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Developing Pre-service Teachers' Design Thinking Mindset Using Interactive Technology

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ABSTRACT

Design thinking mindset is integrated within various fields. It became essential for any organization to develop individuals' design thinking mindset due to the positive impact on the whole organization. Design thinking should be an essential component of pre-service teachers' programs where teachers are facilitators to learning and designers of the learning environment. This study aims to pilot the use of interactive technology in developing pre-service teachers' design thinking mindsets. The participants are pre-service teachers in a university in the United Arab Emirates (UAE). A quantitative study using exploratory and confirmatory factor analysis was used. An online survey was adopted to collect the quantitative data after the semester was ended. The study results showed a positive impact of interactive technology in developing pre-service teachers' mindsets.
Keywords: Design thinking, Mindset, Interactive Technology

1. INTRODUCTION

Educational reform in the United Arab Emirates (UAE) became one of the main goals of the country's National Agenda to shift the focus from dependence on oil to a knowledge-based economy. This study aligns with the UAE vision, UAE's 2030 Agenda, and Science, Technology, and Innovation (STI) Policy. It was stated in the UAE's 2030 Agenda that having a higher percentage of high-quality teachers is one of the key performance indicators for sustainable development [1]. These goals included preparing students for jobs that do not yet exist by reforming the curricula to focus on 21st-century skills where learning is empowered by technology [1]. In addition, enabling learners to acquire the skills needed to be successful citizens is one of the main aims and purposes of Science, Technology, and Innovation Policy STI [2]. In the World Education Forum (WEF) report, a survey of a group of companies was conducted regarding the current skills used, and UAE was rated as average (71.7%) in 2019-2020. The current skills are active learning and learning strategies, leadership and social influence, analytical thinking and innovation, quality control and safety awareness, complex problem-solving, critical thinking and analysis, management of personnel, creativity, originality, initiative, technology use, monitoring, and control, and service orientation [3].

Design thinking (DT) is a multidisciplinary human-centered innovation approach described as inspired by how the design thinkers understand human needs, rapid prototyping, and how they generate creative ideas that will transform how you develop products, services, processes, and organizations are developed [4]. Integrating design thinking in various ways into the organization's operations has positive impact in various business sectors [5]. Design thinking aims at transcending the immediate boundaries of the problem to ensure that the right questions are being addressed. It employs divergent thinking to find many possible solutions to the problem and convergent thinking to narrow down the focus to the best solution. The benefits of design thinking are to view a problem from multiple perspectives; dive deeper into a problem; innovate leverage thinking and creative problem solving; ensure the outcome meets objectives and requirements and encourage iteration and revisions. Design thinking is considered a practical approach to experiential learning that offers a frequentative approach to solving ill-structured and complex problems while building a design thinking mindset that can lead to creative and innovative outcomes [6]. Three striking points constitutes are included in design thinking mindset: human-centeredness, abductive reasoning, and failure in learning that leads to innovation [7].

Design thinking is a structured approach to human-centered design that combines convergent and divergent thinking, multidisciplinary teams, and visualization techniques to develop individuals' 21st century skills [8]. Innovations are developed with this mindset to ensure users' satisfaction. The second mindset is abductive reasoning, which challenges the existing solution to invite alternatives and generate new ideas through deductive and inductive logical approaches. Based on assertion, it seeks to ask and answer the question, "What might or ought to be rather than what is already there" [7]. The third mindset is learning by failing, which frames failure as necessary for learning. Instead of always making appropriate choices and reducing errors, learning by failing recognizes that risk-taking might lead to unexpected results [7]. This distinctive mindset widened the possibility of explorations, confining uncertainty reduction and characterizing innovation routes [9].

Theories of complex human behavior are set as the basis for the mindset action where innovation is considered. The reasoned action and planned behavior theories argue that attitudes and intentions precede behavior [10]. These theories are used in education and have predicted substance abuse, HIV prevention, and other complicated activities [11]. In addition, it was shown in many empirical studies that the theory of self-efficacy states that confidence in the ability to perform a behavior affects carrying it out [12]. Finally, the belief that personal capabilities shape an individual's choices is the theory of implicit intelligence [13]. Individuals who are motivated to learn usually engage in challenging behaviors at the risk of failure, while those who avoid new challenges prove that their skills are inadequate [13].

In conclusion, these theories and actions imply that what is thought influences what is done. Accordingly, Fraser [14] describes the designer's mindset as openness, empathy, intrinsic motivation, mindfulness, adjustment, and optimism. It is described as orientation toward the work with a mentality which approaches problems using experimental or explorative elements, which is tolerant of ambiguity, is optimistic, and future-oriented.

Using interactive technology to plan and teach lessons is a reliable pedagogical approach that enhances teachers' competencies [15], leading to the development of a design thinking mindset. Technological development improves people's

lives, existence, their ability to cope with the environment, and to solve complex problems [16]. Interactive technology can lead to interactive learning where students assimilate information related to the real world. It is a hyperactive social process where students lead their learning journey [17]. The design thinking mindset developed using interactive technology that helps establish a friendly environment among learners and encourages them to connect [18; 19]. Learners will be creative and innovative when they are aware of themselves as learners who can use the information, act as research scientists, solve complex problems and empathize with individual needs in order to create new products that meet their needs [17]. Previous researchers stated that teachers and students should be involved in the analysis, design, development, and evaluation process while using interactive technologies where it leads learners to acquire integrated competencies while working on interdisciplinary technology-enhanced learning [20; 21].

2. PURPOSE OF THE STUDY

This pilot study aims to present and experiment the use of interactive technology in developing students' design thinking mindset at different educational levels. Teachers need to consider the development of students' design thinking mindset while planning for lessons using technological tools. Applying design thinking in the curriculum offers vast potential to enhance learning in various fields through the integration of design thinking. In this study, pre-service teachers were exposed to various interactive technology applications such as Genially, Canva, and iCloud apps. This study seeks to answer the following questions: To what extent does the use of technology impact pre-service teachers' design thinking mindset?

3. METHOD

This study sought to present and experiment the use of technology in developing a design thinking mindset for students at the undergraduate level. In addition, this study will adopt a quantitative method to pilot the tool used in measuring learners' design thinking mindset.

The study participants are pre-service teachers in an early childhood education program. The intended sample size is 60 students from a federal university in the UAE. The criteria set for the participants as students are defined by: (i) studying STEM subjects and (ii) being willing to participate in the study. The final sample size used was 32 participants.

The students' survey is designed to be piloted. The survey is designed with three main sections. The first section is the demographic multiple-choice questions. The second section is design thinking mindset self-evaluation, divided into six sub-categories. The reliability of the survey is measured with the participants using Cronbach's Alpha. The survey was sent to two experts in educational studies to check the content and alignment of the questions to the study's main purpose. Finally, a few terminologies were changed, and the tool was ready to be used.

The study's purpose was explained to all participants, and a consent form was sent to them. Participants felt free not to participate in the study. The survey was sent to them through a web survey, and the quantitative data was analyzed using Statistical Package of Social Sciences (SPSS). Exploratory and confirmatory factor analysis was used to test the tool and ensure validity. Descriptive statistics were also used to present the mean and standard deviation.

4. RESULTS

The reliability test was conducted by calculating Cronbach's Alpha coefficient. First, the teachers' questionnaire was piloted with 42 teachers in another school valued at 0.962 for design thinking mindset, which is considered very highly reliable and suitable for the study. The reliability coefficient of the scale (Cronbach's Alpha) of the categories was determined to be 0.810 for uncertainty, 0.875 for user empathy, 0.629 for mindfulness of the process, and 0.926 for the collaborative working with diversity, 0.934 for learning-oriented, and 0.946 for creative confidence. Then, the survey was then administered to teachers through a web survey.

A descriptive statistic was used to analyze the survey results, including mean and standard deviation. Table 1 compares the means where the highest mean is uncertainty, and the lowest is the learning-oriented mindset.

Table 1. Comparison between the mean and standard deviation of the design thinking mindset categories.

Design Thinking Mindset	Mean	Std. Dev.
A. Being comfortable with problems (Uncertainty)	4.29	0.76
B. User empathy	4.16	0.80
C. Mindfulness of the process	3.89	0.96
D. Collaborative working with diversity	3.79	1.05
E. Orientation to learning (Learning-oriented)	3.61	1.04
F. Creative confidence	3.82	0.99

The item means ranged ($3.6 < x < 4.3$), which is considered to be between moderately high and high according to Handal et al.'s (2013) questionnaire score range of the means to describe the results.

After analyzing the content validity, the construct validity was conducted by running the Exploratory Factor Analysis EFA, a statistical analysis method used to identify the underlying relationship between measured variables.

For uncertainty, the Kaiser-Meyer-Olkin (KMO) value is 0.799, and the Bartlett Chi-square approximation is 71.504 with $p = 0.000$. A KMO value close to 1 indicated that the correlation pattern was compact enough to produce different and reliable factors. In user empathy, the value of KMO is 0.586, and the Bartlett Chi-square approximation is 145.024 with $p = 0.000$. A KMO value close to 1 indicated that the correlation pattern was compact enough to produce different and reliable factors. In mindfulness of the process, the value of KMO is 0.476, and the Bartlett Chi-square approximation is 73.492 with $p = 0.000$. A KMO value close to 1 indicated that the correlation pattern was compact enough to produce different and reliable factors. In collaborative working with diversity, the value of KMO is 0.844, and the Bartlett Chi-square approximation is 175.254 with $p = 0.000$. A KMO value close to 1 indicated that the correlation pattern was compact enough to produce different and reliable factors. In learning orientation, the value of KMO is 0.831, and the Bartlett Chi-square approximation is 190.189 with $p = 0.000$. A KMO value close to 1 indicated that the correlation pattern was compact enough to produce different and reliable factors. In creative confidence, the value of Kaiser-Meyer-Olkin KMO is

0.859, and the Bartlett Chi-square approximation is 202.457 with p = 0.000. A KMO value close to 1 indicated that the correlation pattern was compact enough to produce different and reliable factors. The analysis results in Table 2 indicate that the KMO and Bartlett sphericity tests indicated that the EFA method was appropriate for use in this study.

Table 1
Kaiser-Meyer-Olkin and Bartlett's sphericity tests for design thinking mindset categories.

Category	KMO Measure of Sampling Adequacy	Bartlett's Test of Sphericity		
		Approx. Chi-Square	df	Sig.
A. Being comfortable with problems (Uncertainty)	.799	71.504	21	.000
B. User empathy	.586	145.024	21	.000
C. Mindfulness of the process	.476	73.492	21	.000
D. Collaborative working with diversity	.844	175.254	21	.000
E. Orientation to learning (Learning-oriented)	.831	190.189	21	.000
F. Creative confidence	.859	202.457	21	.000

Then, Confirmatory Factor Analysis (CFA) was undertaken to complement the results obtained with the EFA and to test how well the measured variables represent the number of constructs. The Comparative Fit Index (CFI) is measured and presented in Table 3. In uncertainty, all the values show a good fit for the results. In user empathy, the CFI (0.97) and NFI (0.969) show a very good fit; however, TLI (0.921) show a good fit for results; For the mindfulness of the process, the CFI (1), NFI (0.99) and TLI (1) show a very good fit. Regarding the collaborative of diversity, the CFI (0.979), NFI (0.979), and TLI (0.077) are in a very good fit. For the learning orientation, the CFI (0.958) and NFI (0.958) show a very good fit, while TLI (0.938) shows a good fit. Finally, for creative confidence, the CFI (0.984), NFI (0.983), and TLI (0.976) are in a very good fit.

Table 3
CFA results of the scales used in the research

Category	Fit Index	Value	Fit
Uncertainty	CFI	1	Very Good Fit
	NFI	0.99	Very Good Fit
	TLI	1	Very Good Fit
Empathy	CFI	0.97	Very Good Fit
	NFI	0.969	Very Good Fit
	TLI	0.921	Good Fit
Mindfulness	CFI	1	Very Good Fit
	NFI	0.999	Very Good Fit
	TLI	1	Very Good Fit
Collaborative	CFI	0.979	Very Good Fit
	NFI	0.979	Very Good Fit
	TLI	0.969	Very Good Fit
Orientation	CFI	0.958	Very Good Fit
	NFI	0.958	Very Good Fit
	TLI	0.938	Good Fit
Creative confidence	CFI	0.984	Very Good Fit
	NFI	0.983	Very Good Fit
	TLI	0.976	Very Good Fit

5. DISCUSSION

The results showed that undergraduate students' design thinking mindset is high after using the different applications of interactive technology in online learning. The mindsets measured included: being comfortable with problems (uncertainty); user empathy; collaborative working with diversity; orientation to learning (learning-oriented); and creative confidence. The highest evaluation was in uncertainty and user empathy. These results are compatible with Summers and Scherpereel [9], who stated that the design thinking mindset widens the possibility of explorations, confining uncertainty reduction, and characterizing innovation routes. In addition, high results are shown in mindfulness, creative confidence, and collaborative working with diversity. This implies that when students are aware of the learning process and/or process of solving problems while working with others, it leads to creating confidence and development. These results confirmed what Bandura [12] mentioned that confidence in performing a behavior affects carrying it out. The lowest results were shown in orientation to learning, where not all students are learning-oriented. In other words, some students rely on their peers to lead and direct the process of learning or solving the problems and making choices. This is an important issue that needs to have more focus, as Dweck [13] highlighted in his theory of implicit intelligence that the belief of learners' capabilities shapes their choices.

In the end, the results revealed that using interactive technology helped in developing pre-service teachers' design thinking mindset. Self-efficacy is considered the backbone of the study, where students' thoughts about themselves and their capabilities influence their actions. The results confirmed Fraser's study results [14], which described the designer's mindset as openness, empathy, intrinsic motivation, mindfulness, adjustment, and optimism. It was highlighted that design thinking is a human-centered approach that can be integrated into various fields that combines convergent and divergent thinking, multidisciplinary teams, and visualization techniques to develop individuals' 21st century skills [8]. Abductive reasoning and learning by failure are essential components of developing a design thinking mindset [7]. This was confirmed in the high results shown in the process's uncertainty, empathy, and mindfulness.

6. CONCLUSIONS

This study aimed to develop students' design thinking mindset using interactive technology. This study is to pilot the design thinking inventory with pre-service teachers. The study confirmed the possibility of using the design thinking inventory in measuring students' design thinking mindset. The results revealed that the use of technology developed pre-service teachers' mindset positively. Although orientation to learning shows lower results than other design thinking mindsets, it is considered to be moderately high. However, more attention toward orientation to learning would be beneficial to students. This is because it was proved that students' thoughts influenced their actions [7].

It is highly recommended to include qualitative data analysis in this study to have an in-depth analysis of pre-service teachers' mindsets development. The design thinking mindset inventory

can be used as a tool for pre-service teachers to measure the development of their mindsets.

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