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Determining Elements of Design Thinking Implementation in Schools Using Fuzzy Delphi Method

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Abstract

Design thinking is a design-based learning strategy that flourishes on experiential learning and evolves from the study of unique ways to solve real-world problems. The growing interest in embedded design thinking in educational contexts has given the opportunity for design thinking to be utilised by younger students in schools. This study aims to identify the elements of design thinking implementation for teachers to plan a design-based learning strategy in schools. A total of eight experts were selected to analyse the fuzziness consensus of experts. All collected data were analysed using the Fuzzy Delphi Method. The results show that 40 of the 54 elements meet the conditions in which the threshold value, d is less than 0.2 and the percentage of the expert group is more than 75%. Two elements that were first rejected are added to the list to fulfil the purpose of the design thinking approach. Therefore, based on the consensus of the experts, the elements of design thinking implementation can be used by teachers as a guideline to apply design thinking in schools.

***Keywords**: Design Thinking; Fuzzy Delphi; Design-Based Learning*

INTRODUCTION

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21st century learning contributes to the future competitiveness and success of a nation in the global marketplace. Students need to be equipped with relevant competencies to suit today's job market requirements. Design-based learning in 21st century environment setting concentrates on learning by doing strategies for transformative learning experiences. Design-based learning emphasises the value of iteration and learning through mistakes. It enables students to experience the construction of cognitive concepts as a result of designing and making inventive and creative projects, to initiate the learning process according to their own preferences, learning styles, and various skills (Bozkurt Altan & Tan, 2021). This strategy fosters students' creative confidence and develops self-reflective skills.

Design-based learning strategy provides opportunities for students to have more robust experiences in terms of the ability to design and propose deep investigations. However, most design-based approaches begin by posing a design challenge, which limits the ability of students to begin by asking self-motivated questions worthy of their investigation (Priemer et al., 2020). The application of the design thinking approach may break the limitation by allowing the students to look for their own issues that are relevant to their daily lives. Design thinking is an approach that embeds design-based learning strategies and offers students to use a human-centred approach to design. Hence, students would develop and practice empathy skills in the process of designing for others (Hashim et al., 2019).

The design thinking approach was designed around a real-world problem scenario that the students could tackle as an initial prototype solution on a smaller scale. As the problem had no single solution, students could safely be creative in their approaches and final solutions, as they were not focused only on finding the one correct answer. The design thinking would also enable the students to become creative in utilising their own ideas to help seek solutions during the process., Students will be able to construct appropriate responses and solutions to an open-ended task when they possess a highly creative thinking skill (Hanney, 2019). Thus, this study provides a list of accepted elements by experts that can be used in helping teachers to apply the design thinking approach in school as part of the design-based learning strategy.

Design Thinking Approach in Educational Context

Design thinking is defined as a systematic process to create new user value and market opportunities (Ito et al., 2015). The key aspects of design thinking are empathy and an insightful understanding of the people to sight a solution. Empathy and observation lead to finding a problem and need a multifaceted approach for arriving at a solution through design thinking. The solution has no clear prediction of whether it will work today or not, nevertheless, in the future. Therefore, we need to seek new problems strategically and determine to solve them by thinking of new systems and solutions in teams or organisations (Serpes & Menon, 2017). On the other hand, design thinking is a reflection process that leads to a creative and constructive solution. It can contribute to building a close gap between knowledge and real-life application in schools and industries (Mahil, 2016).

Design thinking has the potential to emerge as a tool in learning. It was proved to have an impact on students' learning process (Clemente et al., 2016; Tschimmel, 2012). Design thinking is widely used as a design process to find a creative solution in product development. Many teachers and school administrators find that design thinking is a valuable tool in their educational design projects. Design thinking has made the students feel connected and engaged in real experiences (Chen & Huang, 2017; Valentim et al., 2017).

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Moreover, design thinking adheres to Bloom's Taxonomy framework, which identifies outcomes for learning and assessing. Design Thinking contributes an array of principles, perspectives, and practices that can be used to design solutions to ill-defined and complex problems (Withell & Haigh, 2014). Thus, guided by the design thinking approach, some necessary skills such as decision-making and creative thinking can be emerged throughout the process. This study uses five steps design thinking approach as shown in Figure 1.

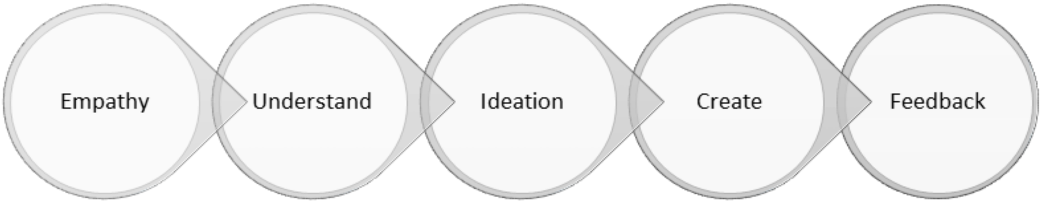

Figure 1: *Design Thinking Implementation in Schools*

METHODOLOGY

This study performed the Fuzzy Delphi method (FDM) to determine experts' consensus on identifying design thinking elements that can be implemented in school. FDM is a combination between the Fuzzy set theory and the traditional Delphi method to overcome the weakness of the existing Delphi method. The concept of integrating traditional Delphi and Fuzzy set theory was proposed by Ishikawa et al. (1993) to improve the vagueness of the Delphi method and the stability of the results (Tadić et al., 2015). Fuzzy sets were introduced by Zadeh (1965) to manipulate data that are defined as non-statistical uncertainties.

Fuzzy set theory is an element with a certain degree of membership. It provided formalised tools to mathematically represent vagueness and ambiguity for dealing with problems with the imprecision intrinsic (Chen et al., 2017). Therefore, when the Fuzzy set theory is integrated into the traditional Delphi method, which consists of several survey rounds to gain acceptable decisions, the uncertainty of the survey process can be solved through group decisions of experts' consensus. Also, it would be able to reduce the survey process time (Gulistan Ahmed, 2016).

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Long-range forecasting in the Delphi method is responsible for introducing imprecise and incomplete data information problems. Moreover, the decisions made by experts rely on their individual competence and are subjective. Other than that, the traditional Delphi requires a long study period until experts' consensus is achieved (Mohd Yusof et al., 2018). Some of the weaknesses of the Delphi method was that the repeated Delphi cycles would cause boredom to the participants. Thus, to overcome these weaknesses, the application of FDM was suggested to solve the ambiguity of experts' consensus in the Delphi technique (Kamarulzaman et al., 2016; Tadić et al., 2015). FDM was proved as a tool that was able to overcome these problems by putting the priorities and the elements of consensus among experts by reducing repetitive cycles of the Delphi process.

Participants in Fuzzy Delphi Method

An expert is defined as an informed individual who has knowledge about a specific subject. An expert is a person who is very knowledgeable and skilful in a particular area which in this study refers to subject matter experts (Baker et al., 2006). The participants of FDM in this phase were teachers who have experience in conducting design thinking approaches in school. Since design thinking education in schools is quite new in Malaysia, the number of teachers available is limited. Moreover, according to Saaty & Özdemir (2014), the number of experts assigned does not necessarily need to be high. There is no strong relationship between the number of experts and the quality of the decisions that could be generated from the group. Adding more experts who are less experienced may weaken the accuracy of the results (Mat Noh et al., 2019).

The number of experts on FDM varies between six to 20 participants depending on the topic (Clayton, 1997; Rowe & Wright, 2001). In choosing experts, it should be from a combination of knowledge and expertise that reflects the full scope of the problem domain. Heterogeneous experts were preferable to experts focused on a single speciality which in this study was the design thinking education. This study managed to get eight experts from various subjects taught in different schools to participate in the FDM consensus. The essential criteria in the participants' selection are their experiences conducting design thinking in school for more than a year. Table 1 summarises the background of the selected experts. The questionnaire was sent through email to each participant via an online form.

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Table 1: *Experts Background*

	Academic	Subject	School	Teaching Experience	Design Thinking Experience
Expert 1	Degree	Islamic Studies	Secondary	Over 10 years	Below 3 years
Expert 2	Master	Islamic Studies	Secondary	Over 5 years	Below 3 years
Expert 3	Master	Science	Secondary	Over 5 years	Below 3 years
Expert 4	Master	Science	Secondary	Over 10 years	Over 3 years
Expert 5	PhD	Science	Primary	Over 10 years	Over 3 years
Expert 6	Master	Science	SISC+	Over 10 years	Below 3 years
Expert 7	Master	Science	Secondary	Over 10 years	Over 3 years
Expert 8	Degree	ICT	Secondary	Over 5 years	Over 3 years

Fuzzy Delphi Instrument and Data Analysis

A listing of initial items using design thinking practitioners' feedback and literature reviews was the basis of the Fuzzy Delphi questionnaire development. The questionnaire was used to select the most appropriate activities, tools and assessment items as elements for teachers implementing design thinking in school. There are 54 items to be answered in the questionnaire.

Activities in design thinking were suggested by design thinking practitioners and based on literature reviews including warms-up, activities, and tools in each step of design thinking. At the beginning of each step of the design thinking approach, warm-up activities and exercises are important to attract students' interest in exploring the design thinking approach. Among activities that were shared by practitioners were paper building and picture guessing. However, not all steps require warm-up activities. It depends on students' readiness to get started on each of the new steps of design thinking. In the questionnaire, experts would decide whether each step needs warm-up activities before implementing the step.

Meanwhile, other activities also were listed for each step of design thinking. For example, experts need to select whether fieldworks are suitable within or outside the school compound in the empathy step. Also, whether students need to use the internet for information or only use data from target users. These activities were retrieved from practitioners' experiences and information from the literature. Equally important, supporting tools for each step of design thinking were listed in the questionnaire to find

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out their necessity as element in design thinking implementation. For example, Empathy map in Define step, Sticky note in Ideation step, and Feedback grid in Feedback step.

Meanwhile, for assessment, experts selected suitable items to assess student's performance during and after each step of the design thinking process. For example, in Empathy step, students were assessed by their ability to self-reflect, communicate effectively and politely. Assessment items were used to evaluate whether students are able to gain potential soft skills and changes in mindset to execute the design thinking approach successfully. For other steps of design thinking, assessment items were listed based on the skills, mindset, and outcomes that students should achieve at the end of the particular step. Another example, in the feedback step, students were assessed by their ability for presentation skills and the mindset of accepting rejection from others for their solutions.

Table 2: *Seven-Point Scale and the Fuzzy Scale*

Linguistic Scale	Fuzzy scale		
Very strongly disagree	0.00	0.00	0.10
Strongly disagree	0.00	0.10	0.30
Disagree	0.10	0.30	0.50
Slightly agree	0.30	0.50	0.70
Agree	0.50	0.70	0.90
Strongly agree	0.70	0.90	1.00
Very strongly agree	0.90	1.00	1.00

Data gathered was collected and transferred to an FDM database template to calculate the Fuzzy number. It was developed based on the FDM calculation proposed by Ishikawa et al. (1993). Applying the FDM to obtain a group decision can solve the fuzziness of common understanding among experts. The result and scores for each question were arranged according to the hierarchy. The analysis of the FDM questionnaire items uses the Triangular Fuzzy Number and the Defuzzification process (Awang et al., 2016). A Microsoft Excel software template by Mohd Jamil et al. (2017) was utilised in this study to analyse the data. A seven-point scale was used to replace the Fuzzy value in this study. A higher point indicated higher importance. Table 2 shows the level of agreement of the seven-point scale and its Fuzzy scale.

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Fuzzy scale was used to calculate the Fuzzy numbering, and all the data were tabulated to obtain the mean value. After the mean value of Fuzzy number is obtained, the threshold value, d can be identified by calculating the differences between the three mean values for all experts on a certain item and the three Fuzzy numbers for each expert on this item (Chen et al., 2017; Kamarulzaman et al., 2016). It can be done by using the following formula.

$$d\ (M,m) = \sqrt{\frac{1}{3}[(M1\ -\ m1)^2\ +\ (M2\ -\ m2)^2\ +\ (M3\ -\ m3)^2]}$$

where
M = mean value of Fuzzy number.
m = Fuzzy number for each expert on each item.

The threshold value, d obtained would determine whether the experts have reached a consensus. To verify the items' acceptance, the threshold value, d of each item should be less or equal to 0.21 and the overall group consensus should be more than 75% (Cheng & Lin, 2002). The percentage of overall threshold values was calculated to get the acceptance of the item by using the following formula.

[(Σ Experts x Σ Items) – (Total Responses > 0.2 / [(Σ Experts x Σ Items)] x 100%

Meanwhile, the defuzzification process enabled the ranking of the consensus to be done. The defuzzification process is needed to help find the highest valued items in the questionnaire by sorting them in a ranking. However, in this study, the defuzzification value and item ranking were not taken into consideration because all accepted items were included as elements for design thinking implementation and no item ranking analysis was needed. In summary, there are two requirements to be fulfilled to determine the acceptability of the items in this study which are

(1) threshold value, d ⩽ 0.22
(2) experts' consensus on the evaluated items ⩾ 75%

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FINDINGS AND DISCUSSION

This study set out to select items only within the requirements of the threshold value, d is less than 0.22, and consensus percentage is over 75%. The FDM analysis found 40 elements of both activities and assessments of each design thinking step that fulfil the requirement. While the threshold values in **bold** are the items that exceeded the threshold value of 0.22, or the percentage value is below 75%. It means that the individual expert opinions are not in consensus with the other experts for the items.

STEP 1: Empathy

Table 3 displays the items for empathy step activities. The experts consensually accepted some items, including warms-up, utilising the internet for data enrichment, and probes to start a conversation. However, videos related to Empathy step were considered highly unimportant by one of the experts. On the other hand, fieldwork to find target users can be done only within the school compound but not outside as rated by one of the experts. However, stakeholders outside of school compounds such as parents/guardians, education officers, and even the students' neighbours or the school area can be considered sources of information for the design thinking project. Working collaboratively with communities and the involvement of relevant stakeholders is highly encouraged in design thinking to discover valuable information that may not get within the school compound (Diefenthaler et al., 2017).

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Table 3: *Threshold Value and Percentage of Items of Activities in Empathy Step*

Item	**Experts**								**d value**	**Expert group consensus**
	1	2	3	4	5	6	7	8		
1	**0.482**	0.205	0.188	0.072	0.205	0.072	0.072	0.072	0.171	87.5%
2	**0.732**	**0.257**	0.123	0.123	0.123	0.123	0.136	0.123	0.217	87.5%
3	**0.307**	0.086	0.086	0.086	0.086	0.070	0.086	0.070	0.110	87.5%
4	0.099	0.221	0.221	0.099	0.221	0.099	**0.761**	0.172	**0.237**	87.5%
5	0.038	0.038	0.038	0.038	0.038	0.115	0.115	0.038	0.057	100%
6	0.085	0.223	0.085	0.085	0.085	0.085	**0.466**	0.170	0.161	87.5%

The assessment of empathy step is listed to observe the skills and mindset that should be applied by students when conducting conversations with users. Table 4 shows the items for Empathy step assessment. During the empathy step, the assessment is related more to communication skills, including starting and conducting a conversation politely and asking the right questions. Asking the right question allow students to get better and more in-depth answers from the users and cultivate their empathy mindset (Matthiesen & Klitmøller, 2019). According to Baron-Cohen (2005), empathy involves a leap of imagination into someone else's headspace. While reading their faces, voices, and postures during the conversation, the internal worlds are not transparent, and one needs to climb inside their heads requires imagining what it must be like to be them. It can be achieved by empathetic conversation and interpreting users' answers from their point of view. Even though students are encouraged to use probes to help them initiate conversations, such as posters or brochures, there is no need to assess their ability in using one, according to the experts.

Other than that, self-reflection at the end of the step was also accepted by experts. According to Boud (1985), self-reflection is the definition of a reflection in the context of learning. It focuses on one's personal experience during conducting steps of the design thinking approach as the object of reflection. It refers to intellectual and affective activities that individuals engage while exploring their experience, leading to new knowledge, understanding, and appreciation (Lew & Schmidt, 2011).

Table 4: *Threshold Value and Percentage of Items of Assessment in Empathy Step*

Item	**Experts**								**d value**	**Expert group consensus**
	1	2	3	4	5	6	7	8		
7	0.067	0.067	0.067	0.067	0.067	0.067	0.089	**0.325**	0.102	87.5%
8	0.105	0.105	0.052	0.105	0.052	0.052	0.105	**0.289**	0.108	100%
9	0.052	0.105	0.105	0.052	0.105	0.052	0.105	**0.289**	0.108	100%
10	0.057	0.057	0.057	0.057	0.057	0.095	0.095	0.095	0.072	100%
11	0.105	0.105	0.052	0.105	0.105	0.052	**0.289**	0.052	0.108	100%
12	0.172	0.172	0.172	0.172	0.069	0.069	**0.808**	0.069	0.213	87.5%

STEP 2: Understand

Based on Table 5, the experts consensually agreed with all items of activities for Understand step. During Understand step, experts agreed that students need to be exposed to videos on how to identify users' point-of-view. Warming-ups activities before initiating Understand step were also accepted so that students could get a general idea of how to interpret others' points of view. A point-of-view refers to someone telling a story based on his/her perspective of some issues. Students need to see the users' side of the story if they want to solve his/her problems. When students perform warm-up activities related to understanding and socialising with people, it will help them develop the ability to analyse situations from different perspectives (Bronson & Merryman, 2010).

The experts also agreed on using empathy maps to help students gain a deeper insight into the user's problem. It can be used to visualise the information and needs of that particular user (Bratsberg, 2012). Slots in the empathy map make people ask themselves about other people's perspectives. They try to wonder and clarify what the thing that they see about others is. What are the other people seeing and doing, and what do other people feel and think? These thoughts and insights will provide a structure to describe and understand the big picture of the problems.

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Table 5: *Threshold Value and Percentage of Items of Activities of Understand Step*

Item	Experts								d value	Expert group consensus
	1	2	3	4	5	6	7	8		
13	**0.513**	0.174	0.045	0.045	0.174	0.045	0.045	0.045	0.136	87.5%
14	0.206	0.191	0.047	0.047	0.206	0.047	0.047	0.047	0.105	100%
15	0.095	0.095	0.095	0.057	0.057	0.057	0.057	0.057	0.072	100%

To assess students' performance while conducting Understand step, experts gained their consensus on all items: self-reflection, identifying a persona, classifying the point-of-view, and being open-minded. Table 6 shows the consensus of items for assessment in Understand step.

A persona is a target person representing a group of users with different needs and expectations to make it easier to design a product or a service (Van Rooij, 2012). Having a persona in Understand step will help the students to understand users' needs and experiences. The persona description can be identified using the empathy map by guiding the students to classify the persona's point-of-view in order to solve his/her problems. To unfold the persona's real problem, students need to be open-minded and openly express their opinions and perspective regarding the issue. The ability to identify the persona's point-of-view will assist students in generating related ideas with solutions that would be able to overcome the real problem.

Table 6: *Threshold Value and Percentage of Items of Assessment in Understand Step*

Item	Experts								d value	Expert group consensus
	1	2	3	4	5	6	7	8		
16	0.105	0.105	0.105	0.052	0.105	0.052	**0.289**	0.052	0.108	100%
17	0.191	0.202	0.191	0.064	0.202	0.064	0.191	0.064	0.146	100%
18	0.045	0.174	0.045	0.045	0.174	0.045	**0.513**	0.045	0.136	87.5%
19	0.038	0.038	0.038	0.038	0.038	0.038	0.115	0.115	0.057	100%

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STEP 3: Ideation

After the point of view has been identified, students need to find suitable solutions to the problem. Based on table 7, out of seven items of activities in the Ideation step, three of them were rejected by experts, which are

- Warm-ups activities.
- Demos/Videos to do brainstorming.
- Use one effective technique of idea generation.

All experts preferred for students to use multiple techniques of idea generation. There are various ways to generate ideas, such as brainstorming, brainwriting, SCAMPER, and Mind-mapping. Generating ideas requires the students to engage in conversation actively and work collaboratively with their teammates. To maintain a positive environment and attitude among students, most experts agreed that a set of rules should be listed so that students will not make fun of someone else ideas and encourage all students to be part of the idea-generating session. Some of the rules are deferred judgment and one person talking at a time. Besides, teachers as facilitators need to ensure that students remain focused on the topics

Utilising tools such as sticky notes was also accepted because sometimes, students tend to forget some ideas that have been suggested if the ideas were not written or drawn. They may give similar ideas if the original idea is not recorded. Therefore, all experts agreed that sticky notes are necessary during this step. Moreover, it is much easier to do idea clustering if sticky notes are used. Ideas can be presented visually in simple sketching. Sometimes, presenting ideas visually is needed because some students may be unable to express their ideas in writing.

Table 7: *Threshold Value and Percentage of Items of Activities in Ideation Step*

Item	**Experts**								**d value**	**Expert group consensus**
	1	2	3	4	5	6	7	8		
20	**0.754**	0.223	**0.455**	0.223	0.223	0.118	0.223	0.223	**0.305**	75.0%
21	**0.761**	0.221	0.172	0.221	0.099	0.099	0.099	0.221	**0.237**	87.5%
22	0.019	0.019	0.019	0.019	0.019	0.134	0.019	0.019	0.033	100%
23	**0.252**	**0.374**	0.304	**0.252**	**0.886**	**0.252**	**0.304**	**0.374**	**0.375**	37.5%
24	**0.792**	0.190	0.073	0.190	0.190	0.073	0.073	0.073	0.207	87.5%
25	0.223	0.172	0.035	0.223	0.172	0.035	0.035	0.035	0.116	100%

To assess students' ability to generate ideas, students need to produce ideas as many as possible. It is one of the rules in design thinking, which is quantity over quality. Bayles & Orland (1993) wrote in their book Art & Fear mentioned the works of

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the highest quality were often produced by people who are busily churning out piles of work" and learning from their mistakes" compared to people who only focused on quality that had sat theorising about perfection and impressive theories which in the end had little time to produce their one ultimate product. Thus, people who keep constantly iterating, evolving, and improving would achieve better results in their work (Collins & Hansen, 2011).

Assessment of Ideation step, experts agreed that students should be evaluated on the ability to generate wild ideas, cluster ideas, and use multiple techniques to generate ideas. In the meantime, students should also maintain their positive attitude as listed in the rules while generating ideas that they cannot make fun of others and embrace other people's opinions. Using proper tools to ease the idea-generating process also can be assessed to evaluate students' creativity in utilising suitable tools other than sticky notes. Self-reflection was also acceptable in this step. Based on table 8, all items were agreed upon as elements in implementing design thinking in school as they have reached the consensus by the experts.

Table 8: *Threshold Value and Percentage of Items of Assessment in Ideation Step*

Item	**Experts**								**d value**	**Expert group consensus**
	1	2	3	4	5	6	7	8		
26	0.070	0.086	0.086	0.086	0.086	0.086	**0.307**	0.070	0.110	87.5%
27	0.062	0.186	0.206	0.062	0.186	0.186	0.062	**0.497**	0.181	87.5%
28	0.119	0.119	0.059	0.119	0.119	0.119	0.059	**0.561**	0.159	87.5%
29	0.102	0.102	0.073	0.102	0.102	0.102	0.102	**0.577**	0.158	87.5%
30	0.086	0.086	0.070	0.086	0.086	0.070	0.086	**0.307**	0.110	87.5%
31	0.052	0.105	0.105	0.105	0.105	0.052	0.052	**0.289**	0.108	100%

STEP 4: Create

Create step requires students to develop a prototype of the selected solution. There were six items in this step, and the experts rejected two of them. Warm-ups and videos related to prototype building would be included as elements in design thinking implementation. Many warm-up activities, such as Marshmallow challenge and Paper building, can be used. These activities not only introduce students to prototype design and train them on how to build robust products, but it also teaches them to collaborate

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with others and be good team members for the project. On the other hand, videos can be used to introduce students to different types of prototypes.

In design thinking, creating prototypes is not limited to a physical mock-up. It can also be done in a digital mock-up (3D CAD drawing), a poster, a storyboard, or a paper prototype to show a system or an Android/iOS operating system application. However, producing prototypes in digital was unaccepted by the experts. A physical prototype is highly favourable because it is easier to understand when used for demonstration during the Feedback step. Moreover, a physical prototype is preferred because users can interact with the suggested solutions to evaluate the prototype's effectiveness in solving the problem. Additionally, producing a poster to explain the suggested solutions is unnecessary as long as the physical prototype can deliver the solution to users. Table 9 shows the items of Create step activities.

Table 9: *Threshold Value and Percentage of Items of Activities in Create Step*

Item	Experts								d value	Expert group consensus
	1	2	3	4	5	6	7	8		
32	0.058	0.168	**0.513**	0.168	0.168	0.058	0.224	0.168	0.191	87.5%
33	0.072	0.205	0.072	0.205	**0.482**	0.072	0.072	0.188	0.171	87.5%
34	0.073	0.102	0.102	0.102	0.102	0.102	0.102	**0.577**	0.158	87.5%
35	**0.700**	**0.283**	**0.283**	0.113	0.113	0.157	0.113	**0.283**	**0.256**	87.5%
36	**0.700**	**0.283**	**0.283**	0.113	0.113	0.157	0.113	**0.283**	**0.256**	87.5%
37	0.038	0.135	0.135	0.135	0.038	**0.258**	**0.258**	0.135	0.141	100%

The solutions that the students suggested would be assessed based on the physical prototypes that were produced by them using certain criteria. The suitable type of prototypes utilised by students based on their suggested solutions plays an important role in Create step to ensure that users would understand and gain insight from the concept of the solutions suggested by the students when gathering feedback from them. The ability to use recycled items for the prototype would also be assessed because design thinking focused on early, inexpensive, and scale down versions of the solution to identify flaws within the current prototype. Create step offers students the opportunity to bring their ideas to life, test the practicability of the prototype, and seek how the users think and feel about the prototype (Dam & Siang, 2020).

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On the contrary, two criteria of creative and sturdy prototypes were rejected because one expert rated these items as unimportant. A sturdy prototype criterion is unimportant in terms of design thinking concepts. It was expected that the prototype would be a bit fragile due to the design thinking low fidelity concept and inexpensive recycled items used to build the prototype. A low fidelity concept involves using a basic mock-up to represent the tested product. The prototype is usually incomplete and utilises just a few of the features available in the final design. It is also constructed using materials not intended for the finished product, usually recycled materials. In design thinking, when used in conjunction with small groups, low fidelity prototypes can improve the accuracy of input from potential users (Liedtka, 2015). Whether in the form of storyboards, journey maps, or paper prototypes, low-fidelity prototypes offer specific tools to make new ideas tangible and gain more accurate feedback. On the other hand, self-reflection assessment was also acceptable in this step. Table 10 displays the experts' rating of all items of assessment in Create step.

Table 10: *Threshold Value and Percentage of Items of Assessment in Create Step*

Item	Experts								d value	Expert group consensus
	1	2	3	4	5	6	7	8		
38	0.095	0.057	0.057	0.057	0.057	0.057	0.095	0.095	0.072	100%
39	**0.466**	0.217	0.090	0.217	0.217	0.090	0.175	0.175	0.206	87.5%
40	**0.482**	0.199	0.080	0.199	0.199	0.199	0.193	0.193	0.218	87.5%
41	**0.700**	**0.283**	0.113	**0.283**	0.113	**0.283**	0.113	0.157	**0.256**	87.5%
42	**0.258**	0.135	0.135	0.135	0.038	0.135	0.038	**0.258**	0.141	100%

STEP 5: Feedback

Table 11 shows the threshold values and percentage of each item for activities in Feedback step. Feedback can be gained from the same user in Empathy step, other users from the same group in Empathy step, or other people like teachers, friends, and fellow students. However, all experts strongly agreed to get feedback from the primary source, the persona himself/herself. Based on the table, one expert rated it unnecessary to do warm-up and refer to videos about techniques to gain feedback from others before executing the Feedback step. Students already gain experience on how to approach potential users when conducting the Empathy step.

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On the other hand, to get valuable feedback from others, students need to plan how to introduce their prototypes in the most effective way. Three techniques were listed in the questionnaire: role play with teammates, pitch the idea and do a brief presentation about the prototype. However, the roleplay technique was rejected by two experts. Roleplay could be too time-consuming to prepare; therefore, it is understood that the roleplay technique is unfavourable to be used in the Feedback step. Doing a brief presentation or simple pitching can be sufficient to deliver the solutions to the problems. Nevertheless, users' interaction with the prototypes is more important in order to get their valuable feedback.

Students need to review their solutions after collecting relevant feedback from users. They need to evaluate whether a modification is needed to the prototype's design, the idea itself, or even the persona during the Understand step. It is to ensure that their solution can be used to solve the specific problem they have chosen at the beginning of the project. Students are encouraged to do iteration if needed to fulfil the needs of their users.

Table 11: *Threshold Value and Percentage of Items of Activities in Feedback Step*

Item	**Experts**								**d value**	**Expert group consensus**
	1	2	3	4	5	6	7	8		
43	**1.038**	0.222	0.108	0.222	0.222	0.108	0.108	0.108	**0.267**	87.5%
44	**0.716**	**0.270**	0.140	**0.270**	0.124	0.124	0.140	0.140	**0.240**	87.5%
45	0.034	0.124	0.124	0.124	0.034	0.034	**0.271**	0.034	0.097	100%
46	**0.413**	**0.270**	**0.270**	0.140	0.140	**0.413**	0.124	0.140	**0.239**	75.0%
47	0.034	0.124	0.124	0.124	0.034	0.034	**0.271**	0.034	0.097	100%
48	0.038	0.135	0.135	0.135	**0.258**	0.135	0.038	**0.258**	0.141	100%
49	0.135	0.135	0.038	0.135	0.038	0.135	**0.258**	**0.258**	0.141	100%
50	0.031	0.153	0.153	0.031	0.031	0.153	**0.240**	**0.240**	0.129	100%

Feedback step is when the students would be assessed on their ability to highlight their prototype effectively during the Feedback session. At the same time, they should also be able to handle rejection and be willing to accept comments and suggestions from the user and other people. Being able to handle rejection is one of the top qualities of design thinking. When students are able to deal with rejection, it means that they are not easily feel demotivated and are willing to improve themselves to get

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better results for their projects. Facing rejection would give the students valuable experience and lessons in their life. It would be perfect for them to reflect and see the opportunity to improve themselves.

In contrast, two experts thought that maintaining a positive attitude is unnecessary to be included in the assessment. It can be seen that students' ability to handle rejection has a similar effect to maintaining a positive attitude. Therefore, the item can be rejected from the assessment. On the other hand, self-reflection also was accepted by the experts. Table 12 shows the threshold value and percentage of assessment items in Feedback step.

Table 12: *Threshold Value and Percentage of Items of Assessment in Feedback Step*

Item	Experts								d value	Expert group consensus
	1	2	3	4	5	6	7	8		
51	0.067	0.067	0.067	0.067	0.067	0.067	0.089	**0.325**	0.102	87.5%
52	0.116	0.116	0.052	0.116	**0.276**	0.116	0.116	**0.276**	0.148	100%
53	0.170	0.170	0.170	0.170	0.170	0.170	**0.509**	**0.509**	**0.254**	75.0%
54	0.086	0.086	0.086	0.070	0.086	0.086	0.070	**0.307**	0.110	87.5%

Selection of Elements for Design Thinking Implementation

The selection of elements for the Design thinking implementation, including activities, tools, and assessments of each step, is based on the consensus by experts in the FDM. Some items were rejected based on the threshold value or the acceptance percentage. However, they seem important because some of the rejected items were rated as unimportant only by one expert compared to others. As experts with vast experience in design thinking implementation in schools would know some of the items, both activities and assessments, necessary for a successful design thinking project. Nevertheless, some experts may think and experience differently in their schools.

Moreover, these elements are important to achieve the purpose of the design thinking approach. Therefore, these items were decided to be accepted and would be included as elements for design thinking implementation in schools. The items that were rejected at first and then be accepted as elements are shown in table 13.

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Table 13: *Accepted Items as Elements for Design Thinking Implementation*

	Activity	Assessment
Empathy step	Fieldwork outside the school compound	
Create step		Ability to build a creative prototype

CONCLUSION

In summary, the findings of this study proposed 42 elements of design thinking implementation that can be used as guidelines for teachers to apply the design thinking approach in schools based on the consensus of expert opinion. Figure 2 shows the structure of elements for implementing design thinking in school. Activities, tools and assessments of each step of design thinking of this study were selected accordingly and are suitable for school level students. This study's findings will help teachers prepare a design thinking project that can be integrated to subject content and relevant to students' real life. This learning strategy may change the classroom environment and develop students' skills and point-of-views toward experiential learning.

Design thinking is an effective approach to promoting experiential learning that is required for the 21st century. Design thinking is able to assist students in developing thinking skills for the future. Through experience and iteration process in design thinking, students will develop their cognitive and social skills such as curiosity, innovation, empathy and communication (Noel & Liu, 2017). Exposure to design-based learning strategies in schools could develop a solid foundation that would benefit students to facilitate their creative thinking and give them the opportunity to engage in active learning at school and future success in their professional lives.

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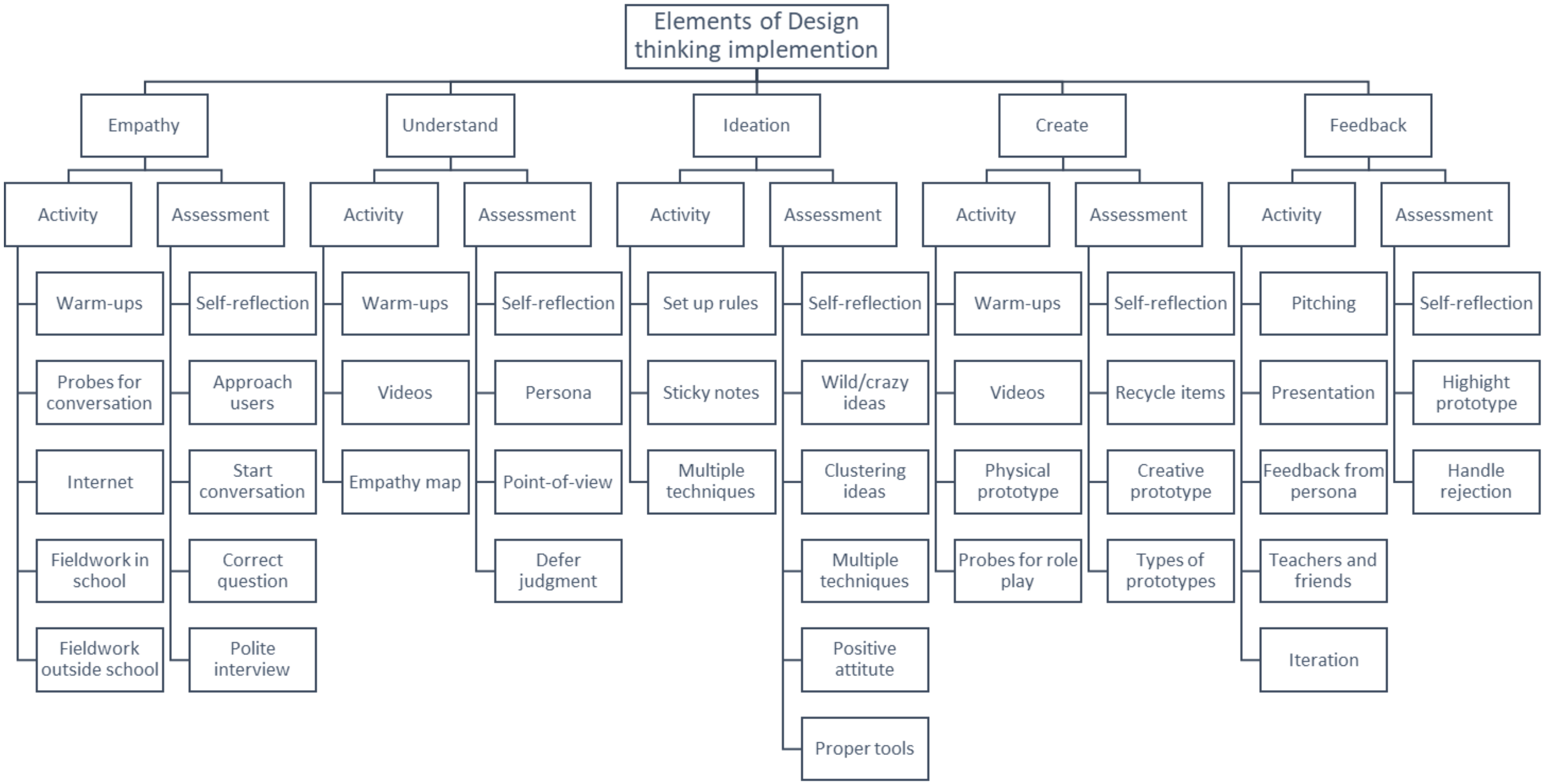

Figure 2: *Elements Structure of the Design Thinking Implementation*

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