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Analysis of Students' Design Thinking in Creating 3D Creative Works Utilizing Mobile Technology within the Framework of Local Wisdom

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Abstract

This study investigated students' design thinking in creating 3D creative works using mobile technology in the framework of local wisdom. By employing a mixed-methods approach, the study compares the design thinking abilities of students who engaged with mobile technology in the context of local wisdom with those who do not. Quantitative analysis, involving sixty students, revealed that the experimental group, exposed to mobile technology and local wisdom, demonstrated significantly higher competencies in design thinking, particularly in areas such as comfort with uncertainty, human-centeredness, and collaborative work. Qualitative insights further illuminated the enriched learning experience, showcasing students' deepened engagement and connection to cultural heritage through the integration of local wisdom into their 3D creative projects. The findings underscore the pivotal role of mobile technology and local wisdom in fostering innovative design thinking, suggesting that this approach not only facilitates creative problem-solving but also instills a sense of cultural identity and pride among students. Despite its focused educational context and limited sample size, the study suggested broader implications for curriculum development, recommending the incorporation of these elements into design and creative courses to enhance students' design skills and cultural understanding.

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INTRODUCTION

The concept of design thinking has received significant attention from professionals and scholars alike, owing to its profound impact on fostering innovation (Kimbell, 2011; Micheli et al., 2019). This approach pays a crucial role in driving society towards modernization (Li & Zhan, 2022). In the field of design, design thinking revolves around understanding design expertise to facilitate the development of students' skills, enabling them to emerge as skilled and exceptional designers (Cross, 2004). Expert designers are renowned for their adeptness in creative problem-solving, serving as valuable sources of innovative insights (Kimbell, 2011).

Design thinking is a methodology that involves the identification of human needs and generating innovative solutions using design principles. Scholars argue that design thinking can be taught and adopted by individuals in various design fields (Micheli et al., 2019), which has led to a growing interest in expanding design education (Brenner et al., 2016). Previous research has explored the integration of design thinking in education, highlighting its role in promoting abductive reasoning and its potential as a competitive advantage (Li & Zhan, 2022). Design thinking is widely recognized as a valuable skill that can be applied to different domains, including information technology (IT) (Dorst, 2011).

Within the field of IT education, design thinking has a significant impact on students' ability to create innovative digital products (Chang et al., 2022). Another study (Lin et al., 2020) emphasizes the importance of design thinking in IT courses, demonstrating its effectiveness in achieving curriculum objectives, developing information skills, and enhancing the value of students' digital creations. However, recent findings show that students' performance in design thinking is poor level in information technology courses (Indriaturrahmi et al., 2023). This finding is quite surprising, considering that design thinking plays a vital role in enabling someone to produce innovative work. Developing students' thinking abilities relies on interventions during the learning process (Prayogi et al., 2018; Verawati et al., 2021), such as providing a supportive and motivating learning environment (Papadakis et al., 2020) that is engaging and interactive (Suhirman & Prayogi, 2023), along with relevant digital resources (Bilad et al., 2022; Verawati et al., 2022). Moreover, presenting students as autonomous learners and employing a digital learning framework through an online system can be a practical solution (Ou et al., 2023; Zhao, 2023).

There is an opportunity to provide supporting resources in the design process, for example presenting technology that utilizes local wisdom contexts as highlighted in previous research (Rashid & Ara, 2015; Sándorová et al., 2020). Local wisdom values can be a source of authentic learning for students (Zidny et al., 2020). Students' knowledge and thinking capacity can continue to develop if local wisdom values are integrated by utilizing developing technological resources (Wahyudi et al., 2023). The integration of technology into education has transformed traditional learning paradigms, fostering innovative approaches to creativity and design thinking. This transformation is particularly evident in the realm of 3D creative works, where mobile technology has emerged as a pivotal tool in enhancing learning experiences and outcomes. Amidst this technological evolution, local wisdom—comprising the knowledge, traditions, and practices inherent to specific cultures—remains a crucial element in shaping students' design perspectives and fostering a deep connection with their cultural heritage.

In IT courses, students showcase their creative capabilities through their digital creations. To foster creative product designs, we facilitate 3D content learning projects via online courses that raise design issues in the context of local wisdom. The process of creating 3D digital content involves several key steps, including concept and planning, modeling, and rendering (Tytarenko et al., 2023). Students are encouraged to explore their own unique ideas and designs according to the context of local wisdom, such as mosque minarets, statues, and others. They meticulously model these objects and apply various elements, including structural lighting, shadows, textures, and other effects, to achieve the production of high-quality images. Figure 1 showcases some exemplary digital creations that have been crafted by our students.

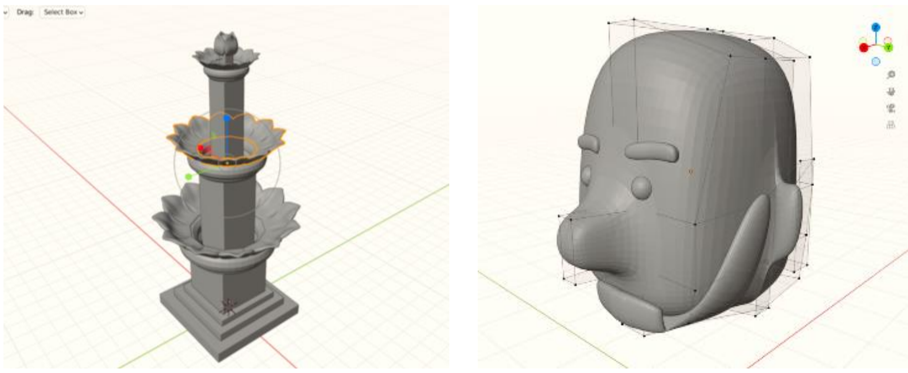

Figure 1. Examples of 3D content creation in the context of local wisdom, such as mosque towers and statues made by students

Previous research established a positive correlation between the ability to generate creative designs and students' proficiency in design thinking (Liu & Li, 2023). Additionally, a recent study provided insight into the factors that influence students' digital creativity in the context of a 3D digital course. These factors include digital openness, digital skills, self-directed learning, and supportive learning environments, all of which positively impact students' digital creativity (Nguyen et al., 2023). However, to the best of our knowledge, there is a lack of research exploring the design thinking characteristics of information technology students in the 3D Content online courses oriented towards creative designs within the context of local wisdom.

To foster design thinking in students, it is crucial to provide an appropriate pedagogical model that empowers them to develop their cognitive skills and produce creative designs. This study aims to investigate and analyze of students' design thinking in producing 3D creative works using mobile technology within the context of local wisdom. The research questions guiding this investigation are as follows.

- Research Question 1: What are the students' design thinking processes in producing 3D creative works using mobile technology within the context of local wisdom?

- Research Question 2: How do students respond during the 3D creative works course using mobile technology within the context of local wisdom?

METHODS

Research Design

This study utilized a mixed-methods approach (Creswell & Creswell, 2018), incorporating both quantitative and qualitative research paradigms to offer a comprehensive understanding of students' design thinking in the context of creating 3D creative works using mobile technology, with a specific focus on local wisdom. The quantitative portion utilized an experimental design, specifically a quasi-experiment with a post-test only control group design. This framework was selected to systematically evaluate and compare the design thinking competencies of students who were exposed to mobile technology in their creative work process and those who are not, thereby addressing the first research question (Research Question 1).

On the other hand, the qualitative aspect of the research was designed to delve deeper into the students' experiences and perceptions during the 3D creative works course, employing interview techniques to gather in-depth, descriptive insights. This methodological choice aimed to uncover the nuanced ways in which students engage with mobile technology and local wisdom, providing a detailed understanding of their responses and interactions throughout the course, which directly pertained to the second research question (Research Question 2).

Sample

The sample comprised of sixty Information Technology students from a university in Indonesia, with an average age of nineteen years. These participants were evenly divided into two classes of thirty students each and then randomly assigned to either an experimental group or a control group to ensure the study's comparative analysis was valid. The experimental group comprised seventeen male and thirteen female students, while the control group consisted of sixteen male and fourteen female students. It is important to note that both groups were taught by the same educator to ensure consistency in teaching. Importantly, before the start of this study, neither group had prior experience with 3D creative works courses that utilized mobile technology in the context of local wisdom, ensuring a fair assessment of the intervention’s impact.

Ethical Consideration

Ethical considerations in this research were meticulously followed to respect the rights and well-being of the participants. Informed consent was obtained from all participants, ensuring they were fully aware of the study's purpose, their involvement, and their right to withdraw without facing any consequences. Confidentiality and anonymity were strictly maintained throughout the study, with all data anonymized and used solely for research purposes. These measures were taken to adhere to ethical research standards, protecting participant welfare and maintaining the integrity of the research process.

Research Instrument

Quantitative data were collected using a self-perception questionnaire called the Design Thinking Scale, developed by Ladachart et al. (2022). This instrument assessed six indicators of students' design thinking competencies, including comfort with uncertainty and risks, human-centeredness, mindfulness of process and impacts, collaborative work with diversity, orientation to learning by making and testing, and confidence in using creativity. The thirty-item questionnaire utilized a five-point Likert scale, to comprehensively evaluate design thinking attributes. The reliability of this scale was confirmed through Cronbach's α, which yielded a value of 0.927, indicating high internal consistency and validating its use for evaluating students' design thinking in this study.

For qualitative data, interviews were conducted based on a set of guidelines that had been previously validated by experts. This ensured that the qualitative inquiry was structured yet flexible enough to delve into students' experiences and perceptions during the course, with a focus on their engagement with mobile technology and local wisdom.

Data Analysis

The analysis of quantitative data to address Research Question 1 involved an examination of the students' scores on the Design Thinking Scale. An ANOVA test was conducted to identify any significant differences in design thinking competencies between the experimental and control groups across the various dimensions of the scale. Prior to the ANOVA test, a normality check was performed on the collected data to verify its distribution. The test confirmed that the scores from both groups followed a normal distribution, satisfying the prerequisite for normality with a p-value greater than 0.05. This allowed for a valid comparison of design thinking competencies between the groups.

To analyze the qualitative data gathered through interviews for Research Question 2, a thematic analysis was carried out. This process involved transcribing the interviews and conducting a thorough reading to identify recurring themes and patterns related to students' responses and interactions with mobile technology in the context of local wisdom. The thematic analysis allowed for the extraction of nuanced insights into how students perceive and engage with the course material, highlighting their challenges, strategies, and the overall impact of integrating local wisdom into their 3D creative works. This qualitative analysis provided a comprehensive and detailed understanding of the students' learning experiences, complementing the quantitative findings and offering a holistic view of the research questions.

RESULTS AND DISCUSSION

This study was conducted to investigate and analyze students' design thinking in the production of 3D creative works using mobile technology in the context of local wisdom. The quantitative analysis conducted to address Research Question 1 reveals the students' design thinking in producing 3D creative works utilizing mobile technology in the context of local wisdom. The results of the difference analysis in design thinking between the experimental and control groups are presented in Table 1 and Figure 2. The ANOVA test results on the average scores of students' design thinking are presented in Table 2.

Table 1. The descriptives analysis results of students' design thinking between groups

Group	N	Mean	SD	SE	Coef. of var.
Control	30	2.964	0.468	0.085	0.158
Experimental	30	3.840	0.811	0.148	0.211

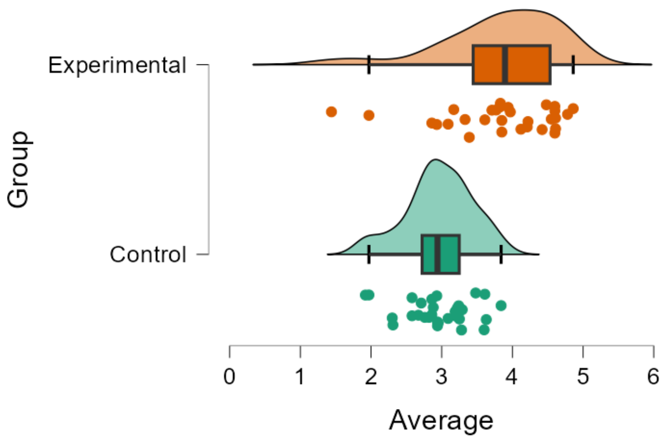

Figure 2. Raincloud plot of difference in average students' design thinking

Table 1 presents the findings from a comprehensive analysis of the design thinking abilities of students in both the experimental and control groups. The control group, consisting of 30 students, exhibitd a mean design thinking score of 2.964 with a standard deviation (SD) of 0.468 and a standard error (SE) of 0.085. These results in a coefficient of variation of 0.158. In contrast, the experimental group, which also comprised 30 students, achieved a higher mean score of 3.840, with an SD of 0.811 and an SE of 0.148. The coefficient of variation for this group was 0.211. The outcomes presented in Table 1 are further supported the Raincloud plot shown in Figure 2. These findings indicate that students in the experimental group, who were exposed 3D creative works course incorporating mobile technology within the context of local wisdom, demonstrated superior design thinking competencies compared to their counterparts in the control group.

Table 2. ANOVA test results on students' design thinking scores average

Cases	Sum of Sqr.	df	Mean Sqr.	F	p	η^2
Group	11.511	1	11.511	26.267	< .001	0.312
Residuals	25.416	58	0.438			

Table 2 present the results of the ANOVA test on the average design thinking scores of students demonstrating a statistical comparison between the experimental and control groups. The analysis yielded an F-value of 26.267, indicating a highly significant p-value of less than 0.001 and an effect size (η^2) of 0.312. This significant difference suggests that the integration of mobile technology in the creation of 3D creative works using local knowledge significantly affects students' design thinking abilities, with the experimental group performing better than the control group. Furthermore, Table 3 displays the results of the differences analysis in design thinking between the experimental and control groups for each design thinking indicator.

Table 3. The descriptives analysis results of students' design thinking between groups for each indicator of design thinking

Indicator	Group	N	Mean	SD	SE	Coef. of var.
(1) Being comfortable with uncertainty and risks.	Control	30	2.256	0.598	0.109	0.265
	Experimental	30	3.295	0.939	0.171	0.285
(2) Human-centeredness.	Control	30	2.975	0.717	0.131	0.241
	Experimental	30	3.800	0.952	0.174	0.251
(3) Mindfulness to the process and impacts on others.	Control	30	3.156	0.806	0.147	0.255
	Experimental	30	3.834	0.958	0.175	0.250
(4) Collaboratively working with diversity.	Control	30	3.080	0.717	0.131	0.233
	Experimental	30	4.080	0.845	0.154	0.207
(5) Orientation to learning by making and testing.	Control	30	3.042	0.883	0.161	0.290
	Experimental	30	4.133	0.935	0.171	0.226
(6) Being confident and optimistic to use creativity.	Control	30	3.277	0.787	0.144	0.240
	Experimental	30	3.898	0.918	0.168	0.236

A thorough analysis of the descriptive analysis for each design thinking indicator reveals a significant disparity between the control and experimental groups (refer to Table 3). For instance, the average scores for confort with uncertainty and risks, human-centeredness, mindfulness towards the process and impacts on others, collaborative work with diversity, orientation towards learning through experimentation, and confidence and optimism in utilizing creativity were all notably higher in the experimental group compared to the control group. This disfference is further highlighted by the coefficient of variation values, which, despite a slight increase in variability among certain indicators in the experimental group, generally indicate a wider range of responses and higher competencies in the experimental group.

Table 4. ANOVA test results on students' design thinking scores average for each indicator

Cases	Sum of Sqr.	df	Mean Sqr.	F	p	η^2
Design thinking indicator	30.137	5	6.027	18.150	< .001	0.086
Design thinking indicator ✻ Group	2.934	5	0.587	1.767	0.120	0.008
Residuals	96.308	290	0.332			

The ANOVA test results outlined in Table 4 confirm the substantial impact of the experimental intervention on students' design thinking abilities across all six indicators. The sum of squares, mean square, and F-values indicate a significant difference in design thinking scores between groups, with a p-value of less than 0.001 signifying statistical significance. The eta-squared (η^2) values further quantify the effect size of the intervention, suggesting a moderate to substantial influence on students' design thinking competencies. Although the interaction between design thinking indicators and group was not deemed statistically significant ($p = 0.120$), the overall impact of the mobile technology-assisted learning approach on enhancing design thinking skills, particularly in the areas of creativity and collaboration within the context of local wisdom, is evident. These results highlight the effectiveness of integrating mobile technology into educational practices, specifically within the field of 3D creative works, to enhance crucial design thinking skills among students. These findings align with previous research indicating that technology-based courses that emphasize hands-on learning yield higher design thinking scores compared to traditional teaching methods (Lin et al., 2020). Furthermore, prior studies have also demonstrated that students' design thinking performance improves when involved in design-based learning (Ladachart et al., 2022).

The qualitative analysis conducted to address Research Question 2 reveals valuable insights from the students regarding their experiences during the 3D creative works course, which incorporated mobile technology in the context of local wisdom. Through thematic analysis of the interview data, several key themes emerged shedding light on how students interacted with the course material and technology.

Firstly, students expressed a high level of enthusiasm and engagement with the use of mobile technology for creating 3D designs. They appreciated the opportunity to utilize contemporary tools in exploring local wisdom, finding that this approach made the learning process more interactive and enjoyable. The integration of mobile technology was seen as a significant advantage, enabling them to visualize and manipulate their designs in real-time, leading to a deeper understanding of the 3D creative work process.

Secondly, incorporation of local wisdom in the course curriculum deeply resonated with the students. They reported that infusing elements of local culture and wisdom into their projects not only enhanced their creativity but also instilled a sense of pride and connection to their cultural heritage. This aspect of the course was deemed as instrumental in prompting them to think critically about the design process and the importance of cultural identity in their work.

Furthermore, students highlighted the collaborative nature of the course, noting that mobile technology facilitated easier and more effective collaboration among peers. The ability to share ideas, receive feedback, and work together on projects in a digital environment was highly valued. This collaborative process was credited with improving their communication skills, fostering teamwork, and enhancing the overall quality of their creative work.

Challenges were also mentioned, particularly in adapting to new software and technologies, which some students initially found daunting. However, they also recognized that overcoming these challenges was part of their learning journey, contributing to their personal and professional growth. The supportive learning environment, coupled with the practical application of mobile technology, played a crucial role in successfully navigating these challenges (Sophonhiranrak, 2021).

The response of the students in the 3D creative works course higlight the significant role of mobile technology in improving learning experiences (Indriaturrahmi et al., 2023). This is particularly true when integrated with elements of local wisdom. The course not only facilitated the development of design thinking skills but also promoted cultural awareness, collaboration, and a positive attitude towards embracing technology in the creative process. These qualitative insights offer a detailed understanding of how students perceive and engage with mobile technology and local wisdom in the domain of 3D creative works. They complement the quantitative findings and provide a comprehensive view of the students' learning experiences.

The results of this study indicate that intervention factors have a crucial influence on the characteristics of design thinking among students. Specifically, the 3D Content online courses focused on creative designs is a significant determinant shaping students' design thinking. Previous studies have shown that learning activities involving design thinking are more engaging than the traditional teaching methods (Goldman et al., 2014; Noweski et al., 2012). Building on this body of research, this study proposes a pedagogical approach that centers around creative designs-oriented learning, utilizes technology, and integrates local wisdom. This approach effectively supports the design process and enhances students' design thinking skills. It encourages active problem-solving rather than relying on predetermined solutions,which is particularly beneficial for generating creative products (Grammenos & Antona, 2018). Additionally, students are taught the fundamental aspects of design while simultaneously developing their creative abilities, enabling them to explore and apply design resources more comprehensively.

CONCLUSION

The study conducted a comprehensive analysis of students' design thinking in the production of 3D creative works, utilizing mobile technology within the framework of local wisdom. This examination revealed significant improvements in their design thinking abilities. The quantitative results clearly demonstrate a noticeable difference between the experimental group, which utilized mobile technology, and the control group. The former exhibited stronger design thinking attributes in various aspects, including adaptability to uncertainty and risk, focus on human-centeredness, and collaboration. These findings are further supported by qualitative insights, as students expressed a higher level of engagement and a deeper connection to their cultural heritage through the incorporation of local wisdom in their projects. The combination of mobile technology and local wisdom not only facilitated innovative design thinking but also fostered a greater appreciation and understanding of cultural identities, thereby enhancing the learning experience and outcomes for students.

LIMITATION

Although this research offers valuable insights, it is not withoutlimitations. The scope of the study was limied to a specific educational context and cultural setting, focusing solely on IT students. As a result, the generalizability of the findings to other disciplines or cultural environments may be limited. Additionally, while the sample size was adequate for the research design, it may restrict the ability to extrapolate the results broadly to all students in IT or design-related fields. Future research should incorporate a wider demographic and cultural diversity to explore the universal applicability of these findings and further validate the impact of integrating mobile technology and local wisdom on design thinking in various educational contexts.

RECOMMENDATION

Based on the findings, it is recommended that educators and curriculum developers integrate mobile technology and local wisdom into the design and delivery of courses, particularly those centered around creative works and design thinking. By doing so, students' design competencies can be enhanced, while also deepening their cultural understanding and appreciation, which is crucial in a todays globalized world. Further research should investigate explore the integration of these elements in other disciplines and broader educational contexts to fully comprehend their impact on students' learning experiences and outcomes. Furthermore, developing strategies to overcome the identified challenges, such as adapting to new software and technologies, will be crucial in maximizing the benefits of this pedagogical approach.

Author Contributions

The authors have sufficiently contributed to the study, and have read and agreed to the published version of the manuscript.

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Conflict of interests

The authors declare no conflict of interest.

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