteristics, and established the objective assessment of its attributes from the user perspective. Subsequently, the highly reliable Photo-Based Research Analysis (PBA) assessed designers' interpretations, demonstrating that observing unintentional interactions uncovers real-world needs, identifies potential product affordances, and effectively challenges critical thinking to explore new design opportunities. The cognitive core of the study, the Verbal Protocol Analysis (VPA), was conducted in three sequential episodes. VPAE1 (Response to Phenomenon), using grounded theory, confirmed designers' capacity to interpret UHBE and critically respond to its four core attributes, acknowledging its inherent value and opportunities for design consideration. VPAE2 (Reflective Thinking and Interaction) documented diverse reasoning patterns, revealing how design expertise influences the prioritisation of technical versus ergonomic factors in UHBE-based solutions. VPAE3 (Reflective Practice) analysed the "reflection-in-action" (Schön, 1983) of designers, confirming their ability to construct critical evaluations that identify product "misfits" and "misuse," structure complex design problems, and enhance product value through informed conceptual ideation. Finally, the Design Syntactic Analysis (DSA), employing Warell's (2001) framework, verified the usability and applicability of the proposed Unintended Behaviour Design (UBD) Model framework. The DSA confirmed that conceptual design sketches, generated with UHBE considerations, exhibited consistent, opportunistic characteristics promoting innovation, incorporated essential functional content, and adhered to stringent designer-suggested criteria.

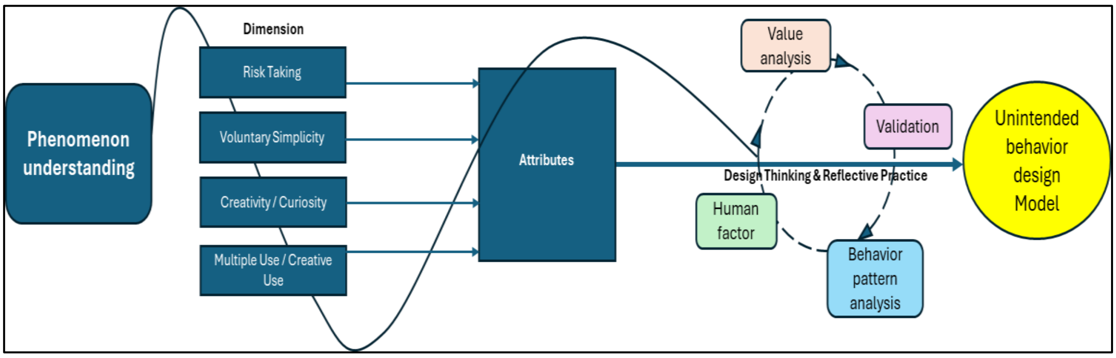


Figure 4.118 Proposed UBD: Product Development Strategic Framework

The findings from the design syntactic analysis indicate that the proposed conceptual framework of UBD in mainstream products is both applicable and advantageous, inspiring designers to create valuable conceptual ideation, sustainable design solutions, and increased product value. The empirical evidence from this integrated methodology robustly validates the UBD model framework as a relevant, applicable, and valuable framework for inspiring sustainable, meaningful conceptual creations, thus successfully achieving all research objectives (see Figure 4.118). This study examines how unintended product use influences designers' thinking and reasoning. Contextual studies illustrate the model in practice, demonstrating its relevance and potential application across related areas of design and product development. As an exploratory study, examining unintended human behavior through the roles and uses of photography, mediators, and sketching revealed opportunities to understand the cognitive strategies employed by designers during conceptual design practice, thereby developing and extending an understanding of designerly ways of knowing, thinking, and acting. Through proposed conceptual model, exposure to real user experiences enhances designer's design thinking parameters, design decisions, sensitivity, creativity, and fostering inclusive product design concept. The findings have implications for design pedagogy, expanding the body of knowledge in design thinking and the development of a conceptual design. This study integrates design research theory with the behavioral research model through pragmatic design research in the Malaysian context, focusing on designers’ design thinking towards the phenomenon of unintended use of the mainstream product that bridges the knowledge GAP within the research problem statement.

CHAPTER 5
RESEARCH SUMMARY, CONTRIBUTIONS, APPLICATIONS, AND RECOMMENDATIONS FOR FUTURE STUDY

5.1 Researcher Interpretation of the Research Findings

Through a series of research conducted during 5 years of the study, the researcher satisfied the overall research method used to achieve three Ros as well as answering three RQs. Based on the findings, this section will present research outcomes of every single approach in this study from the researcher's perspective. Firstly, the outcomes of the VIA approach indicated that four main attributes and one representative of most unintended behaviour were identified and reliable to use as the subject research of the PBA study. Trial and error and Quick solution are the most attractive attributes motivating factors for users to use the product unintentionally when the existing product doesn't meet their needs or in expected situations, followed by social sharing and object ability attributes. Thus, by using the VIA method, the survey study has been proven as an efficient approach to identify the subject under study and answer RQ1. Secondly, through the PBA method, the outcomes indicated that object ability and quick solution are the most motivating attributes for users to use a product unintentionally based on the designers' perspective.

However, users and designers demonstrate different patterns of perception towards the UHBE attribute, where the users emphasize quick solutions and social sharing, while designers focus on object affordance and quick solutions. The diverse perceptions reflect the gap in understanding of the everyday product. Thus, highlighting the importance of integrating both perspectives (user perception and designer interpretation) during the early stages of the design process will enhance usability and functional clarity, thereby supporting human-centered & sustainable product development grounded in real-world interaction. Therefore, in this study, the researcher believed that proposing Photo-based research analysis has been proven as an efficient approach in evaluating responses from the subject under study and answers RQ2.
In investigate deep interpretation from the designer's perspective on understanding UHBE interaction and attributions, this study conducted Verbal protocol analysis to

understand how designers respond towards the UHBE phenomenon, based on their experiences and knowledge through verbatim experiment episode and design task. Three series of episodes conducted during the observation activity indicate that the proposed methods are able to provide meaningful information for this study. For episode VPAE1 (response to phenomenon through photo elicitation), most of the designers interpreted that (i) trial and error is considered a natural learning process in users daily life, (ii) social sharing of the UBHE interaction is socially influencing the behaviour of peoples, and (iii) divergent experience shapes how users make quick decisions and understand the product affordance. Although positive responses were consistent, two expert designers disagreed on unintended interaction, gave justification, and proposed other solutions.

For researcher, VPAE1 approach is significant for (i) recognizing the importance of understanding designers' responses to research topics as a means of generating new product design concepts, (ii) capturing designers' suggestions and feedback on research topics, (iii) providing guidance and justification for their responses, and (iv) fostering higher levels of critical thinking among designers to address hidden user interactions. Furthermore, VPAE2 (reflective thinking and interaction during moment inspiration through mediator provides), there are diverse patterns of interactions identified according to the designer's level of expertise. A total of 1363 interactions towards mediators were captured and recorded reflected that designers' thinking strategies towards the subject under study are supported by real-world feedback, affirmation, stance, and cognitive consideration during the design task. Junior and intermediate designers recorded the highest interaction on technical information mediators (focus on the existing product technically and functionality), senior designers focused on ergonomic information patterns to form the solution, while expert designer engage with artefacts and technical information during the conceptual design stage. Based on the findings of VPAE2, it is indicated that the interaction protocol analysis shows that (i) mediators play an important role in bridging the gap between theoretical and practical design concepts, and (ii) as a tool for evaluating the designer's moment of inspiration (short-term memory). To investigate designers' reflective practice during design task, VPAE3 conducted to evaluate unintended use reasoning in design activities that may aid designers' interpretation in generating product design ideations while framing the problem and integrating their thoughts, as well as design strategies towards UHBE attributes. The key findings of VPAE3 (a qualitative content analysis) indicated how sketching activity provided the necessary context for the framing of the design problem and acted as a catalyst to support the development of problem frames. Based on the finding, four categories of designers reflect their cognitive thinking patterns and link design strategies based on short-term memory, design practice, mediators' interaction, and UHBE attributes during the conceptual design process, moving from broad theoretical perspectives to specific, based on individual abstraction level. Within the experiment, thirty designers formulated eleven design criteria based on unintended attributes and proposed thirty conceptual designs for solutions (based on the subject under study). Through the findings, four levels of designer expertise presented the reflective practice according to the level of experience in design. Junior designers primarily operate at the abstract and semi-concrete levels, focusing on conceptual understanding with limited translation into concrete outcomes (predominantly using a hermeneutic approach in design thinking). Intermediate designers work mainly at the semi-concrete and concrete levels, effectively integrating reflection into practical sketches and solutions (predominantly using a reflective and hermeneutic approach in design thinking). For senior designers, they engage evenly across all levels, balancing conceptual framing, reflection, and implementation systematically (predominantly using a normative Approach in design thinking), while expert designers emphasize the abstract level, strategically reframing problems through deep reflection before developing solutions (predominantly using a problem-solving approach and a reflective approach in design thinking).

Throughout the VPAE3 approach, the outcome of the study indicates (i) how mediators may facilitate solution-focused reasoning, providing a necessary catalyst for creative leaps of insight towards more appropriate or desirable solution ideas, (ii) how sketching is used to address design problems of different levels of complexity, by different level of designers' design thinking, practice, experience, and expertise. To wrap up, after three episodes of the VPA method, the researcher believed that VPAE1, VPAE2, and VPAE3 have been proven as an effective approach for examining designers' reflective practices, cognitive parameters, and interaction during conceptual sketching that integrates UHBE values into the form-giving process, answering RQ2.

Design Syntactic Analysis (DSA) (Warrell, 2001) was conducted using the designer's conceptual sketches during the experiment as an approach to analyse visual or structural elements of a design, as well as to test the applicability of the UHBE principle in the design development process, and propose Unintended Behavioural Design (UBD) framework as a product design strategy and approach for new conceptual ideation that may aid designers' interpretation in generating existing and new product design. Through the DSA study, the key findings indicated that the form structure of 5 representative designers' sketches was successfully assessed using descriptive analysis based on Warell DSA (2001). It revealed that through DSA analysis, justification of design objectives (form and structure) was aligned, the connection between form, function, & meaning was communicated, user experience & emotional comfort (the idea) was demonstrated, visual language, aesthetic, and design components were aligned according to the design format. The outcomes of this study extend the application of DSA into the context of unintended interaction, enriched theoretical discussion on the relation between form structure, function, and behaviour design (UBD conceptual model), which supports both academic rigor and practical design clarity. Based on the method, the researcher believed that DSA has been proven as an efficient approach to test the applicability and the usefulness of the UBD Conceptual Model comprehensively from the subject under study and answers RQ3.

To conclude, the findings of this study provide empirical evidence that addresses the research problem. Through the analyses conducted, this study successfully links the research objectives and the research questions, demonstrating how ROs have been achieved and RQs have been answered. These results not only clarify the issues highlighted in the problem statement but also provide new insights into design thinking and behavioural research.

5.2 Associated Design Research and Behavioural Design through User-Designer Interpretation

Behavioural design, rooted in psychology and cognitive science, plays a vital role in bridging the gap between theoretical models and user reality by focusing on how people act, not just assuming how they act (Lindstrom, 2010). Bloch (1995) argues that the physical form and appearance of a product not only influence user perceptions but also shape psychological responses that can determine the success of a product in the real market (Chapman, 2005; Gilal et al., 2018). This perspective complements the goals of design research by providing empirical tools for evaluating and making realistic, human-centred design decisions. This research fundamentally falls under the category of design research consist of three main components. The first component, the selection of methodology in this study, started with identifying the categories of knowledge involved, citing the categorisation of experiential and practical knowledge by Reason (1994). In research involving the investigation of human behaviour, Reason (1996) recommended a cooperative inquiry approach. The second component, the theoretical framework and design elements, was based on Hassen and Andreasen's (2002) examination of the components of design theory (the design process, design objects, and factors that influence design), which helped to explain how it supported the research process and contributed to the creation of new knowledge, especially concerning human behaviour and interaction with the environment. The third component referred to Cross's (2006) framework, which classifies design research into three main categories, particularly concerning human actions and behaviour in the design process to contribute to new knowledge (research into, for, and through design). In research involving the investigation of human behaviour, empirical research was a methodology highly recommended by Warell (2001) and supported by Cross (2006). Therefore, a paradigm and schematic representation of research activities was developed to clarify the study, including its scope, limitations, and related areas of knowledge that were considered and examined, based on the Design Research Methodology (DRM) developed by Blessing and Chakrabarti (2009). Based on a review of the phenomena of unintended behaviour, theoretical perspectives on unintended product use, a conceptual framework of UHBE was developed. It was also supported by the basic theory of human interaction, use innovativeness, and human behaviour research in the field of marketing and consumerism to obtain a comprehensive perspective. Therefore, the Unintended Behavioural Design (UBD) framework was developed, encompassing design thinking, forms of reasoning, and reflective practice to trigger new questions that arose from participatory and reflective processes, celebrating user experiences, generating data, analysis, and conclusions that contributed to the body of knowledge.

5.3 Research Contributions Component

This chapter presents the conclusions and contributions of this study, focusing on the design research implications for the phenomenon of unintended product use. It is divided into several sections, starting with a summary of the theoretical and empirical studies, the contribution of UHBE research to the fields of education and industry, the contribution of research methodology, and the contribution of the conceptual framework to design education and product development strategies. The last segment in this thesis followed by research verification, validation, and recommendations for future work.

5.3.1 The Key Insight from the Study

Based on the methodology component, there were two sections: theoretical and empirical study. Theoretical studies focused on acquiring and understanding theories from prior research that contributed to the development of the study plan for this study, while empirical studies emphasized various trials designed to validate the theoretical study phase. The specific process and research strategies of the experiments were proposed to meet the research objectives and address the research questions, as well as support the findings and central proposition of the study.

5.3.1.1 Highlight of the Theoretical Study

Blessing and Chakrabarti (2009) introduced a systematic design research approach known as Design Research Methodology (DRM) to support researchers in the field of design to produce research that is structured, iterative, and has a practical impact on design practice. This research adapted the DRM approach by organising design research activities comprehensively, starting with determining the research content, the scope of the literature review, identifying the problem and developing solutions that could be tested in a real context. The explanation of the theoretical study in the first phase of the research was divided into two stages of the design research methodology, consisting of Research Classification (RC) and Descriptive Study 1 (DS-1). In the first stage (RC), the researcher established the background of the study, defined the study area, and refined the problem statement to ensure it was realistic, academically sound, and practically relevant to ensure a holistic view of the field being explored and helped the process of designing a research framework. During this phase, the researcher conducted a comprehensive literature review to identify knowledge gaps, relevant theories, current developments in the field, formulated the research objectives, key research questions, and the preliminary scope of the study. Next, Descriptive Study 1 (DC-1) was aimed at gaining a clear understanding of the current situation related to the research problem, which may or may not contribute to the results of the study. In this stage, theoretical data were analysed in depth to collect strong evidence and understand the theoretical basis that may not be directly identified through previous literature and develop the conceptual framework of the research. The scopes of the theoretical study divided into three components: (i) Design Interpretation and Transition, (ii) Design Thinking in Design Practice, and (iii) Behavioural Study: The Phenomenon of Unintended Use of Product. Through the mentioned strategy, this research was able to identify the current product design challenge in the postmodern era, the design thinking strategy in design practice. While in the study of human-product interaction, the researcher was able to understand the importance of human interaction and behavioural design in design research, identify the behavioural design model from a wide perspective, and understand the phenomenon of unintended use of product.

5.3.1.2 Highlight of the Empirical Study

This chapter details the Prescriptive Study (PS), constituting the third phase of the research, which executed an empirical investigation to generate sufficient knowledge and supporting evidence for the theoretical basis established in the preceding phases. Employing a mixed methods research approach, combining quantitative and a major qualitative strategy, the study was designed to achieve a comprehensive understanding of the research problem and allow for in-depth exploration of human factors, especially in instances of surprising or counterintuitive initial results. This robust methodology guided the study’s three objectives and corresponding research questions. RO1 aimed to identify attributes of unintended product interactions on users’ everyday experiences and behaviour, addressed by RQ1. The study deployed a Visual Inventory Analysis (VIA), drawing on frameworks from Leslie (2012), Collier and Collier (1986), and Hirschman's Use Innovativeness Model

(1980), to identify and understand the factors and attributes of UHBE in everyday life. Preliminary quantitative data were collected via a survey, where seventy participants assessed fifteen photographs depicting unintended product use. The data analysed using SPSS version 28, highlighted patterns that subsequently informed the visual elicitation stimuli for the next stage of research. RO2 sought to evaluate designers' responses towards unintended behaviour attributions through design protocol activity, responding to RQ2. This involved a Photo-Based Analysis (PBA), developed from Pauwel's (2010) framework, to assess thirty practising designers' interpretations of UHBE and compare them with user perceptions derived from the VIA. The results demonstrated that designers possessed the capability to comprehend, assess, and augment a product's value by identifying the four key attributes of unintended interaction. The core of this objective was the Verbal Protocol Analysis (VPA) series, which explored human thought processes in complex design reasoning. The VPA series involved three episodes with thirty practicing designers across four experience levels. VPAE1 (Designers' Response to Phenomena) utilised photo-elicitation stimuli to trigger designers' thoughts, with responses categorised via Grounded Theory coding (Charmaz, 2014; Saldana, 2009). This successfully identified four patterns of unintended use from the designer's perspective and significant weighted considerations for conceptual design. VPAE2 (Designers' Reflective Thinking and Interaction) investigated thinking strategies and interaction patterns, identifying five patterns of designer thinking (Abidin, 2020) and highlighting how reflective and interactive designs helped generate conceptual ideas based on UHBE attribute. VPAE3 (Designers' Reflective Practice - Designing Task) captured reflective actions during a design task, assessing how designers addressed "wicked problems" in the ideation phase. The protocol analysis, utilising Valkenburg and Dorst's (1998) components (naming, framing, moving, reflecting), revealed patterns of reflective practice across three levels of abstraction, providing insight into conceptual ideation within the Unintended Behavioural Design (UBD) conceptual framework. The VPA series collectively substantiated that observing everyday, unintentional user interactions serve as a potent trigger for critical design thinking, facilitating the creation of human-centred conceptual ideas that enhance product functionality and value. RO3 aimed to develop a comprehensive model that integrates unintended behavioural design elements into design development process and strategies, corresponding to RQ3. The aim was to verify the relevance of the UBD model in supporting design strategy and innovation. The conceptual product designs produced by the VPA participants were analysed based on three crucial elements: (i) functionality content, (ii) form consistency and opportunistic design, and (iii) design format based on designer criteria (ergonomics, protection, structure). This analysis concluded that the UBD conceptual framework is effective, serving as a viable initiative for designers to produce conceptual ideas that meet human needs and maximise product value, performance, and functionality at an optimal level.

5.3.2 Research Contribution Towards Understanding Unintended Human Behaviour in Mainstream Products

This thesis presents a unified conceptual framework for Unintended Behavioural Design (UBD), which critically integrates the phenomenon of Unintended Human Behaviour within the context of mainstream product design and the cognitive processes of professional designers. This synthesis constitutes four interconnected and substantive contributions, bridging previously wide and fragmented scholarly material across design thinking and behavioural studies. The contributions are directly tied to the study's three core objectives: First, the research provides a fundamental comprehension of the elemental characteristics and determinants influencing unintended behaviour, empirically validated through a Visual Inventory Analysis (VIA) of user scenarios. Second, it substantially advances the understanding of designers' responses to UHBE, illuminating critical perceptual disparities between users and designers through Photo-Based Research Analysis (PBA). Furthermore, the study elucidated the designer's creative ideation and problem-solving process, the genesis of UHBE related conceptual product ideas which was meticulously articulated and analysed via the Verbal Protocol Analysis (VPA) and the reflective practice model. Third, the work validates the applicability and practicality of the UBD conceptual model for designers. Demonstrated through Design Syntactic Analysis, the framework is proven to effectively guide the generation of innovative conceptual ideas that robustly prioritise product functionality and usability. The conceptual foundation of the thesis is moored in a rigorous literature review across three seminal domains: (i) Design Interpretation and Transition, addressing paradigm shifts; (ii) Design Thinking in Design Practice, examining strategies and reflective skills; and (iii) Behavioural

Studies: The Phenomenon of Unintentional Product Use, which focused on models of Hirschman's (1980) use innovativeness. This comprehensive exploration, initially rooted in psychological perspectives of human cognition and behaviour, successfully established the theoretical basis for accidental interactions, which underpins the novel UBD conceptual framework as an indicator of latent user needs.

5.3.3 Contributions to the Academic Sector

The 21st-century design research landscape, focused on tackling critical challenges, demands a deeper understanding of designer cognition and practice. This research significantly contributes to this evolution by systematically investigating how designers think, reflect, and reason when addressing the unintended use behaviour of products (UHBE). The study's methodological advancement lies in its detailed application of the Verbal Protocol Analysis (VPA), segmented into three episodes (VPAE1, VPAE2, VPAE3). This VPA approach provided an unparalleled, real-time observation of the design process, demonstrating how designers effectively deploy short-term memory, intuition, spontaneous judgment, and tacit knowledge to justify and solve complex design problems. The research strengthens the theoretical framework of design thinking by empirically validating and applying Schön's (1983) reflection-in-action theory within a contemporary, human-centred design context. Moreover, it introduces a novel hybrid analysis model by synergistically combining VPA with Design Syntactic Analysis (DSA), allowing for an underexplored, simultaneous examination of design outcomes from both cognitive (reflective thinking) and structural (syntactic form) perspectives. The findings carry significant implications for design education, offering a structured, pedagogical approach for training students to critically develop their reflective thinking patterns. Ultimately, this study's primary contribution is methodological: it endorses and advances VPA as a robust, scientific tool for systematically investigating the subjective and cognitive dimensions of design thinking, with potential for broader application across diverse design contexts.

5.3.4 Contributions to the Industry Design Context

Design thinking has expanded beyond the boundaries of creative and design disciplines and into the realm of wicked problems in social and ecological systems.

Design thinking in research prioritised comprehending users' needs, behaviours, and challenges through methodologies such as ethnography, contextual observation, and user interviews. In parallel, this research investigated how designers used a variety of cognitive strategies to solve design problems that are closely related to unintended human behaviour towards mainstream products. In this research, designers strived to demonstrate their tacit knowledge, experience, interaction with mediators, and intuition throughout the design process, which indirectly improved their thinking ability within the industrial design context. Based on these findings, the UBD framework was believed to be useful for non-mainstream product designers in overcoming wicked problems from the beginning of the assessment process to systematic analysis. There are five contributions in the context of design thinking that can be contributed by the UBD framework, namely: (i) by using the framework, the designer's language ability is observed through the way designers think analytically, reason, and reflect on their understanding of human behaviour in their design process; (ii) the process of analysing the designer's response to design problems is assessed through utterances, stance assertions, body gestures, and reasoning methods that are identified through a series of experiments in the developed UBD framework; (iii) the reference model used in this research guides design research to identify appropriate observation processes, understand how designers connect cognitive and psychomotor in design activities, and effectively form attributes in conceptual ideas; (iv) understanding the developed framework serves as a reference for use in the academic context; and (v) the data collection method is designed to show a targeted investigation strategy, which can serve as a methodology for understanding design problems related to more complex human behaviour. However, the UBD framework developed in this research still has room for improvement. Therefore, all aspects that can be considered according to their weight and feasibility for other and future research must align with specific objectives.

5.3.5 Contributions to the Methodology in Design Research

This research employed a rigorous methodological framework comprising four interconnected components: Visual Inventory Analysis (VIA), Photo-Based Research Analysis (PBA), Verbal Protocol Analysis (VPA), and Design Syntactic Analysis (DSA). Each component objectively contributed to elucidating the complexities of

UHBE in Everyday life and designer cognition. Visual Inventory Analysis (VIA) constituted the initial quantitative approach. Utilising survey research during a Movement Control Order period (2020-2022) and employing visual elicitation stimuli photos depicting UHBE, from which the VIA gathered raw data from users. Statistical analysis via SPSS version 28 confirmed the high reliability (Alpha Cronbach) of the data, successfully identifying the core attributes influencing UHBE from the user's perspective and establishing a vital foundation for the subsequent phases. The Photo-based Research Analysis (PBA) served as the second component, applying the VIA derived visual stimuli (the wash basin case study) to a survey evaluated by practising designers. PBA, adhering to Pauwels' (2010) framework, quantitatively assessed designers' interpretations of UHBE attributes to identify the perceptual disparities between users and design practitioners. This analysis further confirmed the stimuli's reliability for the cognitive-focused phase. The Verbal Protocol Analysis (VPA) was the methodological backbone, systematically investigating designers' complex cognitive processes across three episodes (VPAE1, VPAE2, VPAE3). VPA was deployed to understand how designers spontaneously think, reflect, and generate conceptual ideas in response to UHBE phenomena. This technique provided insights into the deployment of tacit knowledge and short-term memory during design reasoning (VPAE2) and, crucially, captured reflection-in-action (Schön, 1983; Valkenburg and Dorst, 1998) during the design task (VPAE3). The VPA approach is a significant methodological contribution, offering a scientific, systematic approach for investigating subjective design thinking and promoting a pedagogical strategy for structured reflective development in design education. Finally, the Design Syntactic Analysis (DSA), informed by Warell's (2001) framework, was the culminating component. DSA was employed to verify the feasibility and usability of the conceptual designs produced during VPAE3 by evaluating three critical areas: form functionality, form syntactic consistency, and design format. This analysis provided empirical evidence for the efficacy of the proposed Unintended Behavioural Design (UBD) framework, affirming its capacity to generate innovative and functionally robust solutions to UHBE challenges. The combination of VPA and DSA created a unique pragmatic model, substantially advancing the methodology for analysing both cognitive and structural design outcomes.

5.3.6 Suggestions for Design and Non-Design Stream Education

UHBE research through the UBD framework was used in education as well as design. In line with the current needs in design that prioritised understanding of human needs through behaviour and interaction with everyday objects, the availability of the UBD framework to explore the potential for creating new products was relevant to be revealed or introduced in formal design education. It provided a new perspective in the early-stage idea generation process to increase student creativity, broaden perceptions, and act as a trigger for innovation in efforts to produce human-centred products. This conceptual framework, which was based on observation on observation, helped design education in depth through a basic framework that was systematic, practical, and reliable. Through the construction of this conceptual framework, it not only supported students from the design stream in exploring human needs that were unintentionally revealed but can also inspire other fields to understand the interaction between humans and the environment, ultimately benefiting third parties. In addition, the availability of this conceptual framework was also applicable to non-design stream fields such as business, entrepreneurship, psychology, which specifically benefited their research (according to their respective case studies) and elevated unintentional interactions to intended considerations. Apart from that, this framework was also seen as suitable for use in the fields of photography, creative writing, and fashion design to see how design practices (e.g., shooting or creative writing) aligned with their respective domains. In short, UBD was described as a simple and systematic conceptual framework that could be understood from various educational perspectives.

5.3.7 Suggestions for Product Development Strategies

In design research and development activities, both professionals and design practitioners had the potential to use the UBD framework. In general, research and new creation activities of user products involve a combination of products, humans, and the interpretation of interactions intended by the designer. In line with this research, unintentional interaction was a phenomenon of product use outside the original context (functionality) of the product carried out by humans through cognitive relationships channelled to behaviour that unintentionally allowed the emergence of new functionality for the product. Through the investigation conducted, the reliability and applicability of the UBD framework were applied as a more systematic improvement of existing strategies into interaction product research and development activities based on the findings as presented in chapters three, four, and five in this study. This confidence was based on the characteristics of the conceptual framework, which included flexibility, reliability, and applicability towards mainstream products. In research characterised by innovative products, the UBD framework helped increase the value and quality of products through the characteristics of multi-use, efficiency, comfort, safety features, and human factor design. In other words, design firms or private research and development bodies could apply this framework as a new initiative to deepen the relationship between humans and product interactions through research strategies, analysis, and proposed tools such as the use of planned mediators as authentic sources (offsite observation and investigation) for the development of innovative designs in providing more competitive services. Based on the observation-on-observation approach, the UBD framework, which aimed to deeply understand the value of user interaction, contributed to the embodiment of new functions for existing products. Through this contribution, the application of UBD as an improvement of conventional design frameworks was achieved through the integration of UBD framework applications according to their respective fields.

5.4 Research Verification and Validation

As explained at the end of each chapter for each research activity, the evaluation process of the whole body of work (methodology, analysis, and research procedures) was carried out continuously according to the needs of the study to obtain verification and validation of the research work. In addition to emphasising the level of methodological rigour and assurance of reliability through an integrated approach, it aimed to ensure scientific integrity, applicability of results, and validity of theories developed throughout the research process, align with Prochner (2022). In this study, the verification encompassed an accurate comprehension of the body of work, the provided conceptual framework, and the empirical framework. Therefore, in ensuring the integrity and reliability of this research, two main verification approaches using Abidin (2012), namely internal validation and external validation, were used as a reference basis. Internal validation, or logical verification, was carried out by ensuring that each phase of the study, which included the formulation of objectives, the selection of methods (such as visual inventory, photo-based research, verbal protocol, and design syntactic), and data analysis (photo analysis, SPSS analysis, reflective practice, and design syntactic analysis), was mutually supportive and logically aligned. In addition, it ensured continuity between the study design, the conceptual framework developed, and the interpretation of the data analysed systematically and was free from contradictions and internal confusion, as proposed by Prochner (2022). For research activities involving experiments, the reliability of the analysis was based on triangulation analysis, as proposed by Creswell (2009), which covered video observations, audio records, verbal transcriptions, investigation reports, and copies of design sketches. The VPA experiment used four pieces of evidence as proposed by Cash (2012): content, demonstration, experimental, and construct validation. For research activities involving statistical evaluation, the reliability of the analysis referred to the internal consistency of questionnaire responses through Cronbach's Alpha analysis.

External verification, or verification by acceptance, was also integrated through various forms of review and cross-checking. Acceptance by the academic community was achieved through a process of continuous monitoring and review by research supervisors, PhD fellows in related fields, faculty professors, professional designers, and design practitioners. In addition, evaluation was also made by manuscript reviewers through initial research results presented in proceedings papers and conferences (local and international) as a form of community validation that strengthened the level of acceptance of these research results by the academic community. This verification approach not only strengthened the validity of the research in terms of content and methodology but also added credibility to the findings and design recommendations produced, especially in the context of understanding designer thinking, reflective practice, and the potential of UHBE-based design in mainstream products. Therefore, this study contributed not only to the development of theory but also to the standard of empirical design methods that could be used in future research.

5.5 Recommendations for Future Work

In this research, the researcher produced a conceptual approach proposal through a combination of visual inventory analysis and photo-based research (identifying attributes and reliability of subject research), verbal protocol analysis (assessing the designer's design thinking and practices), and design syntactic analysis (testing the consistency of conceptual product design) with the study of unintended human behaviour towards mainstream products, which contributed to a deeper understanding of the reflective thinking process in design. However, the author realised that this study, through the conceptual framework developed, was not absolute or definitive. On the contrary, it served as a foundation that could be refined and further developed in future research. There were several parts in this research that were limited in certain scopes and components that the researcher may have overlooked. Therefore, several suggestions for future research were identified and could be proposed so that the results of this study and approach could be strengthened in a more organised, appropriate, and systematic way, which may support the development of the conceptual framework, achieve a certain scope of the study, and contribute to other related domains. Several improvements could be made to certain components in UHBE-based research to remain consistent and flexible in every respect.

1. Scope of data collection: The results of this research were based on a modest sample size, but the researcher believes that the involvement of more participants, such as those from nursing, early childhood care, and nursery centres, could have produced more patterns that are difficult to find in the existing literature. This might have provided more external input to this study. Therefore, the involvement of participants from various backgrounds could further enhance future research findings. Another aspect that the researcher identified for improvement in future studies is the data collection method for user groups, which should be conducted face-to-face, allowing for observation through interviews with participants. Through this approach, more detailed and implicit information might further expand the discovery of attributes for UHBE.
2. Selection of study subjects: In this research, the researcher only used one study subject (a wash basin). The subject of this study was chosen (based on the highest selection from the survey results) to represent four attributes of unintended human behaviour. Research on different subjects could contribute to the development of more innovative ideas within its cluster and help preserve the relevance of the theory for designers. The use of a wider range of subjects could ensure that the conceptual basis of UBD remains reliable, applicable and useful for different domains.
3. Research on design practices with designers from other domains: In addition to

design research in the targeted product or industrial design domain, the researcher feels that involving other design practices could also contribute valuable input and views to the subject of study. This was because the subject of study, while focused on ceramic-based product design materials, was not limited to designers alone. It also extended to fields such as UX design, architecture, and engineering. This could assist in identifying essential criteria required for conceptual product design and in generating different concept ideas based on design practices and knowledge.

4. Expansion of the study sample: This study focused on Malaysian professional designers, design educators, and design students, including those from the ceramic field, across various levels of expertise, aged 20 to 50 years and above. In the researcher's opinion, considering the current situation and factors in design education at public and private universities in Malaysia, the involvement of designers from different backgrounds, such as education, culture, experience, knowledge, lifestyle, and religion, could have introduced different inputs and thinking patterns compared to local designers. This includes international designers from countries like China, Iran, and Indonesia who are pursuing their studies in Malaysia. Therefore, the researcher suggests improvements in the scope of designers' backgrounds in design related to UHBE.

5. Comprehensive interaction experience: This research focused on (i) interaction cognition, which examined how users processed information to interpret the function, use, and meaning of the product based on their existing experience and knowledge, and (ii) the sensorial mode, which assessed how users engaged their sense of sight, for example, how a product’s shape attracted attention and created an initial impression. The researcher recognised the need to improve the comprehensive understanding of unintended product use behaviour, for example, by studying the user's affective mode before product use or interaction. The affective mode involves the user's emotional responses to a product, such as feelings of liking, joy, or excitement, which could have been influenced by the product's aesthetics, personal memories, or symbolic associations. Through this consideration, we believe it could expand the scope of attributes and contribute to development of the UBD concept for future product design.

Overall, the researcher acknowledges that there is room for expanding the scope and rigour of this study. Improvements to the conceptual framework and the adoption of broader methodological applications could strengthen its contribution to the development of reflective, responsive, and human-centred design theory and practice.

5.6 Research Summary

As a conclusion to this thesis, this research emphasises that the association between designers and users in exploring unintended human behaviour toward mainstream products has led to numerous significant findings. From the designer group, two key insights emerged: (i) the importance of careful consideration in design thinking and practice, and (ii) the critical role of empathy in solving design problems. For the user group, this research reveals a wide range of human behaviours when interacting with and using products, many of which are beyond the designer's control. In today's global market, products are used by various layers of users with different cultural backgrounds, abilities and contextual needs. This diversity creates challenges in the work environment of designers, especially when they have to adapt designs to various user needs that are sometimes unexpected or unintentional, where the process of coordinating these situations is increasingly complex. By exploring the questions, 'What factors influence unintended behaviour?' and 'How do users perceive and respond to such behaviour?', designers can identify key design priorities and interpret unintended behaviour as valuable feedback. This perspective opens up opportunities for improvement and innovation through a more reflective and context-sensitive design process aligned with actual product use. This study synergised the relationship between user input and designers through VPA experiment activities, focusing on how designers responded to UHBE phenomena using design thinking and design practices and how these responses were translated into conceptual product designs. Further research into designer activities has shown that key considerations, such as structural form, safety, ergonomics, and functionality, can be significantly enhanced when designers are exposed to real user experiences through mediators during simulation tasks in a controlled lab setting. Experiencing situations involving unintended behaviour enables designers to better understand the challenges users face when interacting with a product. This approach not only increases designers' sensitivity to user needs but also deepens their understanding of design, fostering more innovative ideas. When designers are provided with in-depth information and real user experiences, they are better equipped to maximise their creative capacity and promote inclusive innovation through genuine awareness and empathy.

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APPENDICES

APPENDIX A

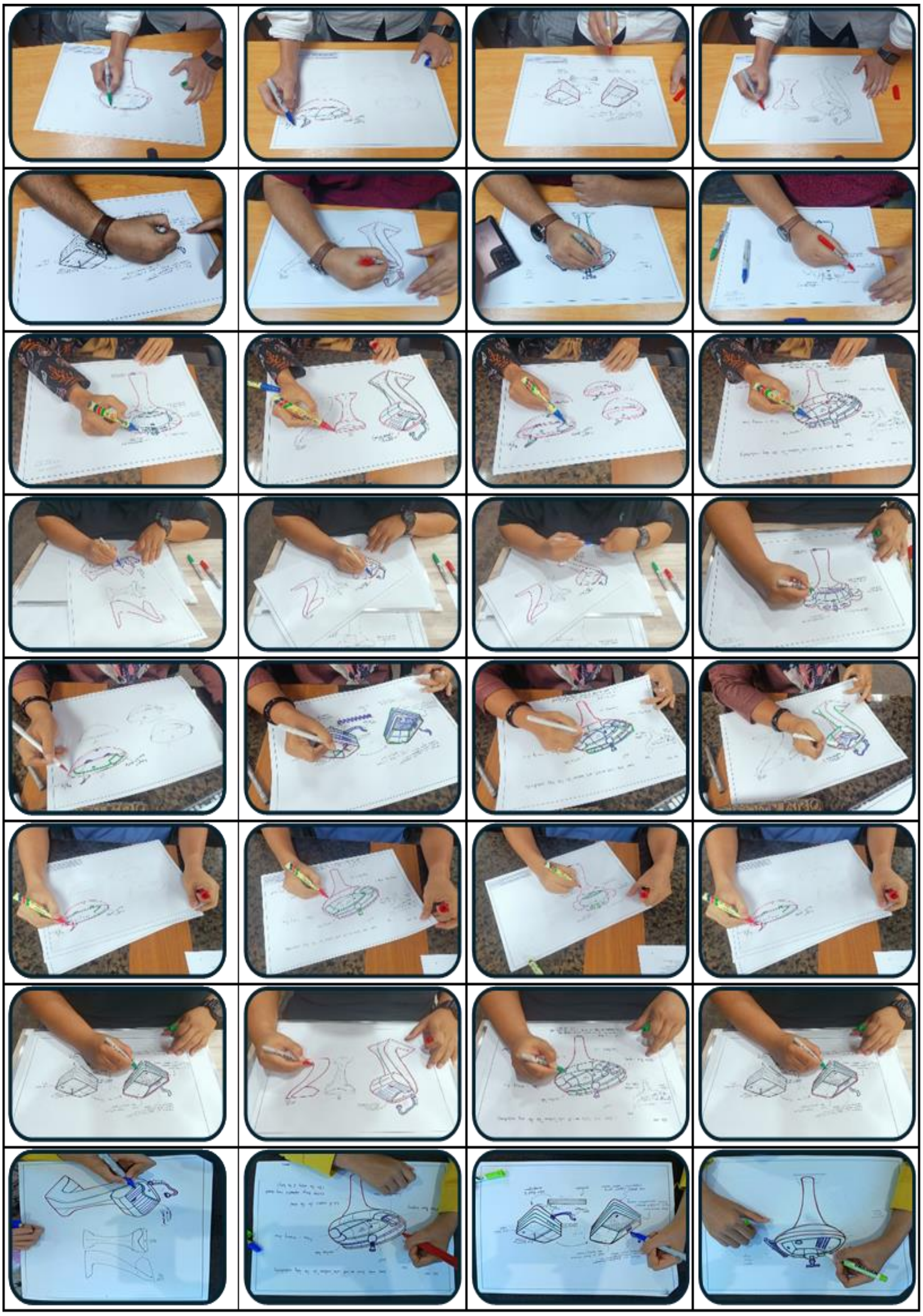
30 Participants of Photo-Based Research and Verbal Protocol

APPENDIX B

30 Sketches of 30 Participants in VPAE3

APPENDIX C

8 Respondents of Design Syntactic Analysis



APPENDIX D
Questionnaire

College of Creative Arts
Unintended Reasoning: Understanding Designer Design Activity Towards User Interaction Experience and Behavior In Mainstream Product

Assalamualaikum and hi to everyone,

My name is Zulkarnian Hassan, currently I am taking a Ph.D. at the College of Creative Arts, UiTM, Shah Alam. I want to take a few minutes of your time to answer this survey. The purpose of the survey is to collect information and user feedback regarding the significant factors that contribute to the interaction of unintended behavior by users with everyday products. The term "unintended use of product" is referring to a daily use object that used out of original function. The objective of this study is to investigate how and why users accidentally use a product outside of its original function to fulfill a specific task, activity or mission.

Visual Inventory Analysis

Introduction

This questionnaire consists of THREE sections: Section A, Section B and Section C. You are asked to answer all the questions, and all information provided will be kept confidential /

Section A: Background information and demographic profile
Section B: Understanding towards unintended use of product
Section C: The Motivation of unintended behavior
The respondents also are welcome to give their perception that could help the researcher in the near future of study

Section A: Background Information and Demographic Profile (Personal)

1. Gender

( ) Male	( ) Female

2. Age

( ) 20-29 years	( ) 30-39 years
( ) 40-49 years	( ) 50 > years

3. Race

( ) Malay	( ) Chinese
( ) Indian	( ) Others

4. Occupational

( ) Student	( ) Employed
( ) Unemployed	

5. Educational Background

( ) SPM / STPM	( ) Diploma
( ) Degree	( ) Master
( ) PHD	

6. Location of residence

( ) City Area	( ) Rural Area

Section B

Understanding unintended use of everyday product

The illustration below represents context of use of unintended behavior of mainstream products among users. All the questions in **Section B and C** refer to the representation of the image

 Context 1: use a hair clip to fix the earphone wire	 Context 2: use food tongs to squeeze the lemon	 Context 3: bathing the baby in the wash basin	 Context 4: flip the chair as a waste container	 Context 5: the cup serves as an elevated tool to heat the food in microwave
 Context 6: Local residents wearing plastic bag on head walk in a rain	 Context 7: bag hanging on the back of the chair	 Context 8: winding the wire with the bottle	 Context 9: put the spoon on the cup	 Context 10: the handle of the food container serves to stick
 Context 11: Separating egg yolk with a Water Bottle	 Context 12: man sitting on a luggage	 Context 13: air mattresses as transport to move goods during floods	 Context 14: pot as a host for breeding fish and eggs	 Context 15: fence serve as hanging clothes

Instruction: please rate to indicate your answer based on the scale;

1 Strongly Disagree
2 Disagree
3 Moderate
4 Agree
5 Strongly Agree

Item	Questions	Strongly Disagree	Disagree	Moderate	Agree	Strongly Agree
7.	You familiar with the situation as above?					
8.	The behavior of using the product out of its original function occur among users?					
9.	You / family / friends ever experienced a situation using a product out of its original function as in the illustration above?					
10.	Human behavior that used the product out of the original function can affect others					
11.	Using products outside of the original function have risk?					
12.	Using the product beyond its original function is to fulfill a specific purpose.					

Section C

The Motivation of Unintended Behavior

MOTIVATION OF UNINTENTIONAL BEHAVIOR						
	tor that influences why user create unintended use of product					
		Strongly Disagree	Disagree	Moderate	Agree	Strongly Agree
PERSONAL						
	Age					
	Based on personal experience					
	Income (personal / family)					
	Technical skill					
	Knowledge					
	Lifestyle					
PSYCHOLOGY (Curiosity & Creativity)						
	Creativeness					
	Innovativeness					
	Trial and error					
	Spontaneous interaction					
	Belief					
	Perception					
	Attitude					
SOCIAL & CULTURAL (Voluntary Simplicity)						
	Influence by others					
	Living style					
	Experience (family / friends)					
	Social Sharing					
	Culturally based conventions					
CONTEXT of USE (Risk taking)						
	Unavailability of the actual product					
	Unexpected situation					
	Save Cost					
	Convenient					
	Quick solution					
	Save Time					
	Economic circumstances					
	Location					

PRODUCT SEMANTIC THAT INFLUENCE USER BEHAVIOR (Preference to explore object Multiple use / Propensity to Reuse object): (How product design can affect user response and behavior						
	Product features that affect users add to or change the product's functionality					
		Strongly Disagree	Disagree	Moderate	Agree	Strongly Agree
	Materials cues					
	Product performance					
	Form cues					
	Object ability					
	Texture					
	Size					
	Usability					
	Fit (for purpose)					
	Symbolic communication					
	Manipulability					
	Symbolic form of original product form					
	Representative of original product function					
ASSESSMENT AND SATISFACTION						
		Strongly Disagree	Disagree	Moderate	Agree	Strongly Agree
	Objects and Situations affect the probability of human behavior changing					
	'Unintentional' behavior occurs when the user is facing a specific problem.					
	Unintentional behavior helps to complete a goal / task in a certain situation?					
	When the discovery of new functionality benefits users, they tend to repeat it.					
	When the behavior is repeated often, it can become a habit in human life.					
	When 'unintentional' behavior becomes habitual, the act can be considered 'with intent' to do it.					

Please choose FIVE of the most significant situations that you / family / friends ever experienced or seen.

( ) 1	( ) 6	( ) 11
( ) 2	( ) 7	( ) 12
( ) 3	( ) 8	( ) 13
( ) 4	( ) 9	( ) 14
( ) 5	( ) 10	( ) 15

Thank you

Consent Statement

Research Information:

Research Title: Unintended Reasoning: Understanding Designer Design Activity Towards User Interaction Experience and Behavior in Mainstream Product

Researcher: Zulkarnian Hassan

Supervisors: Professor Dr Shahriman Zainal Abidin, Assoc Prof Ts Dr Rusmadiah Anwar, Assoc Prof Ts Dr Verly Veto Vermol

Introduction: Brief Description of Research Study

Thank you for agreeing to be a respondent of the survey. I'm Zulkarnian Hassan, a researcher from (Formgiving Design Group) and teaching at the College of Creative Arts, Universiti Teknologi MARA, Perak Branch. I am conducting research on the relationship between affordances and perceptual information of users while interacting with mainstream products "unintendedly". In this study, the term 'unintended' use of product refers to the phenomenon of daily used object that is used out of original function. Users accidentally used a product outside its original function to fulfill a specific task, activity, or mission. The products' functions are added or manipulated in unexpected ways. The purpose of the study is to collect information and feedback from a designer's perspective within the contexts as well to assess data reliability and validation from the respondent. This study aims to investigate how designers respond to unintended interaction in mainstream products. I will be questioning your experience relating to *User Product Design*. What we learn from today's discussion will offer novel design thought parameters concerning product design and expand the current body of knowledge on design education to develop innovative mainstream product design.

Method: Photo-Based Analysis (PBA)

The use of images is one of the generative techniques to elicit people's experiences and thoughts about a product's scenario of use. The role of images in representing and interpreting 'behavior' is considered as a concept of 'visual logic' to analyze user interaction towards mainstream products. To investigate images from a design perspective, a visual investigation and analysis that shapes and is shaped by social practices is conducted on respondents. The purpose of the visual survey is to assess the reliability of the data and get confirmation from the respondents on the visual analysis done by the researcher based on user most selection. The data will be gathered in the form of respondent (designer's) feedback regarding the significance of interaction of unintended human behavior with everyday products. Previous studies have focused on improvising and re-purpose objects, re-use and transforming disposal products and temporary properties. Due to lack of research literature in unintended interaction of human behavior and experience in design perspective, Chamorro-Koc et al. (2011), Dahl (2001), and Collier & Collier (1986) suggest validating the findings through visual data. Visual or photograph inventory is used as a communication tool between respondent-researchers to increase participant control over the research process through participant self-representation so that contextual accuracy and data relevance are valid (Liebenberg. L (2009). This argument was supported by Churchill (1979), Prosser J. and Schwartz D. (1995), and Chamorro-Koc (2011). Further, within this study, the PBA use selected images of action between users and products represented attribution components of unintended interaction of human behavior in mainstream product such: curiosity, voluntary simplicity, risk-taking, and multiuse. The Attribution components were introduced by Price and Ridgeway (1983) and simplified by Menold et al. (2014) in measuring innovativeness action (unintended behavior) of the consumer. Respondents are requested to review and verify visual data photos that show how people use a product unintendedly through Pauwels' Visual Analysis Framework (2010) by; 1) rate to indicate their answer based on the result of analyzed data (visual dimension-attributions of unintended interaction of human behavior in mainstream product), and 2) interpreting responses to gain their further insights. This is done to find out what the answers may show. Validation and reliability data will be utilized to analyze designers' design activities through VPA.

Method: Verbal Protocol Analysis (VPA)

Verbal protocol analysis (VPA) is a qualitative research technique. In verbal protocol analysis (VPA), participants verbalize their internal mental processes while they do an activity, making decisions, or form an opinion. It is common practice to apply content coding to verbal protocols or to analyze them in terms of the underlying cognitive processes. This study was undertaken to find out what designers think about how to deal with unintentional human behavior in everyday situations. It will also look at how the designer's imagination connects design elements based on the idea of "ability" and how this is decided. This finding leads the researcher to decide on an empirical study in which data will be collected on the synthesis of design activities. This can show some of the ways the designer thinks.

Method: Design Syntactic Analysis (DSA)

Design syntactic analysis scientifically links conceptual sketches to the UHB in mainstream product. The researcher hopes to find valuable conceptual ideation, design solutions, and product enhancements related to design technical aspects in each conceptual sketch based on designers' perception, analysis, and reflection during VPA observation. Examining the relationship between form and entity is the focus of syntactic analysis, which points to indicate a consistent approach to visual composition, functionality, and design format of the product (Abidin et al., 2016; Kamil & Abidin, 2015; Abidin, 2014, Warell, 2001;). The elements of design syntactic analysis are denoted according to the theory of modeling [Mortensen, 1995]: (i) Form functionality: A structural and behavioral model based on the domain theory, describing the effect of visual form on the function and organ levels; (ii) Form syntactics: A constitutive model describing the structure and configuration of the form on the organ level (form entities), and material- physical level (form elements); and (iii) Design format: A phenomenon model describing the pragmatic aspect of form design in product development, related to the philosophy of design at a company or design department level. There are four form entity levels in describing evidence of form entity's structure, communicative functions, and characteristics of form elements (Warell, 2001). However, the fourth form entity (The fifth element: Product identity) is not evaluated because it is more inclined to represent product symbols and brands. Those three levels are (i) The superior gestalt level (form entity and elements); (ii) The intermediate level (form features); and (iii) The lower level (product component). In conclusion, syntactic function describes the visual effect of form and gestalt elements interacting. The designer must confirm that the form element's purpose is necessary and intended to achieve the desired visual impression. As described by Warell (2001), If the functionality of some classes is lacking in the design, this may indicate the potential to add functional content to the design.

Concern: if you have any questions or concerns about any parts of this research during implementation or after, please feel free to contact the researcher at;

Ts. Zulkarnian Hassan
College of Creative Arts,
Universiti Teknologi MARA,
Perak Branch, Seri Iskandar Kampus, Perak
Tel: 05 3742136
zulka246@uitm.edu.my

Professor Dr Shahriman Zainal Abidin
Professor
Universiti Teknologi MARA,
Shah Alam
Tel: 03-5521 1699
shahriman.z.a@uitm.edu.my

Participant Consent Form

I, ____ volunteering to participate in an interview/survey/video recording session conducted by Zulkarnian Hassan from College of Creative Arts, UiTM, Shah Alam. I realized that the session (survey/verbal protocol analysis/design syntactic analysis) was intended to collect data on the research of designers' design thinking.

a) Participation is voluntary. I understand that I will not be paid for my participation. If, however, I feel uncomfortable in any way during the session, I have the right to decline to answer any question or to end the session.
b) I am free to stop participating at any time if I no longer wish to do so without penalty.
c) Each session will take approximately.
    (i) PBA survey: 10 - 20 minutes. A copy of the survey result will be sent to me.
    (ii) VPA session: 20 - 30 minutes. A copy of the finished video will be sent to me.
    (iii) DSA session: 20 - 30 minutes. A copy of the finished video will be sent to me.
d) The researcher may use photographic images of my works or write and quote my words with my express permission in his publication.
e) The researcher may only use the video of me demonstrating the sketching activity with my permission.
f) I realized that this fieldwork has received approval and review from the UITM Ethics Committee and College of Creative Arts.
g) Use the contact information provided to get in touch with the researcher (or my advisor, if applicable) with any questions or concerns you may have about the research being conducted.
h) The information was clearly explained, and I have read it and comprehended it. My concerns have been addressed, and I give my informed consent to take part in this session.
i) This information form has been given to me.

☐ By ticking (√) here, I affirm that I am 20 years above and voluntarily consent to participate in these sessions.

All your responses will be kept confidential within reasonable limits.
I will take all reasonable steps to protect your identity.

Thank you for your participation in this study.

Concern: if you have any questions or concerns about any parts of this research during implementation or after, please feel free to contact the researcher at;

Ts. Zulkarnian Hassan
College of Creative Arts,
Universiti Teknologi MARA,
Perak Branch, Seri Iskandar Kampus, Perak
Tel: 05 3742136
zulka246@uitm.edu.my

Professor Dr. Shahriman Zainal Abidin
Professor,
Universiti Teknologi MARA,
Shah Alam
Tel: 03-5521 1699
shahriman.z.a@uitm.edu.my

No Siri				

Survey Questionnaire

Unintended Reasoning: Understanding Designer Design Activity Towards User Interaction Experience and Behavior in Mainstream Product

Method: Photo-based Research Analysis (PBA)

The use of images is one of the generative techniques to elicit people's experiences and thoughts about a product's scenario of use. The role of images in representing and interpreting 'behavior' is considered as a concept of 'visual logic' to analyze user interaction towards mainstream products. To investigate images from a design perspective, a visual investigation and analysis that shapes and is shaped by social practices is conducted on respondents. The purpose of the visual survey is to assess the reliability of the data and get confirmation from the respondents on the visual analysis done by the researcher based on user most selection. The data will be gathered in the form of respondent (designer's) feedback regarding the significance of interaction of unintended human behavior with mainstream products.

Previous studies have focused on improvising and re-purpose objects, re-use and transforming disposal products and temporary properties. Due to lack of research literature in unintended interaction of human behavior and experience in design perspective, Chamorro-Koc et al. (2011), Dahl (2001), and Collier & Collier (1986) suggest validating the findings through visual data. Visual or photograph inventory used as a communication tool between respondent-researchers to increase participant control over the research process through participant self-representation so that contextual accuracy and data relevance are valid (Liebenberg. L (2009). This argument was supported by Churchill (1979), Prosser J. and Schwartz D. (1995), and Chamorro-Koc (2011).

Within this study, the selected images of action between users and products represented attribution components of unintended interaction of human behavior in mainstream products: ***curiosity/creativity, voluntary simplicity, risk-taking, and multi-use***. The Attribution components were introduced by Price and Ridgeway (1983) and simplified by Menold et al. (2014) in measuring innovativeness action (unintended behavior) of the consumer. Respondents are requested to review and verify visual data photos that show how people use a product unintendedly through Burri's Visual Dimension Analysis (2012) by; 1) rate to indicate their answer based on the result of analyzed data (attributions of unintended interaction of human behavior in mainstream product), and 2) interpreting responses to gain their further insights. This is done to find out what the answers may show. Validation and reliability data will be utilized to analyze designers' design activities through VPA.

Please fill in all the information as required.

Name: ______________________________ email: ___________________________

Gender: (   ) Male   (   ) Female

Years of experience in design field:
(   ) 1 - 5 years   (   ) 6 – 9 years   (   ) 10 - 19 years   (   ) > 20 years

Look at the visual. Please rate your perception of the image.

Strongly Disagree	Disagree	Moderate	Agree	Strongly Agree
1	2	3	4	5

Photo-Based Analysis




Visual Research Focus & Design

Photo Analytical Focus: *A wash basin is often used for bathing babies*				
1	2	3	4	5
Photo Content Analysis: *achieve the goal (bathing a baby), user exploits the physical properties of the object (form, surface, height, and water sources)*				
1	2	3	4	5
Visual Dimension: Attributions *Users unintendedly added functionality of the existing product based on:*				
Attribution 1: Curiosity & Creativity *(Trial and error & creativeness)*				
1	2	3	4	5
Attribution 2: Voluntary Simplicity *(Social sharing)*				
1	2	3	4	5
Attribution 3: Risk-taking *(Quick Solution)*				
1	2	3	4	5
Attribution 4: Multiple use *(Ability of the object)*				
1	2	3	4	5

Visual Data Resource					**Subject of Research**				
Photo's Sources: *Images can be found through social media & internet sources*					Photo's Subjects: *user is bathing 2nd user on wash basin*				
1	2	3	4	5	1	2	3	4	5

Overall analysis:
Please rate your satisfaction on overall analysis of the image?

1	2	3	4	5

Unintended Reasoning: Understanding Designer Design Activity Towards User Interaction Experience and Behavior in Mainstream Product

Verbal Protocol Analysis & Design Activity

Verbal protocol analysis (VPA) is a qualitative research technique where participants verbalize their internal mental processes while they do an activity, make decisions, or form an opinion. It is common practice to apply content coding to verbal protocols or to analyze them in terms of the underlying cognitive processes. This study was undertaken to find out what designers think about how to deal with unintentional human behavior in everyday situations. It will also look at how the designer's imagination connects design elements based on the idea of “affordances of form ability" and how this is decided. The finding leads the researcher to decide on an empirical study in which data will be collected on the synthesis of design activities. This can show some of the ways the designer thinks. I am conducting research on the relationship between functionality, interaction, and experience information of users. As a researcher, I will be questioning your experience relating to *User Product Design*. What we learn from today's discussion will help designers and users to differentiate more clearly between three aspects of design: Designing the functionality of an object (system performance), designing ‘potential affordance’ (form element) and designing experience (user experience). All the answers provided in this session will be kept confidential and will not include your names or any other information that could identify you in any report’s writing. During this session, I will keep the notes and audiotapes only for academic purposes of the study and publish the results. Before we begin, do you have any questions about studying?

Design Development: Brainstorming

Calibrating Dimensions

Objective of the experiment: Calibrating designer’s sense and awareness to product function, element, and dimension.

Designer task: To sketch new proposal of the design concept. You may use whatever device you might think of in organizing practical needs into your design. Please make sure that the design has the typical necessities covered (basin, faucet, drain hole and overflow hole). It must appeal to a wide range of users. Use your experience and practical understanding to comprehend the issues related within the product.

- Instruction: Participant will need to refer to the design brief and product as provided. There is also an artificial object provided for your references.
-On design brief, there are technical drawings of the product. Participants may use the technical drawing prepared for them as guided master drawing. You may explore through imitation of situation.
-Use a pencil to structure your ideation and confirm your final idea using a pen.
-Each element provided by participant will be important for product usability potential.
-Please provide any written information that you think would be useful in making your design concept more informative.

APPENDIX E

Research Ethics Approval Letter

www.uitm.edu.my

UNIVERSITI TEKNOLOGI MARA

Pejabat
Timbalan Naib Canselor
(Penyelidikan dan Inovasi)

Reference : 600-TNCPI(5/1/6)
Our reference : REC/12/2021 (MR/1074)
Date : 4th February 2022

Professor Dr Shahriman Zainal Abidin
(Zulkarnian Hassan - 2019896352)
Faculty of Art and Design
Universiti Teknologi MARA
40450 Shah Alam
SELANGOR

Dear Professor Dr Shahriman,

APPROVAL LETTER - UiTM RESEARCH ETHICS COMMITTEE

Thank you for submitting your research proposal to Research Ethics Committee (REC). After considering your application, the Committee approved your proposal entitled "Unintended Reasoning: Understanding Designer Design Activity Towards User Interaction Experience and Behavior in Mainstream Products" at Faculty of Art and Design, UiTM Shah Alam and Seri Iskandar Campus, Majlis Rekabentuk Malaysia Kuala Lumpur, Persatuan Pereka Perindustrian Malaysia Kuala Lumpur and Roca Malaysia Sdn. Bhd., Selangor.

Details of the approval are as follows:

Ref. number:	REC/12/2021 (MR/1074)
Approval Period:	4th February 2022 until 30th January 2023
Authorised personnel:	1. Professor Dr Shahriman Zainal Abidin 2. Zulkarnian Hassan

The UiTM Research Ethics Committee operates in accordance to the ICH Good Clinical Practice Guidelines, Malaysian Good Clinical Practice Guidelines and the Declaration of Helsinki. The approval of this project is conditional upon your continuing compliance with these guidelines and declaration.

We draw to your attention the requirement that a report on this research, must be submitted every 12 months from the date of the approval or on the completion of the project, whichever occurs first. Failure to submit reports will result in withdrawal of consent for the project to proceed. Amendments, if any, to the study documents are to be submitted to REC for approval.

If you require further information, please contact REC Secretariat at 03-55448069/03-55442794 or email at recsecretariat@uitm.edu.my.

Yours sincerely,

PROFESSOR DATO' DR ABU BAKAR ABDUL MAJEED
Chairman
UiTM Research Ethics Committee

c.c.: Dean, Faculty of Art and Design, UiTM

Universiti Teknologi MARA
Aras 3, Bangunan Wawasan
40450 Shah Alam, Selangor, MALAYSIA
Tel: (+603) 5544 2004/2255
Faks: (+603) 5544 2070

APPENDIX F

Research Copyright Registration (Myipo)

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INTERNATIONAL CONFERENCE ON ENGINEERING AND PRODUCT DESIGN EDUCATION
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THE VALUE OF UNINTENDED HUMAN BEHAVIOUR IN EVERYDAY PRODUCT DESIGN

Zulkarnian HASSAN, Shahriman Zainal ABIDIN, Rusmadiah ANWAR* and Verly Veto VERMOL
Formgiving Design Research Group, Universiti Teknologi MARA, Malaysia
*Corresponding Author. Email: rusma935@uitm.edu.my

ABSTRACT
Everyday product design strives to identify a fit between people and technology towards higher usability and more human-centric design approaches regarding product concept ideation. Notwithstanding, limited discussions on unintended human behaviour in interaction design studies and ambiguous methods to interpret the daily phenomena in design activities deter a sound understanding of human-product interaction and communication: a vital criterion for designer's education purpose. This study aims to disclose a pattern of unintended behaviour design (UBD), emphasize its values from various multidisciplinary design expert viewpoints, offer novel design thought parameters concerning everyday design, and expand the current body of literature on design education to develop innovative everyday product designs.

Keywords: Unintended human behaviour, everyday product, user experience, interaction design

1 INTRODUCTION
Individuals interact and communicate with multiple product types for various purposes daily. For example, empty bottles are innovatively utilized to separate egg yolks from their whites, Coca-Cola is employed as a substitute for household cleaning detergents and wire hangers are transformed into disposable towel holders. Such inadvertent discoveries render human life as meaningful and convenient rather than the creations derived from empirical trial-and-error studies. Specifically, a washbasin could be used beyond its intended purpose of washing hands and faces to clean clothes, bathe babies and take ablutions (for Muslims). However, non-designers unintentionally engage in the creation of novel functions with innovative product usage (see Figure 1) [1].

Figure 1. Example of unintended use of product in everyday contexts

Everyday design is not a novel phenomenon in design-oriented studies with a fair acknowledgment of diverse design concept connotations. Regarding the term 'everyday design' under unselfconscious design, users inadvertently employ present product functions in novel ways for goodness of fit [2]. Suri [3] coined the term 'everyday thoughtless acts', which implies perceptions of intuitive designs and individual behaviours and experiences for optimal ideas and alternatives. The notion was then empirically explained as unexpected behaviour [4],

designing for appropriation [5], unorthodox use [6], non-international design, design by use [7], and unselfconscious interaction [8].
The design process is perpetuated through projects, re-usage, customization, appropriation, do-it-yourself, and everyday designs without undermining designers' intentions [9]. Design activities that strive to attain a specific objective in specified circumstances extend beyond designers to other relevant and professional design and non-design areas. Users are acknowledged as 'actors' in everyday product development following the interest and enthusiasm in designing user experience, which leads designers to holistically comprehend and interpret human behaviours and interactions by examining unforeseen elements with the potential to inform the product development team. The widely-utilized everyday design notion by scholars relates to human behaviour where users consciously (or unconsciously) and intentionally (or unintentionally) engage with everyday objects. This study employs the term 'unintended behaviour design' or UBD to emphasize its attributes. Unintended behaviour denotes (i) inadvertence as a purpose or goal without deliberate intention (ii) or an impromptu behaviour demonstrated without planning. In Leon Seltzer, "the state of mind that gives rise to creativity does not occur consciously and critically but occurs when the mind is unconscious, not evaluating, unintentional or spontaneous" [10]. Notably, research on unintended human behaviour towards product usage remains lacking compared to the intended counterpart. The 'unintended behaviour' underpinning human activities could potentially be factored into product design strategies. Based on past research, the UBD impact on user-designer proves to be ambiguous following a lack of strategy in comprehending user interpretation and behaviour from designer viewpoints. Given that the paucity of such discussions cause designers to disregard its potential and value, this study attempts to justify UBD values together with the key determinants of everyday product design. The proposed study would elaborate on implicit user interpretations of individual behaviours from designer perceptions to recommend how designers could examine the other side of human values and expand their design thoughts to another level.

2 AIMS AND OBJECTIVES OF STUDY

This study strived to present (i) a novel design thought parameter, (ii) guidelines for new product development, (iii) the expansion of design education, (iv) a sound comprehension of user response, and (v) the exploration of design-based activities towards unintended human behaviour-mainstream product interactions within an impromptu setting. The current study also aims to determine the (i) key determinants and characteristics of unintended use interactions in daily life and (ii) explore designers' interpretations and responses towards unintended use behaviour interactions. The reasons underpinning unintended use reasoning in design activities would be further assessed to facilitate designers' interpretation in product design conceptualization. The researchers would also identify the viability of establishing a UBD guideline encompassing approaches, methods, and skills for designers' guidelines.

3 RESEARCH BACKGROUND

3.1 'Unintended behaviour' from psychology perspectives

Gibson's [11] book, 'The Ecological Approach to Visual Perception', presented the term 'affordance' in psychology to justify people's environmental perspectives based on the possibilities for action through object and space affordance, which are reliant on users' physical capacity. Affordance implies user competence with an object. For example, a pair of pliers enables users to perform specific actions: tightening and opening, knocking, and throwing. In the design community, Norman [12] coined the term in his book, 'Psychology of Everyday Things', where object 'affordance' denotes users' perceivable action possibilities as a novel potential. Nevertheless, Gaver [13] rectified the misconceptions entailing the Gibson-Norman affordance connotation through his framework: false affordance exists when action is palpably depicted despite its impossibility. Figure 2 illustrates the affordance theory and how an object facilitates user actions that differ from its intended function.

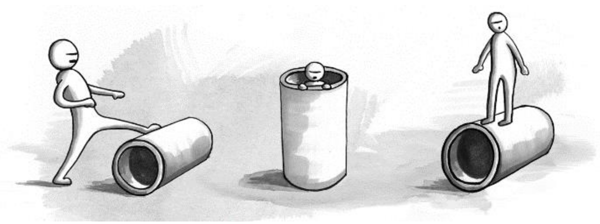

Figure 2. The concept of affordance

Unintended behaviour demonstrates similarities in the given context where object-oriented capacities cause inadvertent usage. Nevertheless, both connotations require due consideration in the design process as the action could only be performed if the object permits it and the user is cognizant of its competence. Based on human creativity-oriented studies, human (locus of control and metaphoric thinking capacity) and situational (time restrictions and situational engagement) elements impact daily interactions: intended behaviour, creative consumption, self-expression, and experience [14]. Individuals would plot object performance possibilities based on their model concept of object performance. The affordance concept denotes object attributes and human interactions to implicitly create the potential actions associated with perception and ability. People create novel object competence to complement their requirements across other settings in the wake of affordance under UBD. Such capacities could catalyse novel design possibilities and insightful ways for designers to develop a specified purpose.

3.2 Research on human interaction and behaviour factor of everyday product

The term ‘interaction design’ was derived from a user interface design-software integration in the early 1980s. Nevertheless, recent research contended the aforementioned connotation to be a common misinterpretation where interaction-oriented designs solely concern software interface and its subsequent intricacies [15]. The interaction process occurring in daily routines motivates people to engage with, adapt to, and internalize their immediate environment. Essentially, interaction design aims to foresee individuals’ product usage, experience modification, and self-designing. Norman’s book, ‘The Design of Everyday Things,’ presents three design levels: visceral, behavioural, and reflective. Specifically, “the interaction at behavioural level is the home of learned skills, triggered by situations that match the appropriate patterns. Actions and analyses at this level are largely subconscious. Even though we are usually aware of our actions, we are often unaware of the details” [12]. The behavioural level denotes the controlled element of unconscious human actions that perform situational assessments to develop a goal-based approach that could be effective in the short run with minimal actions. Behaviour design entails usability, usage effectiveness and pleasure, performance, and object workability. Notwithstanding, designers themselves struggle to outline their association with relevant experiences and predict product functionality. The process of transforming and appropriating objects from design has expanded the current body of knowledge across multiple disciplines in interaction design for the past years [9]. Although design-based studies serve to explore how individuals interact with designed objects using observation and analysis, new functions, and innovative and creative re-use, the interaction did not occur parallel to designer intentions following insufficient resources, human factors, daily experiences, and specified contexts. Although most scholars are positively conscious of creative product behaviour for novel functions [16][17], the designed artifact is utilized as opposed to designers’ initial plans or expectations following an inadequate comprehension of everyday design towards unintended behaviours. Design engineers opine that the design principle for creative unintended use could be significantly developed and applied to complement future design works. The experience of emergent behaviours during product interaction would project future potential values for designers.

3.3 Significance of unintended human behaviour in design research

Human behaviour denotes human-environment connections with the potential to express mental, physical, and social capacities and address internal and external stimuli throughout their lifespan. Unintended behaviour is a psychologically-controlled physical activity encompassing potential human creativity and innovation in daily interactions. Suri's book implies that "things like unintended way usually indicate something about people's need that designer should take for granted to translate into design opportunities" [3]. Furthermore, users create novel and multi-uses that imply the extent to which people accept novel notions and make innovative and autonomous decisions following their experience and that of others through unintended behaviour. Creative use (unintended behaviour) denotes problems integrations to resolve novel notions [18] and experience new sensations based on use innovativeness-oriented studies [19]. Hirschman [20] proposed the use innovativeness model constituting three primary elements and two behavioural types while creatively employing a current product: (i) various product usage in its context (multiple use) and (ii) product usage outside its context in unintended ways (creative re-use) (see Figure 3).

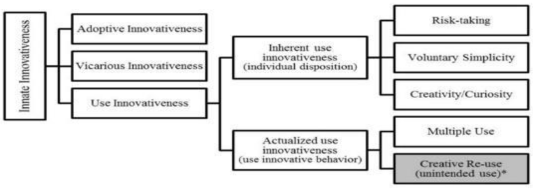

Figure 3. A use innovativeness model

The UBD could not be separated from design education albeit its distinction from professional designs given its part in education. From professional designers' assumptions, UBD allocates artifacts for alternative usage, which only depicts designers' misconception of multiple contexts or the designer-user intention gap. Although UBD merely offers design prerequisites for designers, relevant research is deemed pivotal as designers could not foresee dynamic design usage and contexts. Thus, people are entitled to customize an artifact following their needs. As UBD is a more valuable design resource to be employed with other counterparts (personal experience) compared to novel creations, the proposed study would examine the UBD value in design activities within a broader setting.

3.4 Design for behaviour change

Individual wrong behaviour leads to larger-picture social issues, which all too often struggle with taking actions that are not the result of a lack of motivation or information. The intention-action gap refers to the large gap that exists between people when one's values, attitudes, or intentions don't match their actions. In behavioural change research, people always struggle to turn their motivation into action or to make good decisions. Behavioural science studies in product design help designers understand how users think and how their minds work. To intentionally change behaviour in the best interests of the users, a thorough understanding of how their minds work should be developed. They perform optimally in the wrong context, which can lead to cognitive biases and unintended behaviour or unexpected decision making because of limited attention, memory, and willpower of the user. It demonstrates that the intention-action gap occurs as a result of user minds and environmental influences. There is no such thing as a neutral design. The contextual environment heavily influences user decisions and behaviours. Environments and objects with which users interact should be thoughtfully and carefully designed in order to make the process intentional and beneficial to the people in lines with current design education.

3.5 Interpreted human experience through designer hermeneutic perspective

Martin Heidegger's hermeneutic circle concept (1927), envisions the whole in terms of the reality underpinning an individual's enriched experience on a daily basis. Gadamer further denoted hermeneutic as "the anticipation of meaning or an iterative process based on the horizon of understanding, prejudice, and conversation as a model of understanding [21]. The hermeneutic circle approach in the design process, which constitutes any form or product, denotes the past circumstances of both designer and artifact that constituting the meaning of human experience, mitigation of prejudice, and expansion of the designer's horizon. Designers are aware of the potentially misleading past experiences following human experience despite multiple predictions on product functionality strategies. As such, designers are required to integrate hermeneutic skills and attain congruence between (i) creativity, technologies, and human behavioural interactions and (ii) user's perceptions of daily experiences rather than interpreting personal intentions. Overall, utilizing a product as a medium for user response provides a broad viewpoint for designers parallel to Cross [22]. Interpreted user behave our might include functional quality, performance, efficiency, and ergonomics following Crilly's [23] elaboration on Mono's semantic functions (product factor: form and material) - description, expression, exhortation, and identification. Mono's communication process model outlines product-user communication strategies through transmitted meaning (an optimal conversation) for designers to learn the origins of a personal memory system and ascertain the presence of inspiring, challenging, and expansive ideas with the hermeneutic circle [21]. In this vein, a design functions to translate user needs through hermeneutic circle and interactions with the designer under Shannon and Weaver's model.

4 PROBLEM STATEMENT

Products are regularly employed in multiple ways as opposed to their original functions intended by the designer [1]. Unintended product use implies a daily conversion from normal to abnormal phenomena regardless of person and place [4]. Following Wongkitrungrueng [24], unintended behaviour is regularly disregarded by multiple designers. Product usage satisfaction and dissatisfaction might be portrayed in implicit product functions through unintended behaviour, which is unaddressed by scholars, designers, and organizations, rather than explicit counterparts. Based on Dix [5], an intended use (by designer)-actual use (by users) gap was determined following creative misuse owing to various aspects. The ignorance of intended functions instigates two implications that are deemed disrespectful to designers: i) positive values and ii) negative and risky impacts for users. The situation suggests there is a huge communication gap between users-designers. The question of why designers ignore unintended behaviours in the design process will unravelled from their perspectives. Hence, the UBD context needs to be duly expanded in the design process stages to benefit designers, users, and product sustainability and address the paucity of relevant scholarly discussions: an inevitable gap that must be addressed.

5 UNDERSTANDING SIGNIFICANCE FACTORS BASED ON LITERATURE

The substantial aspects entailing UBD value with potential contributions in designing everyday product design are duly revealed. The discoveries here are presented under the study background (i) integrating and interpreting designs and users in every design activity remain ambiguous despite multiple relevant studies, (ii) the human-centred design concept with individual experience is a broad phenomenon that complements people's requirements through a holistic comprehension of behaviour, interaction, psychology, and environmental aspects, (iii) the UBD value should be included as a design requirement in the design process to successfully envision the user-based design concept, (iv) user-oriented and user experience design concepts for design interaction ideas prove to be more valuable than designers' hermeneutic skills, and (v) a critical study should be performed to assess how designers interpret a user's idea by integrating the UBD value in mainstream products through designers' sketching activities.

6 PROPOSED RESEARCH METHOD

A qualitative study would be conducted using a descriptive research design to (i) address pertinent questions and (ii) assess the elements frequently incorporated by product designers in the industry and academicians with emphasis on designers' interpretations of unintended human behaviour values in idea creation through summaries in the literature review. The first approach implies a semi-structured interview session involving local respondents through verbal protocol analysis to examine the key determinants of unintended behaviour in everyday activity. Local product design experts would be interviewed to denote the UBD value and answer why most designer disregards it. The next approach involves naturalistic video observations for data gathering on inherent gesture patterns in unintended human behaviours towards a particular product. Empirical research would parallel users' psychological activities during product interaction. Respondents would be arbitrarily involved in the simulation session of how and why their unintended behaviour occurs towards a specified product based on the designer-controlled environment. This study primarily aimed to aid designers' interpretation of inadvertent behaviours and gesture patterns. The final approach entails video observation and verbal protocol assessment that would be conducted with a sketching activity. The product design experts are required to comprehend the reasons underpinning unintended behaviour and how users could experience the product during this experiment. This technique strived to observe the degree to which product designers interact and communicate with visual language by sketching [25] in the design following the UBD value. Data validation would be conducted with the perceptual product experience (PPE) framework [26] entailing two dimensions (presentation and representation), which involves a presentation on the direct stimuli ability related to experience, interpretation, comprehension, and recognition. Interactive elements, behavioural response, and experience are significantly associated with the presentation dimensions in the proposed study setting.

7 CONCLUSIONS

Designers function as actors who are explicitly engaged in the design process and accountable for their parameter development in design thought by perceiving all the significant opportunities and potentials by exploring and evaluating unintentional human behaviour. The examination of such a phenomenon and its intricacies would induce positive outcomes in product design and other disciplines following past study statements. An in-depth exploration would motivate designers to focus on user experience designs encompassing daily behaviour and interaction. Specifically, a critical descriptive study is necessary to support the argument and affirm the potential in designers' design process. Unintended behaviour remains significant in generating novel ideas and comprehending potential human needs despite inconsistent opinions owing to the complexities in determining unintended behaviour responses within human cognition. Behavioural research under the design process would leverage design education in resolving the issues pertaining to daily behaviour and interaction towards built intuitive designs, user experiences, and understanding user unintentional behaviour with mental, physical, and thought-based interpretations. Unintended behaviour has reflected its distinct value, which has been constantly disregarded by designers who should perceive implicit user requirements by observing their behaviours for innovative design education concepts. Notably, empirical contributions from multiple disciplines, including behavioural science result in multiple methods entailing the multidimensionality of product experience given the shift in design research trends from intended design to human experience.

ACKNOWLEDGEMENTS

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VISUAL INVENTORY ANALYSIS: IDENTIFYING ATTRIBUTES AND PATTERNS OF UNINTENDED INTERACTION TOWARDS MAINSTREAM PRODUCTS FROM USER'S PERSPECTIVES

Zulkarnian Hassan[1*]
Shahriman Zainal Abidin[2]
Rusmadiah Anwar[2]
Verly Veto Vermol[2]

Universiti Teknologi MARA, Selangor, Malaysia

*Corresponding e-mail: zulka246@uitm.edu.my

ABSTRACT This paper reports empirical studies that have been conducted explore the context of use and user experience towards the phenomena of human behaviours within mainstream products. Through a natural observation approach, this study investigates the nature and factors that trigger unintended behaviour between users and daily objects. Unintended use of the product has been identified as being triggered by individual experiences, psychological factors, environmental insistence, and object affordances that shape the behaviour. In this study, visual representation method that represented images of unintended interaction was used to collect data and information through a survey. Preliminary results show significant descriptive pattern within different dimensions, which led to the identification of the attributes of unintended interactions between human cognition and behaviours in the mainstream products. The findings of this study will assist designers in expanding their perspective on the potential for discerning users' needs within the design thinking process through an examination of the motivations behind unintended behaviours and human interaction toward mainstream products.

Keywords: Mainstream Product, Unintended Behaviour, Visual Inventory, User Interaction, Design Thinking

INTRODUCTION

The phenomenon using a product in a novel way encompasses the interaction between cognition process and behaviour pattern that influences human actions. In daily routine, users interact with a mainstream product to perform and streamline their everyday tasks. In this study, mainstream products refer to items that are widely accessible to the general population, such as cups, chairs, etc. In certain circumstances, individuals may encounter a lack of access to essential products, whether due to urgent or emergency conditions. For instance, people pour soft drinks on rusted nuts and bolts to help loosen them. To address the issue, individuals seek alternative items that possess the capability to effectively fulfil the intended objective. In psychology studies, the phenomenon was defined as unintended behaviour when people unintendedly use a product in a way that deviates from its designer's intent. Nevertheless, the occurrence of unintended conduct remains uncertain and dynamic, influenced by individuals' creativity and environmental interaction. Unintended behaviour can be a behaviour exhibiting inconsistency as a goal or objective without intentional intent, and/or unintentional behaviour exhibiting a behaviour without planning (Hassan et al., 2022). According to Leon Seltzer," the state of mind that gives rise to creativity does not occur consciously and critically but occurs when the mind is unconscious, non-judgmental, involuntary or spontaneous" (Dan, 2015). Unintended interactions occur regularly as users connect with diverse objects. In other cases, object-oriented causes unanticipated object use. Both meanings must be considered in designing process because such activity can only be performed if the object allows, and the user believes in its efficiency. The statement posits that the concept of "affordance" reveals that things and human interactions inherently offer perceptual and ability-based opportunities for action. Norman (1988) coined "design affordance" in "Psychology of Everyday Things" that design affordance pertains to the way users perceive the capabilities of an object. Amri and Akrout (2020) assert that Gibson's 'theory of perception' posits that human beings acquire information about objects by direct perception, and this comprehension is intricately linked to the potential behaviour manifested by the environment. In users research studies, the ‘use innovativeness’ behaviour model (Ridgway and Price, 1994) has similarities with unintended behaviour in such a way that it is impacted by the context of use, the attributes of the object, and the individual's experience. Nevertheless, comprehensive elucidation of the characteristics that embody the behavioural aspects of user innovation is inadequately examined in the realm of user design research. Therefore, this study will employ the 'use innovation model' approach to evaluate and explore the patterns of unintended product interactions among users.

LITERATURE REVIEW

Human behaviour demonstrates a human-environment relationship with the potential to express mental, physical, and social capabilities that address internal and external stimuli throughout their lifetime. In this paper, unintended behaviour is defined as psychologically controlled physical activity encompassing potential human creativity and innovation in daily interactions. In user research, unintended use of a product is a term which refers to the creative use of a product by an individual when there is an integration of problems to solve and new sensation experiences by the individual (Hirschman 1980). Ridgway and Price, (1994) agree that unintended behaviour incorporates new ideas and solutions to problems and the desire to experience new sensations. In this case, Midgley and Dowling (1978) argued that the use of products in different ways refers to the degree to which an individual is receptive to new ideas and makes innovative decisions independently of the experiences of others. Suri states that" things like unintended means usually indicate something about the needs of people that the designer should translate into design opportunities" (Suri, 2005). In user experience research, academics and practitioners are interested in seeking innovation to satisfy users’ responses to the design process, while industrial and products designs seek to identify early adopters who provide insight into a product that enhanced designers’ thinking. However, the literature review reveals that existing product studies only focus on down-cycling (recyclable) and up-cycling (remanufacturing). There is lack of investigation on an existing product interaction with no alterations to its physical attributes. To assess the factors that influence of unintended behaviour, use innovativeness model was applied as a dimension to investigate the attributes represented. It measures the degree to which individuals are willing to try, adopt, and creatively use existing products in new ways in their daily lives. However, one of the problematic features of research on innovation is the measurement of used behaviour (Hirschman 1980). According to Hirschman, research is needed to refine distinctions between types of innovative behaviour towards using the product in various ways and in unintended ways. Thus, he introduced the use innovativeness model encompassing two types of behaviour when users use existing products creatively: Inherent use innovativeness (IUI), and Actualized use innovativeness (AUI). Hirschman [1980] along with Ridgway and Price [1994] provide theoretical support for the use of innovativeness definition by emphasizing 5 dimensions in Model of use innovativeness to assess human innovative behaviours: (i) risk-taking, (ii) voluntary simplicity, (iii) creativity/curiosity, (iv) multiple use and (v) creative use. Through a critical review of measuring innovativeness, Menold et al. (2014) have proposed the use of psychometric instruments for the evaluation of innovative behaviours in general. They summarize Hirschman and Ridgway and Price dimensions into four dimensions in measuring use innovativeness attributes, actions, and cognition: (i) creativity/curiosity, (ii) voluntary simplicity, (iii) risk-taking and (iv) multiple use. These components are the focus of this paper to identifying unintended attributes and patterns. The attributes representing each dimension are extracted through a systematic review under the notion within the research area such as unexpected behaviours, designing for appropriation, unorthodox use, non-international design, design by use, and unselfconscious interaction (Hassan et al., 2022). The following are the main components of the dimension as well as attributes representation of unintended behaviours used in this study.

Creativity and curiosity: According to Menold et al. (2014), creativity and curiosity are defined as creating new products or disassembling products to view their inner workings that are indicative of cognitive style. Through systematic study, creativity and curiosity are influenced by perceptions, beliefs, attitudes, creativeness, innovativeness, spontaneity, and trial and error. **Voluntary simplicity:** Menold et al. (2014) defined voluntary simplicity as an individual preference for recovering previous products for full utilization, with cognitive effect as the motivational factor. Voluntary simplicity is not limited to individual preference but is influenced by social, environmental, and political aspects. The characteristics may be influenced by living style, cultural context, ethical factors, ecological awareness, and social experiences. **Risk-taking:** Risk-taking preferences refer to humans who lack a fear of trying new things with the objects surrounding them (Hirschman, 1980). People tend to take risk because of individual comfort (Menold et al., 2014). The attributes of risk-taking are unavailability, unexpected, cost-savings, convenience, quick solutions, time-saving, location, and economic factors. **Multiple use:** Multiple use refers to the preference to explore objects with varying potential and propensity to reuse objects (Hirschman, 1980). Menold et al., (2014) defined multiple use as the relationship between a product's perceived value by an individual and the potential of the product to be used in multiple ways. Norman asserts that the symbolic communication occurring between an object and a human has a direct influence on how the individual perceives the accessible behaviour that is offered within the surrounding environment (Norman, 1988). Through systematic review, multiple use is influenced by material cues, product performance, form cues, object ability, texture, size, usability, fit for purpose, symbolic communication, manipulability, symbolic form of original object, and representation of original product function. Most of these studies discuss how factors determine the level of motivation that affects the user's interaction with the product and how it correlates with factors of unintentional use of the product.

METHOD

This study uses questionnaires as a means of collecting data. The photograph inventory method is a quantitative approach that can be utilized to assess the unintended use of mainstream products by individuals. Images of the photo inventory are sourced from natural observation, social media sharing, etc. The utilization of imagery is employed in the assessment of human behaviours, as outlined by Collier and Collier (1986). Image representations have the capacity to evoke individuals' cognitive processes and personal encounters pertaining to the utilization context of a particular product. The investigation was conducted through the lens of "visual logic," which analyses how visual elements reflect and interpret various forms of user behaviours. This approach was developed as a distinct sub-discipline of sociology that specialized in the analysis and interpretation of photographs. **Profile of the Respondents:** This study collected data from end users using stratified purposive sampling. Observing their behaviours on natural and social media platforms helps pick respondents who were using a product unintentionally, which could inform their questionnaire results. Out of 100 questionnaires distributed, 73 were completed and returned, while 3 were removed owing to outliers. Adults aged 20 and older made up the sample population, with 45.7% male and 54.3% female. **Research Instrument:** A total of 100 preliminary images were taken of users using the product outside their original function. Next, photos exhibiting unintended conduct in diverse circumstances were assessed and filtered to 15 images to ensure measurement significance. This survey examined the meanings of images as (i) original objects with additional functions and (ii) original objects with temporary functions. Respondents rated 15 images via an online survey over 7 months. The preliminary study used a 50-item, 4-section closed-ended questionnaire: demographic information, comprehension of unintended use of mainstream products, motivation, and reflection. All questions were scored from 1 (strongly disagree) to 5 (strongly agree). **Data Collection and Analysis Procedure:** Researchers required clearance from the university research ethics committee to acquire data. Using SPSS v28, the main goal was to determine the potential data that can be derived from the survey through a purposeful and methodical approach. The questionnaire data were analysed using descriptive frequency distribution tests. The questionnaire's reliability was assessed using Cronbach's Alpha. According to Hair et al. (2016), a 50-item scale with a Cronbach alpha value of 0.956 is considered excellent. The researcher used Hirshman (1980)'s use innovative behaviour model, modified by Menold to determine factors that affected unintended product use: creativity/curiosity, voluntary simplicity, risk-taking, multiple use. The scores were transformed to mean to interpret the data. Nunally's (1997) mean score interpretation table was used: Low (1.00–2.00), Moderate Low (2.01–3.00), Moderate High (3.01–4.00), and High (4.01–5.00).

Table 1. The reliability of the data

Section	Constructs	Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	No. of Items	Score Interpretation
B	Understanding	.741	.798	6	Good
C1	Creativity / Curiosity	.738	.745	7	Good
C2	Voluntary Simplicity	.794	.796	5	Good
C3	Risk Taking	.870	.878	8	Very Good
C4	Multiple Use	.904	.904	12	Excellence
D	Perception / Reflective	.894	.897	6	Very Good

FINDINGS

This section is structured into three subsections that aim to address the research question, providing a framework for developing the data gathering and analysis procedures. **Reliability of Data:** The findings and discussion for this research were based on analysed data derived using SPSS v28 as shown in Table 1. The researcher used descriptive statistics and frequency distributions as the main analysis methods, which are appropriate for the questions being asked in this research. According to Mahbobi & Tiemann (2015), the implementation of both approaches enables a lucid depiction of the samples. **Understand unintended human behaviour:** Questions used in the visual representation inquiry focus on phenomenon that are closely related to the users' experience and behaviours towards the mainstream products. To interpret the data, the amount of the obtained scores were converted to frequency distributions to facilitate the interpretation of understanding behavioural level. Based on Table 2, the level of knowledge and users' awareness of the phenomenon is high with 90% of respondents agreeing/strongly agreeing that unintended behaviour occurs among users with 98.6% of respondents having experience (at least once) the behaviour shown in the visual representation. However, 77.2% of the respondents were aware of the risks involved in unintended interaction between users and products that are used outside of their original function. **Factors influencing unintended use of product:** Analysis of sub-factor representation of four main dimensions were based on the percentage of the highest mean score for each sub-factor. The mean score interpretation for the creativity/curiosity dimension is creativeness with the highest mean score value of 4.31, and SD=0.73. The factor which was least affecting unintended behaviour is belief with the mean score of 2.80, and SD=0.894. As second dimension (voluntary simplicity) shows that the highest mean score is social experience with a mean value of 4.20, SP=0.651 which is categorized as high based on the mean scale interpretation. While the lowest score is cultural context. For the third dimension, out of 8 factors influencing unintended behaviour in the risk-taking component, the highest mean score is represented by quick solution, min=4.93, SD=0.687 while the lowest score is economic circumstances with a mean score of 3.26, SD=0.958. The last dimension, multiple use has the most factors where it was represented by 12 items in total. The highest mean score value for the dimension is object ability with the mean score=4.17, SD=0.72. This clearly shows that ability of an object has the highest influence on users in the multiple use dimension. As conclude, the highest values of four sub-factors are quick solution followed by creativeness, object ability and social experience. **Reflective Thinking on Unintended Behaviour:** The findings of the analysis, as depicted in Table 3, indicate unanimous agreement among the respondents that product characteristics and context influence behavioural change while addressing an issue. The respondents reached a universal consensus that when individuals frequently engage in the same acts, unintended behaviour is perceived as routine. The participants also affirmed that unintended behaviour might be intentionally performed if an individual's activities become habit in his/her daily life.

Table 2. Understanding on unintended use of mainstream product

Instrument	Strongly Disagree	Disagree	Moderate Agree	Agree	Strongly Agree
Are you have any experience with the scenario described above?	0.0	1.4	10.0	44.3	44.3
The behaviour of using the product out of its original function occurs among users.	0.0	0.0	10.0	54.3	35.7
Have You / family/friends ever experienced a situation using a product out of its original function as in the illustration above?	0.0	1.4	21.4	40.0	37.1
Human behaviours that use the product out of the original function can affect others.	0.0	0.0	11.4	57.1	31.4
Using a product outside of the original function may have risks.	7.1	15.7	47.1	20.0	10.0
Using the product beyond its original function is to fulfil a specific purpose.	0.0	0.0	12.9	55.7	31.4

Table 3. Reflective thinking on post-unintended behaviour

Instrument	Strongly Disagree	Disagree	Moderate Agree	Agree	Strongly Agree
Objects and Situations affect the probability of human behaviour changing	0.0	0.0	18.6	57.1	24.3
'Unintentional behaviour' occurs when user-facing with a specific problem.	0.0	0.0	18.6	51.4	30.0
'Unintentional behaviour' helps to complete a goal/task in a certain situation.	1.4	1.4	11.4	38.6	47.1
When the discovery of new functionality benefits users, they tend to repeat it.	0.0	0.0	11.4	38.6	50.0
When the behaviour is repeated often, it can become a routine in human life.	0.0	0.0	12.9	40.0	47.1
When 'unintentional' behaviour becomes habitual, the act considered as 'intent' to do it.	0.0	0.0	17.1	47.1	35.7

ARGUMENTS

The findings of the investigation demonstrate that unintended behaviour pattern arises in instances where individuals are confronted with factors such as the context in of use, emergency, impulsive responses, experiences, and human creative thinking. The four dimensions effectively demonstrate that each component possesses its own distinct impact on behavioural change during interactions with everyday objects. While products are primarily designed for their intended functions, humans often employ creative thinking to interact with other products in situations where the desired product is unavailable. Therefore, cognitive processes play a crucial role in motivating individuals to engage in actions that fulfil their needs. Nevertheless, behavioural change might elicit a range of outcomes, both advantageous and detrimental, demanding meticulous investigation by designers. Based on the findings of the analysis, there exists a strong correlation between creativity and quick solution. This correlation can be attributed to the inclination of individuals who willingly engage in trial and error, drawing upon their personal experiences and creative thinking. The investigation reveals that social experiences exert an influence on unintended behaviour, as seen by user observations on social media platforms, mass media, and within local communities. It is consistent with the assertion made by Chamorro et.al (2004) that personal social and environmental experiences significantly impact the adoption of novel uses. However, the pattern of unintended actions is primarily influenced by the capability of the object. According to Norman (1988), the capacity of an object to execute a task has a discernible impact on the behaviour and cognitive ability of the user. According to Crilly et al. (2004), it has been indicated that every component of a product can communicate its significance to the user, whether it is done implicitly or explicitly. Kim et al. (2021) acknowledged that everyday objects have a significant impact on the development of human behaviour. The more human faces a similar problem, experiences will be referred to encounter the contexts. Therefore, there is a shift in human conduct from being unintentional to being intentional. In summary, the phenomenon of unintended use of a product can be attributed to a range of factors including specific contextual circumstances, geographical variations, individual perceptions, experiences, and economic factors. Unintended behaviours are uncontrolled, but still valuable.

CONCLUSIONS

Unintentionally, users use a product innovatively without knowing its risks, benefits, or safety. The product was created, prototyped, and tested in the design lab for a specific function. Unlike product designers, users use their imagination and expertise to use items outside the original context to fulfil their needs. Further, designers should consider that unintended behaviours may lead to the identification of novel uses. Thus, in-depth investigation of the dimensions will be conducted toward designers to evaluate their perceptions and reflections, as well as to determine the degree to which the emerging value may be enhanced for the long-term viability of product design.

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PHOTO-BASED RESEARCH: ANALYSING ATTRIBUTES OF UNINTENDED INTERACTION TOWARDS MAINSTREAM PRODUCT

Zulkarnian HASSAN[1], Shahriman ZAINAL ABIDIN[2], Rusmadiah ANWAR[3] and Verly Veto VERMOL[4]
[1,2,3,4]Formgiving Design Research Group, Universiti Teknologi MARA, Malaysia

ABSTRACT
This paper intends to critically assess the attributes of unintended interaction patterns that influence human behaviour towards mainstream products. Several such studies focus on investigating the influence of human experience on users' and designers ' differing concepts of existing products. Furthermore, some problems are found in current practice regarding whether photo-based research can be used to support scientific design research. This paper introduces the study's methodological approach, which employs photo-based analysis to uncover designers' interpretations of people's perceptions of unintended use of products by evaluating the attributes. The four main dimensions that describe sources or aspects of human experience and interaction with products were evaluated by 30 designers based on photo representation as well as to assess the reliability of photo analysis. Photos were used as research subjects for a series of assessment criteria and thoroughly examined according to Pauwels' theoretical framework of visual analysis. Comparisons were made based on an agreement measure. The findings of the study revealed significant descriptive patterns across several dimensions, resulting in the identification of aspects of understanding, experiences, and perception between users and designers. This study suggests that the approach used is applicable to assist in the design of product usability and in the design thinking process by informing the association between the specific dimension of human experience that is valuable for conceptual product design and innovation.

Keywords: design thinking, mainstream product, unintended human behaviour, user interaction, photo-based analysis

1 INTRODUCTION
Product design and behavioural research are topics of significant relevance for user interaction studies, as these are the main elements that connect people, products, and designers, providing intuitive, enjoyable, and satisfying design of user-products [1]. Research that promotes designers' involvement with users' experiences as a crucial part of the design process emerged in response to improving the design of user-product interactions. Previous studies reviewed the problem that intended use designs do not always translate into actual use and users' needs [2][3]. They conclude that designers directly translate user perceptions or needs based on their understanding. Indirectly, the situation causes the use of products beyond the designer's expectations. Designers' interpretations of the issues may differ due to knowledge and individual experience in understanding users' experiences and the reality of people's lives [1]. In dealing with the issue of using products out of context, understanding the factors that influence human experiences is crucial. In psychology studies, such a phenomenon is defined as "unintended human behaviour" (UHBe) when people unintentionally use a product in a way that deviates from the designer's intent [4][5][6]. The phenomenon of using a product in a novel way encompasses the interaction between the cognitive process and behaviour patterns that influence human perceptions and actions. According to Hassan et al. [6] UHBe exhibits inconsistency in action as a goal or objective without intentional intent and/or planning. In the

context of user research, UHBe interactions occur regularly as users connect with diverse objects, resulting in unanticipated object use. Both conditions can happen if the object allows it, and the user believes in its efficiency. The statement aligns with the concept of "affordance," which holds that objects and human interactions inherently offer perceptual and ability-based opportunities for action. Norman [2] coined the concept of "design affordance" in "Psychology of Everyday Things," which pertains to the way users perceive the capabilities of an object. As claimed by Gibson's theory of perception, human beings acquire information about objects through direct perception, which is intricately linked to the potential behaviour manifested by the environment. Several scholars on the notion of UHBe concur that unintentional occurrences often reveal insights into people's needs that designers can use to create design opportunities [5][7][8][9][10]. Referring to Sleeswijk et al., [11], diverse design methods and approaches have been developed to overcome this problem. These methods and approaches show an increasing interest in understanding user behaviour and interpretation [5][12], context-of-use issues [11], design concept [3], and everyday design [8][13]. Although these design approaches have aided designers in collecting information about user needs, they have not facilitated a deeper comprehension of how human perception aligns with the product's interaction experience. To address this shortfall, this paper introduces a study that investigates how designers interpret and assess the attributes of UHBe based on user perception, which followed the preceding study [14]. Further, a comparison between user-designer interpretations would be discussed based on an agreement measure. The approach provides an early-step evaluation of human perception that can benefit the early design process.

2 BACKGROUND STUDY

2.1 The Attributes of Unintended Interaction

Human behaviour reflects the interaction between humans and their environment, showcasing their mental, physical, and social capacities in response to internal and external factors across their lifespan, intentionally or unintentionally, consciously or unconsciously. Conforming to Freud [15], behaviours that demonstrate the achievement of an unconscious intention appear to be clumsy and interfere with unintentional acts. There is limited discussion on UHBe interaction in design studies to interpret the phenomena in the context of design thinking. For that reason, a comprehensive study has been conducted to investigates the value and prospect of UHBe for enhancing user-product design. The term unintended use of a product in user research refers to the innovative use of a product by individuals and have new sensory experiences. Ridgway and Price [16] concluded that UHBe as "unplanned behaviour" involves the introduction of new ideas, innovation, and solutions to issues. Hirschman [4] concurs with Ridgway and Price's statement and then creates a model of use innovativeness (UI) that includes two forms of behaviour when users creatively use existing products: inherent use innovativeness (IUI) and actualized use innovativeness (AUI). Later, they provided a theoretical framework by highlighting five dimensions in the Model of Use Innovativeness to evaluate such "unplanned behaviour": risk-taking, voluntary simplicity, creativity/curiosity, multiple use, and creative use. Menold et al. [17] condensed the dimensions into four categories for assessing creative attributes, actions, and cognition: creativity/curiosity, voluntary simplicity, risk-taking, and multiple uses/creativeness. In identifying a dominant characteristic that underlines UHBe interaction, 32 attributes were analysed through Visual Inventory Analysis (VIA) from a user perspective. The attributes were derived from research on unexpected behaviours, designing appropriation, unorthodox use, non-intentional design, design by use, and unselfconscious interaction [6]. Figure 1 reveal the attribution of UHBe extracted by the UI model for each dimension. The characteristic of the dimensions as portray in Figure 2.

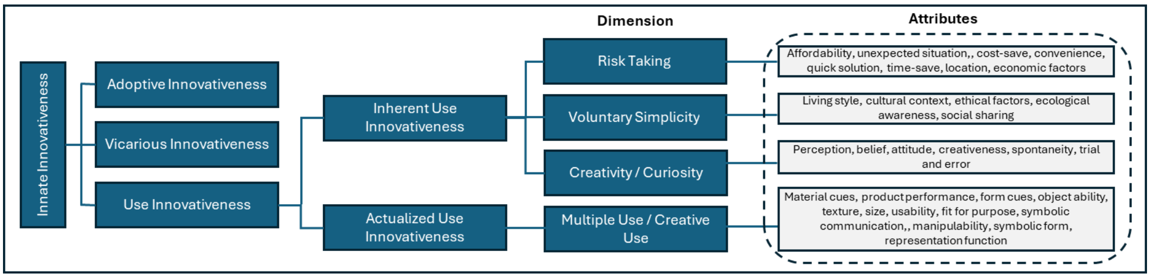

Figure 1. The attributes of UHBe adapted by UI model.

Through VIA, the participants (users) analysed the attributes via a visual that represent UHBe in everyday interaction with mainstream products. The results of the analysis found four dominant attributes that represented four dimensions of UI, as depict in Table 1. Based on the preceding study, 88.6% of respondents (users) concurred that ‘quick solution’ (risk-taking dimension) was a dominant attribute that triggers UHBe interaction with existing products. They corroborate a statement that users unintendedly interact with a product to perform and streamline their everyday tasks due to a lack of access to specific products in urgent or emergency conditions that occur unexpectedly. For instance, some people cover their heads with a plastic bag instead of using an umbrella on a rainy day. Based on this scenario, individuals seek an alternative object (an existing product) that can effectively fulfil the intended objective, even if it involves some risk. As Norman [2] stated, user product design is affected by differences between designers’ and users’ concepts of product. The question arises: how different are their interpretations? Will the difference provide a point of meaningful insight in the early design process and create value for conceptual product design? Thus, this paper suggests an approach using photo-based analysis (P-BA) to assess designer interpretation and associate the differences to inform the value of UHBe interaction.

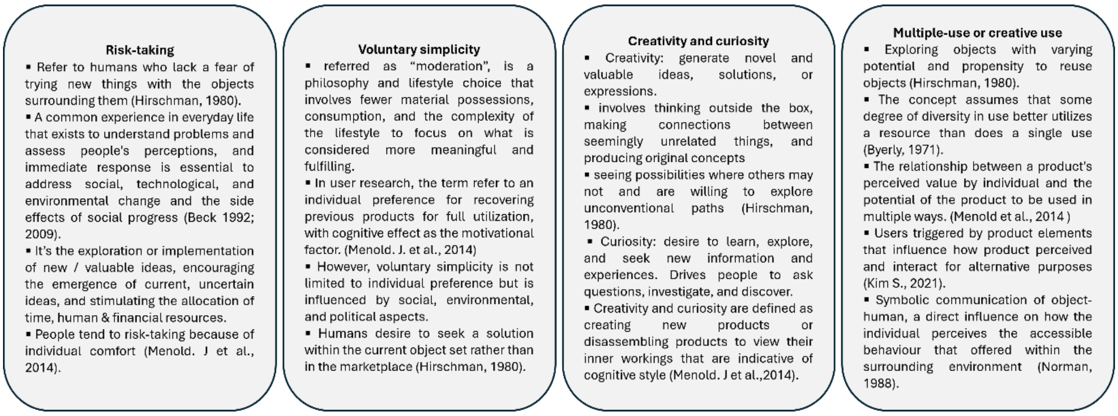

Figure 2. The characteristic of UHBe attribute [14].

Table 1: The result of user’s perception towards UHBe.

Visual Inventory Analysis	Scale Analysis	Dominant Attributes Analysis			
		Curiosity & Creativity: Trial & Error / Creativeness	Voluntary Simplicity: Social	Risk-Taking: Quick Solution	Multiple Use: Object Ability
	Strongly Disagree / Disagree [%]	1.4	0.0	0.0	1.4
	Moderately Agree [%]	17.1	12.9	11.4	14.3
	Strongly Agree / Agree [%]	81.5	87.2	88.6	84.3

2.2 Photo-Based Research

Visual media is having an increasingly significant impact on our society and culture as they depict human experiences, behaviours, and emotions in daily life. In recent decades, researchers in the social sciences have begun to pay serious attention to the use of images to enhance their understanding of the human condition [18] and use photos for the analysis and interpretation of images, focusing on the underlying meaning behind the images [19]. Recently, P-BA research has gained popularity as an important form of “social.”. In a study by Copes and Davis [19], scholars enhance current approaches by introducing a new perspective, collecting detailed multi-dimensional information, and providing valuable understandings about participants' daily lives. Photo images are "active", performing the visual equivalent of speech acts; the audiences of an image participate in interpreting its meaning and responding to its particular "action." Burri [20] proposed the concept of "visual rationality," where images become vital parts of knowledge reasoning processes to be more visual-based rather than just linguistic or textual, and how the visual leads to phenomena like "seeing with images," where insights come directly from engaging with visuals. In mainstream research, P-BA is considered a supplementary resource to text-based research. Thus, this paper employs an integrated framework for a visual research study [21] to provide a comprehensive understanding and critical analysis of the phenomenon.

3 METHODS

This study employs P-BA to assess the attributes of the UHBe interaction. The photo has been extracted through three different approaches: (i) natural observation (researchers’ sources), (ii) voluntary images (participation sharing), and (iii) social media (public posts). There were four sections in this study that the respondents examined. The first section was the visual reference section (focus frame). The other three sections were Visual Data Resource (source and subject), Visual Research Focus and Design (analytical focus, content analysis, and visual dimension attributes), and Overall Analysis (adapted from Pauwel’s integrated framework of visual research) [21]. According to Pauwel’s framework, the visual analysis process continues by carefully presenting plates of photos illustrating the theoretical point. The survey provided a text description to support respondent perceptions in the photo analysis process. The first section was the backbone for the three other sections to determine the response of the respondent in evaluating the attributes of UHBe. The photo was derived from social media and was classified as a "found image" (the highest scored image selected by respondents in the preceding paper) and was the most common interaction and context of use that has been seen, experienced, and practiced by society in unintended ways [14]. The image presented the context of "parents bathing their babies using a wash basin." This study used the Likert scale (1 = “strongly disagree” to 5 = “strongly agree”). Four different levels of product designers involved in the survey responded with a critical understanding of the phenomenon and confirmed that the photo analysis was accurate. 30 designers were involved, consisting of 10 junior, 8 novice, 7 senior, and 5 expert product designers. The designers were selected using a snowball approach from a clearly defined group, as well as to clarify the reliability of the photo analysis.

4 FINDING

This section presents the results of the P-BA on 30 respondents to the research survey. Some photo analysis segments are reported in detail through explanation and discussion by relating the significant findings to the literature gathered in the research area. P-BA was designed based on Pauwel's framework [21] using the highest score image that was selected by the user as representing the significant UHBe interaction, which was extracted from the preceding paper. Due to ethical issues, the image was only revealed to the participants involved in the survey and was blurred for publishing purposes. Figure 1 illustrates a set of evaluation schemes for P-BA designed in the study.

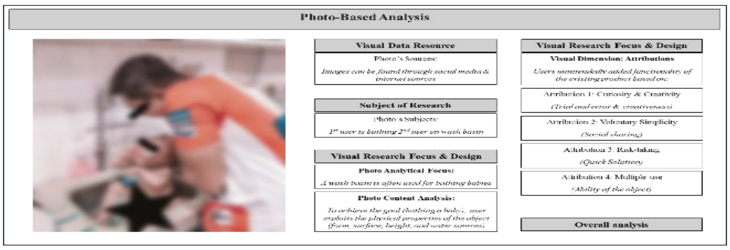

Figure 1. Sample of Photo-based research Analysis

4.1 Photo Analysis finding

The respondent was requested to analyse four sections of the survey scheme, which depended on the photo in Section 1 accordingly. Section 1: Visual research reference (focus frame) indicated that the images were identified as "people bathing a baby using a wash basin." Section 2: Analysis of visual data resources required the respondent to give their opinion on whether the photo can be found on social media such as Facebook, a blog, or on other media platforms. They were also requested to make a validation on the photo's subject, consisting of (i) the first user (the parents); (ii) the second user (the child); and (iii) the product being interacted with (the washbasin). Section 3: For the analysis of visual research focus and design, the respondent interpreted the photo through (i) analytical focus; (ii) content analysis; and (iii) visual dimension. Analytical focus refers to the context of use often practiced by users. They assess the significance of the scenario and whether a wash basin is often used for bathing a baby instead of a baby bathtub due to the unavailability of the product in a daily context. Content analysis indicates that people achieve the goal (bathing a baby) by exploiting the physical properties of the object (wash basin: form, surface, height, water source). The analytical focus and content analysis were the analytical lenses through which the research subjects examined the visual stimuli, revealing any possible biases or focal orientations that might have influenced the interpretation of the data. Visual dimension analysis is the heart of this study. It reveals four main attributes that represent four dimensions of UHBe according to user perception, namely, creativity and curiosity, voluntary simplicity, risk-taking, and versatility. The respondent interpreted the attributes that trigger UHBe interaction in everyday life. Finally, the overall analysis represented a holistic overview of the predominant sources of analysis, shedding light on the primary reservoirs of insights leveraged throughout the study. The result of the analysis will be discussed in the next section.

Table 2: The result of respondent evaluation on photo analysis.

Visual Research Reference	Scale Analysis	Visual Data Resource		Visual Rersearch Focus & Design						Overall Analysis
						Visual Dimension: Attribution				
		Source	Subject	Analytical Focus	Content Analysis	Curiosity & Creativity: Trial & Error / Creativeness	Voluntary Simplicity: Social	Risk-Taking: Quick Solution	Multiple Use: Object Ability	
	Strongly Disagree / Disagree [%]	6.7	3.3	6.7	3.3	3.3	0.0	3.3	0.0	6.6
	Moderately Agree [%]	20.0	16.7	23.3	6.7	16.7	20.0	10.0	6.7	16.7
	Strongly Agree / Agree [%]	73.3	80.0	70.0	90.0	80.0	80.0	86.7	93.3	76.7

4.2 Respondent Evaluation of the Photo-based Analysis

The table (Table 2) encapsulates the findings of a research endeavour aimed at elucidating the factors triggering UHBe in mainstream products, focusing particularly on the four dimensions: curiosity/creativity, voluntary simplicity, risk-taking, and multiple use. The study engaged four distinct levels of product designers (junior, novice, senior, and expert) as respondents to provide a critical understanding of the phenomenon as well as confirm the reliability of the photo analysis. The table is structured into four main sections, delineating critical aspects of the research process and outcomes. Based on the result, the evaluation of the photo analysis gained a positive response from respondents, where all nine items are mostly rated as "good." The analysis went through section by section, except for Visual Reference. In the Visual Data Resource section, the source of the photo evaluation score is 73.3%. However, in the subject column, the score is good and rated at 80%. The respondents agreed that the photo reference was clearly representative of the first and second users using subject research. In the section on Visual Research Focus and Design, there are three components of evaluation: (1) "Analytical Focus" scored 70%, and (2) "Content Analysis" scored the highest at 90%. This means that the respondents strongly agreed with the description that the image portrayed the situation of the user's goal by exploiting the physical properties of the object unintendedly. As the focus of the study, (3) "Visual Dimension Attribution" has mutual agreement among the respondents. The multiple use dimension has the highest score as 93.3%, and respondents strongly agreed that the *object ability* (Oa) influences human cognition while interacting with the product. The second highest rate that portrays UHBe is the risk-taking dimension, with a score of 87.6% through the factor of *quick solutions* (Qs). However, *trial and error* (Tt) and the *social sharing* (Ss) attribute have a lower score than Oa and Qs, with 80% agreement. Meanwhile, there were respondents who strongly disagreed (3.3%) that trial and error and social sharing attributes may influence UHBe. Nevertheless, the overall analysis was rated according to different perceptions of evaluation, with scores of only 76.7% strongly agree or agree, 16.7% moderately agree, and 6.6% strongly disagree or disagree.

4.3 Associating the Differences

The contradiction between the designers' interpretation and the users' perception reveals a slight discrepancy in Oa and Qs attributes. Numerous designers agree that UHBe is influenced by Oa. They make a judgement based on their understanding, knowledge, and experience about design affordance, as emphasised by Norman [2]. Later, the designers agree that Qs attribution is the second-highest attribute that influences UHBe interaction. They perceive that the actions are linked to the context of the use of everyday objects. Contrary to the users' perception, they conclude that Qs and Ss are the most important attributes that trigger UHBe interaction among users. The users believe that such behaviour are influenced by social context and life experiences such as open access to social media, internet of thing, or cultural factors, nowadays. However, the difference in the level of knowledge about the value and objective of the product causes the users to slightly disagree on the Oa of the product, which triggers UHBe compared to the designers' perception. Thus, the design team should consider these differences in early product design activity because users are the buyers of the products. Throughout the literature on UHBe research, scholars have posited that user actions and interactions give an important 'signal' to design team [1][2][5][6][8][15][22]. They believe users would maximise the use of the product function, whether intended or unintended. However, both user-designer interpretations of UHBe have an almost parallel view of the "quick solution" attribution based on the percentage of agreement obtained. In summary, each attribute proposed and discussed in this study has a value that could be considered appropriately in different contexts.

5 CONCLUSIONS AND FUTURE WORK

Principally, designers should be more sensitive to factors that can inspire and innovate ideas, such as sharing on social media and the life context of users. The user's insistence on the nature of instant solutions reflects the real situation of human life today, which is faced with time constraints, emergencies, and economic status. These differences should be celebrated to find a unification that can benefit all parties. Although UHBe faces certain risks, designers should look at the meaningful side by understanding human behaviour more realistically. The implications of this study allow designers to expand their design thinking parameters based on the potential of UHBe interactions and create motivation for new product design concepts. We believe that P-BA approach used in this study can be used as a guideline to improve the parameters of design thinking for designers in conceptual design and does not depend on the interpretation of the designers' experience alone. We can conclude that the objective of this study has been fulfilled: to observe creative ways in which people unintendedly interact with the product, as well as to assess the factors and attributes of interaction and obtain validation of reliability. Despite the limited number of respondents, the study consistently found a cohesive pattern of perceptions. To enhance in-depth understanding of the phenomenon, verbal protocol analysis will be conduct to investigate designer interpretations and reflections through the design activity.

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Smart Lavabo

Zulkarnian Hassan[1, *], Shahriman Zainal Abidin[2], Rusmadiah Anwar[3], and Verly Veto Vermol

1 Kolej Pengajian Seni Kreatif, UiTM Cawangan Perak; zulka246@uitm.edu.myl; 0000-0003-3503-9514
2 Kolej Pengajian Seni Kreatif, UiTM Shah Alam; shahriman.z.a@uitm.edu.my; 0000-0002-6752-3709
3 Kolej Pengajian Seni Kreatif, UiTM Shah Alam; rusma935@uitm.edu.my; 0000-0001-6803-6972
4 Kolej Pengajian Seni Kreatif, UiTM Shah Alam; verly@uitm.edu.my; 0000-0002-6567-7069
* Correspondence: zulka246@uitm.edu.my; 60124484593.

Abstract: *Smart Lavabo is an innovative product design developed through research based on unintended human behaviour (UHB) in daily activities. In design ideation activities, empirical studies have found that designers and researchers pay less attention to UHB than creativity and intention. However, scholars agree that UHB has value and potential that designers can explore using the right strategies. Every day, humans interact with products and use them beyond their original function unintendedly, either for convenience or for a specific purpose. For instance, there are individuals who use the washbasin as a tool and facility to "bath their babies.". Through the survey conducted, factors such as psychology, environment, economy, and product characteristics were identified to affect people. In addition, users often face issues such as the lack of baby-friendly facilities and the inability to support appropriate functions when needed, especially in R&R areas, hotels, shopping malls, and hospitals. To address this weakness, the concept of unintended behaviour design (UBD) was developed using the hermeneutic circle model to assist designers in creating new product concepts. The method used in the production of this project includes four phases: idea development, concept development, digitisation, and the modelling process. The concept of UBD increases the parameters of the designer's design thinking by benefiting the consumer, the hygiene industry, the tourism sector, and human well-being. The discovery of the innovative product concept clearly provides comfort to users and reduces the risk to their babies when using the Smart Lavabo.*

Keywords: Unintended human behavior, Product design, Hermeneutic circle

1. INTRODUCTION

People interact and communicate with various products for diverse objectives, from everyday use to mainstream objects. For instance, individuals ingeniously use plastic bags to cover their heads during rainy days when umbrellas are unavailable; use Coca-Cola drinks as detergents. The term "unintended human behaviour" (UHB) is used in the field of psychology to describe the phenomena that occurs when individuals utilise a product in a manner that is not in accordance with the designer's intended purpose (Hirschman, 1980; Wongkitrungrueng, 2018; Hassan, et al., 2022). According to Meriam Webster, unintended means not planned as a purpose or goal, or not deliberate or intended. In design fields, Suri (2005) used the phrase "thoughtless act" to describe the unintentional use of products in regular tasks. Products' unintended uses did not originate with the designers; they were innovations that helped people overcome difficulties and find meaning (Norman, 1988). Literature analysis reveals that UHB arises from numerous primary psychological, environmental, economic, and product aspects (Hassan, et al., 2022).

Comprehending human interpretation, analysing human behaviour, and investigating experiences might yield superior concepts and beneficial solutions to individuals' needs. A prior study highlighted specific unintended behaviours to the user's attention via a survey (Figure 1). In the poll, the respondents selected five representations of UHB, for instance, "bathing baby using a wash basin". The washbasin is primarily intended for the cleansing of hands and faces. Nonetheless, it is utilised not alone for its intended purpose but also outside its original context (Hassan, et al., 2023). This is regarded as a commonplace occurrence wherein non-designers unintendedly participate in the development of new functionalities by utilizing existing items in novel ways (Kim, et al., 2021).

Our findings indicate that the factors influencing behaviour encompass the impracticality of portable baby bathtubs for vacation use, the unwelcoming nature of public wash basins for infants, maternal back pain considerations during the postpartum period, cost efficiency, time constraints, the pursuit of task simplification, social influences, personal experiences, and product affordances. The project empirically engaged thirty designers in product design across multiple stages of activities such: verbal protocol, design protocol, and design syntactic analysis. Research locations are being done ethically in Perak, Kedah, Penang, Kuala Lumpur, Negeri Sembilan, and Selangor. Smart Lavabo is a product design concept that emerged from an unintended behavioural design (UBD) framework (Hassan, et al., 2024). The goal of the innovation is to enhance the functionality of the product while adhering to the strictest safety regulations, ensuring that both babies and parents experience the desired comfort and usability. The objective is achieved through prototype development strategies, as mentioned in the methodology section.

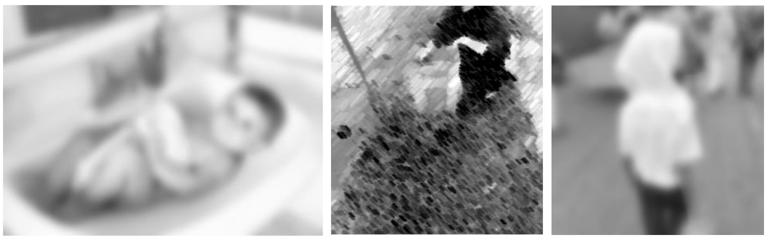

Figure 1. unintended use of product contexts. (the images were blurred for publication purposes)

2. METHOD & MATERIAL

Based on the UBD concept, innovation projects are developed in four phases of development starting from: initial idea generation, concept determination, design digitization, and prototyping. The concept of Unintended Behaviour Design (UBD) was developed using the hermeneutic circle model to assist designers in creating new product concepts (Figure 2). The first phase requires the selection of ideas based on the protocol design activities carried out during the initial research. For this project, several design criteria have been proposed by the designer have been evaluated and set as guidelines. The next phase involves the determination of the design concept which consists of form fitting activities, determination of materials, technical aspects, and presentation. The third phase of design involves the use of the AutoCAD application to interpret the two-dimensional view into three dimensions. The final phase is to translate the 2D digital design to 3D through a 3D printer application (Flash forge Adventurer 4) as a method of producing innovation project prototypes (Figure 3). The project also collaborated with several industries in the development of early prototypes.

Original Smart Lavabo was created from ceramic (basin), polish chrome (telescopic swivel pull-out faucet), memory foam (portable pillow), and dot grip (silicone). For prototype purpose, the smart lavabo using polylactic acid (PLA).

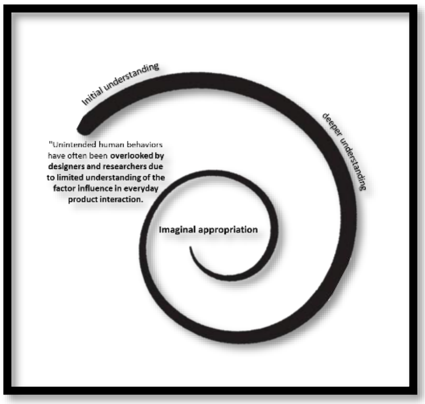

Figure 2. Hermeneutic circle approach used in the research

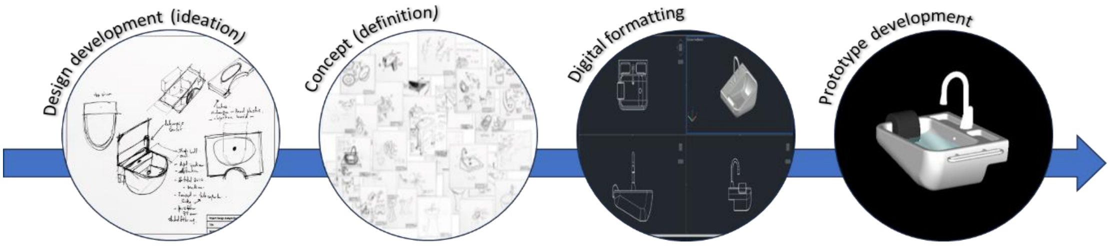

Figure 3. Four phases of Smart Lavabo product concept and prototype development

3. FINDINGS

Smart-Lavabo takes the original basin's qualities and improves to meet the demands of baby bathers. The design was human-centred and safe and comfortable. The basin's major part is ceramic, which is durable, washable, and practical. The height of this basin makes it highly practical for parents and carers to manage bathing activities. The product concept helps lower the risk of back pain. The basin's 'foetal' shape supports the baby's back and position during bathing, ensuring comfort. The steepness of the design at 30° and the drain hole location limit the possibility of 'drowning'. Telescopic swivel pull-out spray features improved user comfort and utility of the tap design. The upgraded portable 'pillow' feature, composed of memory foam, supports the baby's head and increases safety. In addition, a soft silicone dot grip on the basin interior can decrease baby bathing slippage. To prevent mobility when bathing the baby, a towel rack is supplied.

Compared to portable baby bathtubs, Smart-Lavabo offers non-toxic materials, a novel form, a telescopic swivel pulls out faucet, safety features, and dimensions. We believed that the Smart Lavabo would provide the features users need and be affordable for all.

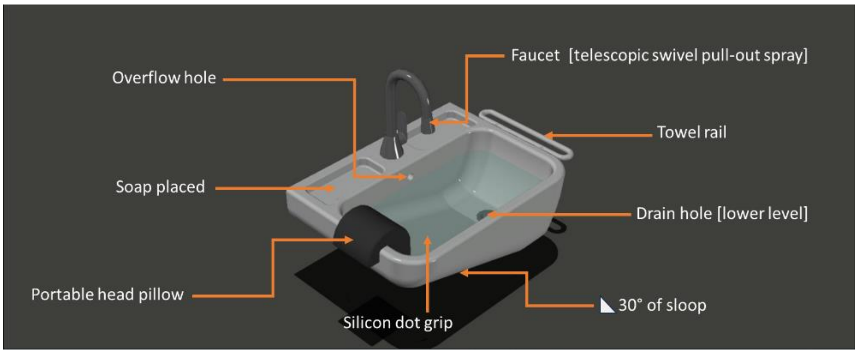

Figure 3. The novelty of Smart Lavabo concept

4. DISCUSSION

Smart Lavabo aims to assess the application of the UBD concept in design activity. By using the UBD concept, every suggestion and new element inspired by design experts during the initial research protocol design session is considered for generating new ideation. The results of this research have an impact on (i) enhancing product design potential through UHB ideas, (ii) reducing the risk of product misuse, and (iii) providing safety and comfort for users to interact with the product according to their daily needs. The creation of this concept product provides users with special features based on new functional improvements without compromising its main function. In addition, it integrates enhanced safety features, is ergonomic, and uses safe materials. This product is recommended to be installed in areas such as R&R, shopping malls, hospitals, hotels, airports, and residences. Therefore, we consider these findings to be highly reliable after a thorough evaluation by the participants involved in the research and design development. This project supports 3 national policies through SDG 9, The Twelfth Malaysia Plan, and National Science, Technology, and Innovation Policy (DSTIN) 2021-2030 This project has been awarded a gold award at the Johor International Innovation, Invention Competition, and Symposium in October 2024. The creation of Smart Lavabo through unintended human behaviour research was also published in the Scopus indexed proceeding. The prototyping was also submitted for copyright application to MyIPO for intellectual property purpose.

5. CONCLUSION

Design research has grown acquainted with the phenomenon of everyday design, which has garnered respect in the design field through diverse definitions of design concepts. Adjustments, exposures, and rules for UBD must be implemented and broadened for product design practitioners to ensure that this initiative benefits all stakeholders. Designers gain advantages from UBD's design idea via the Smart Lavabo product concept. This also creates chances for the sanitaryware business to diversify its product offerings. Ultimately, the implementation of this invention enables customers to fulfil their needs without incurring risks.

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AUTHOR'S PROFILE

Zulkarnian bin Hassan completed his PhD in Arts and Design in 2026 at the Faculty of Art and Design, Universiti Teknologi MARA. He received his Master of Art and Design in Fine Art and Technology (2010) and Bachelor of Art and Design in Ceramics (Hons) (2003) at Faculty of Art and Design, Universiti Teknologi MARA. His doctoral research employed multiple methodological approaches, including Visual inventory analysis (VIA) and Photo-based Research (PBA) on documentation moment of everyday situations within people behaviours, product interaction and contexts of uses. Furthermore, his study explored the communicative dynamics between users and designers through a Verbal Protocol Analysis (VPA) experiment procedure. The investigation examined the implicit factors embedded in product interaction, as well as the role of designers in shaping and adapting user experience, particularly in relation to the determinants of product form through the Design Syntactic Analysis (DSA) approach. In addition, he has actively participated in innovation projects derived from the findings of his doctoral research. These projects contributed to the development of design solutions grounded in empirical insights, and the thesis work has been formally registered for intellectual property under MyIPO to recognising its originality and intellectual contribution. Following the completion of his doctoral studies, he has presented his research at local and international conferences and has published extensively in various academic journals and conferences proceedings.

LIST OF PUBLICATIONS

Hassan, Z., Abidin S. Z., Anwar, R. & Vermol, V. V. (2022). The Value of Unintended Human Behaviour in Everyday Product Design. DS 117: Proceedings of the 24th International Conference on Engineering and Product Design Education (E&PDE 2022), London South Bank University in London, UK. 8th - 9th September 2022.

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