

Understanding Design Thinking as an Innovative Approach in Engineers in Society Course from Civil Engineering Student's Perceptions

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ABSTRACT - Design Thinking (DT) is a robust framework to identify and solve various human problems creatively. It offers a systematic solution to train engineering students in critical and creative thinking to solve complex engineering problems. The DT method is integrated within the Engineers in Society (EIS) course to develop problem-solving skillset among the final year engineering students. This paper presents the understanding of DT towards achieving the program outcome related to Engineers and Society attribute for the final year civil engineering students taking the EIS as one of the culminating courses. Community problem-based learning (Com-PBL) was used as a teaching and learning method in the course where the students participated in a community project. The findings from the survey questionnaires responded by 165 indicate that most students demonstrated good understanding on the Design Thinking approach implemented in the course. It can be concluded that the DT approach is a good method to improve the cognitive learning domains in developing student attributes toward the understanding of complex engineering problem-solving in societal contexts. Overall, from a Continual Quality Improvement (CQI) perspective, this study is important to improve, develop and evaluate the teaching, learning and assessment methods adopted for engineering education.

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1.0 INTRODUCTION

The concept of Design Thinking has roots in a variety of disciplines. It is frequently, even not necessarily connected with engineering, architecture, and related design disciplines in early Design Thinking literature [1]. The essence of Design Thinking is to immerse participants in situations that need them to think and work like professional designers, fostering civic literacy, empathy, cultural awareness, and risk taking [2]. The tools of observation, experience and inquiry enable designers to comprehend human needs and mold information to drive the creation of goods and experiences that build human connections through aesthetics, need-finding, or producing meaning[3]. Design Thinking seeks to go beyond the immediate boundaries of a problem in order to ensure that the proper questions are being asked [4]. Through drawing, prototyping and storytelling, participants will be able to examine, synthesize, diverge, and develop insights from various fields. The facilitator encourages learners to perceive limits as sources of inspiration during the design thinking process. The outcomes are often aimed toward novel integrations of signs, things, behaviours, and environments rather than a technical "fast fix." Design thinking approach was found to be an effective tool for developing socially responsible students in their first year of engineering students in India [5]. In addition teaching engineering design thinking was used to explore the virtual internships, online simulations of 21st-century engineering design practices [6]. Qualitative approach based on a case study was carried out on the five-step design thinking process in educational museum game design [7]. Similarly, a qualitative analysis of five well-known models of the Design Thinking process and of ten of the most applied DT tools was also carried out [8].

In Malaysia, the current learning strategy includes attempts to improve service learning, as this pedagogical method is viewed to fulfil the national educational goals of creating graduates with employable skills [9]. As a result, the Ministry of Higher Education has developed 'SULAM' (Service-Learning Malaysia - University for Society), a set of national guidelines for service-learning implementation in Malaysian universities. Furthermore, some universities in the country have developed their own set of service-learning criteria that they believe are better suited to their specific setting. This is consistent with the findings of a previous researcher who highlighted that service-learning techniques should strive to create a sustainable environment for collaboration between the institution and the community [10].

Although a considerable amount of literature has been published on Design Thinking, less attention has been given to the integration of assessment tools based on SULAM and DT approaches for engineering programs. A previous study recommended that future work should focus on better understanding unique applications of design thinking within

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engineering course design and methods that might to support more designedly behaviours among engineering educators[11]. Therefore, engineering educators need a better understand of the nature of SULAM and DT to effectively apply them as pedagogical strategies for engineering courses which are heavily problem based [12]. In this study, a final year engineering course involving 462 students was selected as a case study on the use of SULAM and DT approaches based on community projects. Thus, this paper presents parts of the efforts directed towards the optimal integration of Design Thinking pedagogical approach within the academic curriculum for civil engineering program in one of the public universities in Malaysia.

2.0 METHODOLOGY

This study adopted a quantitative approach of data collected through survey questionnaires administered to the targeted respondents who have taken the EIS course to enquire their perception and understanding of Design Thinking approach integrated in the assessment tool. There five (5) sections namely, Section A (Demographic); Section B (Perception and Understanding on Design Thinking approach); Section C (Assessment Tools); Section D (Challenges) and Section E (Recommendations and Improvements). This paper presents only Section A and Section B. The target respondents are 462 students who were in their final year and semester eight (8) using a sampling frame from the Academic Affairs Office of the School of Civil Engineering Universiti Teknologi MARA, Shah Alam for Semester October 2020, March 2021, and October 2021. The survey data obtained was analysed using IBM SPSS software, by assessing the reliability of the instrument and conducting descriptive analyses with the aid of pie charts and histograms to convey the information effectively.

3.0 RESULTS ANALYSIS AND DISCUSSION

There are six (6) statements related to Design Thinking approach namely, related to the effectiveness of the DT process and on the 5-steps in DT process which are empathy, define, ideate, prototype and test. Out of 462 students registered for the Engineers in Society Course (ECC589) around 165 have responded, resulted in a response rate of around 36%. Students were introduced to the concept of the Design Thinking (DT) process as an integral part of the instructional guidance for the EIS course. The process was initially presented to the students at the start of the class and further elaborated upon to create rubrics for evaluating the students' skills and knowledge. A previous study shows that in order to prepare students for project, the concepts and techniques of design thinking are taught so that these can be applied during the project execution[13].

Table 1 show the reliability test carried out for the study for Section B, C and D. The reliability test's Cronbach alpha shows value of more than 0.7 for each section which indicates that the survey tool is reliable with good internal consistency value [14].

Table 1. Cronbach alpha values from reliability test

| Section | Cronbach Alpha Value |
|--|----------------------|
| Section B: Perceptions and Understanding of the Design Thinking Approach | 0.906 |
| Section C: Effectiveness of the Assessment Tools | 0.711 |
| Section D: Challenges faced in Carrying Out SULAM-DT projects | 0.905 |

3.1 Respondent's Profile

Figure 1 shows the respondent's profile based on gender, age, course taken, and their CGPA based on data obtained for Section A of the survey.

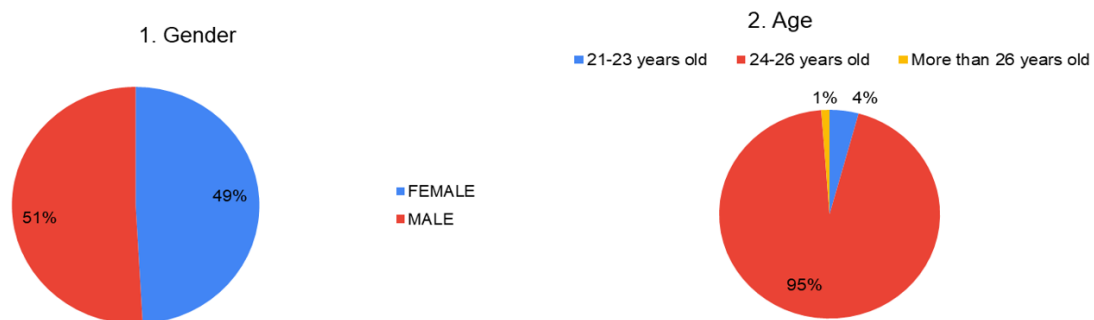


Figure 1. Respondent's profile

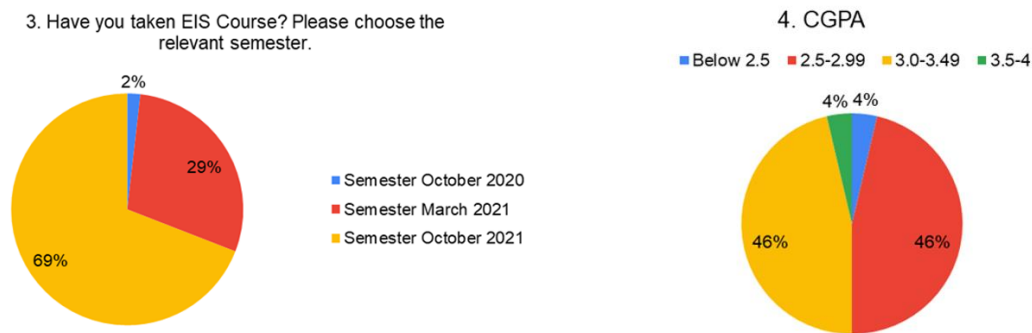


Figure 2. (cont.)

Figure 1 shows an almost equal percentage of respondents in terms of gender, with the majority of them age between 24 to 26 years old. Almost all of them have taken the Engineers in Society course with almost 50% attained CGPA of more than 3.0. The following analysis and discussion are based on Section B of the survey questionnaires that consists of 6 items which are explained in each section.

3.2 Design Thinking as a Process to Develop Critical and Creative Thinking

The assumption is that having gone through the process of applying Design Thinking approach in their community-based projects, the students will have developed their understanding and perception on the suitability of the approach in specific type of problem-solving activities. The statements measured the level of effectiveness using a 5-point Likert rating: 1 – Not Effective, 2 – Less Effective, 3 – Moderately Effective, 4 – Effective, 5 – Very Effective. Data was analyzed using descriptive analysis and simple statistics.

Figure 2 shows that most students (97%) indicated that the Design Thinking approach is an effective process to develop their critical and creative thinking through the community project they carried out. The results show that students benefited tremendously from the learning process and are aware of the advantage of applying the DT approach in problem-solving. A previous study highlighted the importance in using DT method as an effective teaching and learning method to tackle complex problems systematically [15].

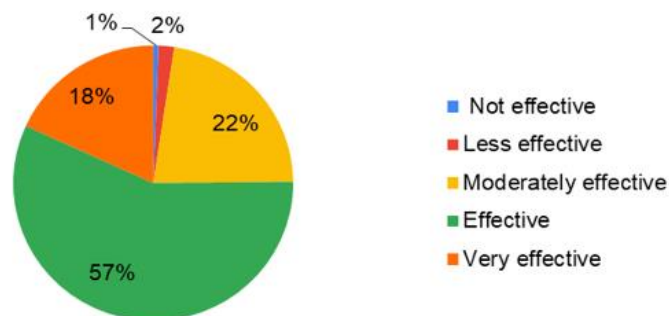


Figure 3. Design thinking as an effective method

It is well known that design thinking and the design process are intrinsically flexible and adaptable, drawing on and developing a student's capacity to frame opportunities for change and bring the form to ideas to improve the human condition [1].

The following five (5) statements are given to the students to indicate their level of understanding on each Design Thinking stage, namely, empathy, define, ideate, prototype and testing using a 5-point Likert rating: 1 – Lack of Understanding, 2 – Poor Understanding, 3 – Moderate Understanding, 4 – Good Understanding, 5 – Very Good Understanding.

3.3 Empathy Stage

The first stage in the Design Thinking approach is known as empathy. The given statement relates to the student level of understanding in the empathy stage, which requires them to understand the community's needs. Figure 3 shows that the students have a good level of understanding in the empathy stage. However, the range of answers given by the students suggests that a small percentage of individuals (1%) may have slightly different perception of how much effort has been made to identify the actual needs of the users.

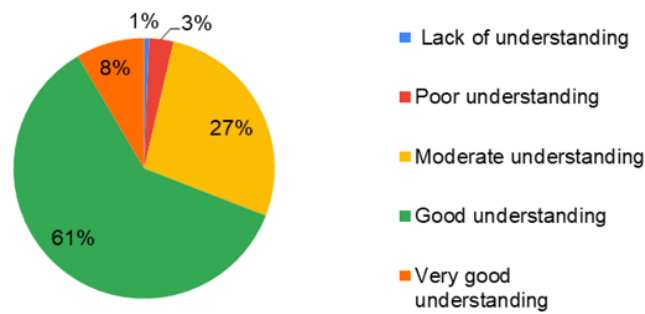


Figure 4. Empathy stage

The empathy stage is the understand phase of the process constitutes the intensive preoccupation with a problem and its needs [8]. The empathy stage can be carried out through several techniques, such as surveys and observation and other methods that may also be appropriate and suitable [9]. Through observations and engagement with the community, the students tried to become experts. Thus, they understand that being empathy allows them to set aside their own assumptions about the world and gain real insights into the community.

3.4 Define Stage

The second stage in the Design Thinking approach is known as the define stage. The define mode is critical to the design process because it results in point-of-view (POV): the explicit expression of the problem that one is striving to address [16]. The given statement is related to the student's level of understanding on the define stage that requires them to state or define the community's needs and problems. Figure 4 shows that majority of the students have a good understanding of the define stage.

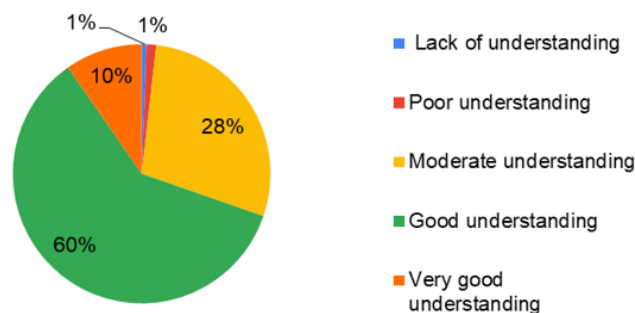


Figure 5. Define stage

In this stage, the students analyzed their observations during the empathy stage. They synthesized them to define the core problems they identified during the empathy stage toward developing solutions. However, the previous study shows that students were aware that the DT process is an iterative process. Thus, if they did not have sufficient understanding of the user requirements during the ideation stage to propose a good solution, they may have to repeat the "empathy" stage [17].

3.5 Ideation Stage

The third stage in the Design Thinking approach is known as the ideation stage. Ideation is the seeking of potential solutions to the identified problems where these solutions are built and then tested [7]. The given statement is related to the student level of understanding of the ideation stage. This stage requires them to challenge assumptions and create ideas through a brainstorming session. Figure 5 shows that majority of the students have a good understanding of this stage.

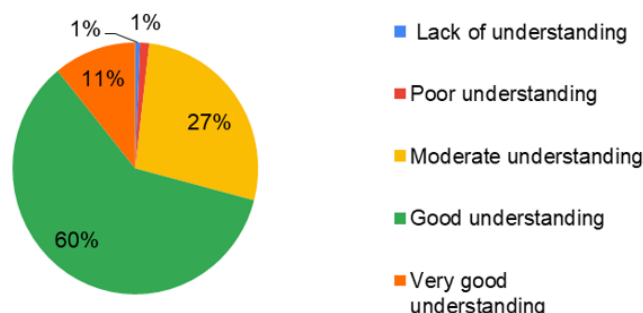


Figure 6. Ideation stage

They understand that they need to carry out brainstorming sessions to stimulate their creativity and flexibility in thinking to generate multiple solutions. The range of answer provided may be an indication of the individual level of understanding in the brainstorming process. Hence, it is a positive indication that more than 80% of the students either have a “Good” or “Very Good Understanding” that this process had taken place. After they understood the user requirements, they moved on to the ideation process by carrying out brainstorming to propose possible solutions that may help to solve the user problems [17].

3.6 Prototyping Stage

The fourth stage in the Design Thinking approach is known as the prototyping stage. The given statement is related to the student level of understanding of ideation stage that requires them to start creating solutions. Figure 6 shows that a majority of the students have a good understanding of the prototyping stage.

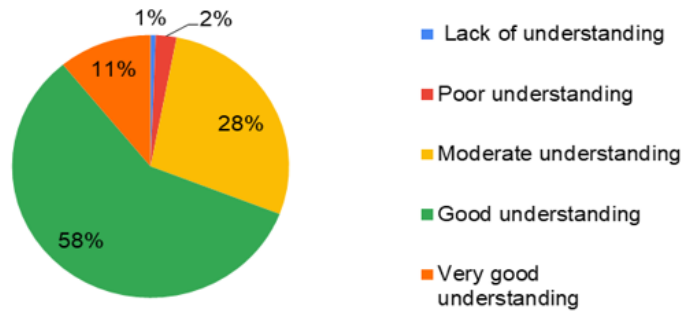


Figure 7. Prototyping stage

This stage is an experimental phase to identify the best possible solution for each problem found where they need to produce a model as a scaled-down version of the product, system, process etc. Initial prototypes roughly represent ideas, using materials such as paper and tape, clay or Play-Doh, LEGOs, cardboard, wood, and other, often recycled material [4]. Based on the presentation of the prototype, the community was encouraged to ask questions or provide feedback to test the product or try out the solutions described in the testing stage. Since users can validate concepts that have been visualized in prototype form, the goal here is to get feedback during the testing stage [12]. User feedback from experiments with prototypes is important as an assimilation process in making sense of the proposed solution, data, and observations coming from the design environment [18].

3.7 Testing Stage

The final stage in the Design Thinking approach is known as the testing stage. The given statement is related to the student level of understanding in the testing stage that requires them to challenge assumptions and create ideas to test or try out their solutions. Figure 7 shows that most of the students (99%) understand this stage well. Compared to other statements on the understanding of DT, this statement has a higher “Very Good Understanding” and “Good Understanding” response indicating that the students are highly aware of this process. Testing with the users allows teams to learn quickly from their failures [19].

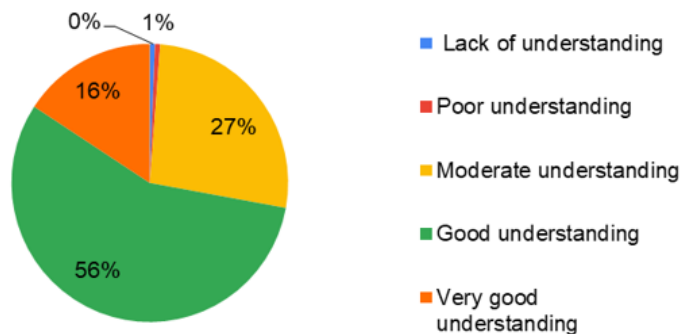


Figure 8. Testing stage

Generally, designers test their prototypes with the users in order to further their understanding of the problem and the solution [19]. This stage requires engagement with the community to obtain the community’s feedback to improve the proposed solutions. Finally, they engaged the community to test-drive, operate, or use the final or finished product, system, process, model, or service provided. On the other hand, inviting other stakeholders outside the community to brainstorm or test solutions with actual users indicates the endeavour to create collaboration [12]. As with prototyping, early testing can often provide valuable feedback to improve future designs [20].

4.0 CONCLUSIONS AND RECOMMENDATIONS

This paper presents one of the important cognitive learning domains used to develop the student attributes toward understanding the application of the Design Thinking process to solve complex engineering problems within the societal and environmental contexts. The survey questionnaires responded by 165 indicate that most students demonstrated a good understanding of the design thinking approach implemented in the Engineers in Society course. It can be concluded that Design Thinking is a flexible and adaptable method in developing student's ability to frame opportunities for change and to bring the form to ideas to improve human life towards complex engineering problem-solving in societal contexts. Thus, this learning model is beneficial and suitable to be continually used in the Engineers in Society course and applicable to other courses that consist of complex engineering problem solving elements. Overall, from a continual quality improvement (CQI) perspective, this study is important to improve, develop and evaluate the teaching, learning and assessment methods adopted for effective engineering education.

5.0 AUTHOR CONTRIBUTIONS

Haidhatul Amizza Azmi: Data curation, Writing- Original draft preparation

Che Maznah Mat Isa: Main Writing- Reviewing and Editing

Fatin Najwa Mohd Nusa: Conceptualization, Methodology

Nur Kamaliah Mustaffa: Validation

6.0 DATA AVAILABILITY STATEMENT

The data used to support the findings of this study are included within the article.

7.0 ACKNOWLEDGEMENT

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8.0 CONFLICTS OF INTEREST

The authors declare no conflict of interest.

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