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Learning Geometry through Design Thinking

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Abstract

This study looked at the efficacy of using the design thinking model to improve Grade 7 students' knowledge of geometry in the context of the fourth industrial revolution (4IR). The study used quantitative and qualitative methods to check the pretest and posttest performance of students, comparing an experimental group exposed to design thinking with a control group using traditional teaching methods. At first, there was no significant difference in pretest scores, showing below-average performance and a gap in basic geometry knowledge in both groups. The succeeding examination of posttest scores repeated the persistent problem of learning geometry, with scores falling below the expected average. The study treats design thinking as a support tool, not an independent replacement for traditional teaching. Participants showed good experience with design thinking, highlighting its clarity, engaging activities, adaptability, and positive impact. This study plays a part in understanding students' performance in geometry and emphasizes the need for a balanced approach that considers students' outlooks while valuing the use of direct instruction. It also serves as a foundation for further research into effective instructional strategies, considering the diversity the students need and the benefits of using design thinking. Furthermore, adapting the constructivist learning theory in teaching mathematics empowers students to go beyond memorization and use mathematical concepts in a meaningful context. This approach promotes comprehensive understanding, cultivates critical thinking, and allows students to see mathematics in a broader context.

1 Introduction

The fourth industrial revolution (4IR), marked by advancements in artificial intelligence, robotics, and many fields, especially education, has prompted the need for innovative instructional teaching strategies to meet evolving student demands. To equip students for the rapid changes of this revolution, enhancing mathematics skills in education is necessary, fostering students' creativity, motivation, and problem-solving skills [19]. However, despite these advancements, many students still struggle with mathematics [12]. Addressing this challenge becomes crucial, empowering students to develop unique problem-solving approaches and engage in mathematical conversation [8].

Global assessments of mathematics and science reveal disparities in students' grasp of geometry. For instance, the Trends in International Mathematics and Science Study (TIMSS)

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conducted in 2019 indicated that only 19% of Filipino students attained the low benchmark, representing "some basic mathematical knowledge," with the remaining 81% below this level. The study details that these students exhibit competence in fundamental arithmetic operations involving one- to two-digit whole numbers. However, they face difficulties with intricate word problems, fractions, and geometric concepts, especially surface area and volume calculations. Geometry's significance in the mathematics curriculum underscores its role in preparing for advanced topics like trigonometry [6].

Within the Philippines, the research underlines a relatively weak understanding of geometry, particularly concerning triangles and quadrilaterals [17]. This deficiency is mirrored in national assessments, emphasizing the need for effective interventions to boost students' geometric skills [9]. At the local level, students encounter challenges in applying geometric concepts practically, limiting their ability to solve real-life problems and hampering spatial awareness and logical thinking [10]. Bridging this gap and fostering a profound grasp of geometry is imperative.

To enhance students' geometric skills, effective interventions are essential [22]. Design thinking, a potent tool for 21st-century skill development, offers a promising avenue. By infusing design thinking principles into mathematics education, students engage in iterative problem-solving processes, cultivate creative solutions, and apply mathematical concepts to real-world scenarios. The design thinking model delivers a structured framework promoting critical thinking, collaboration, and innovation.

Hence, this study assessed the effectiveness of the design thinking model in nurturing students' learning of geometry.

2 Literature Review

Finding solutions to problems that have been the topic of teaching, research, and real-life application in every domain is the emphasis of the design thinking model [14]. This strategy entails tasks like recognizing the needs of people, reframing the problem in human-centric ways, coming up with numerous ideas during brainstorming sessions, and employing a hands-on approach during prototyping and testing [4].

Several studies show a potential positive impact associated with incorporating design thinking into the instructional process. The study [16] extended the inquiry to elementary mathematics and encouraged students to tackle open-ended tasks, effectively connecting mathematical concepts to real-life scenarios. In addition, another study from [1] emphasized the significant positive impact of incorporating design thinking principles and tangible prototyping, which can bridge the gap between abstract mathematical ideas and practical, tangible applications in the realm of high school mathematics. Overall, these studies collectively underscore the versatility and effectiveness of the design thinking model in enhancing various aspects of mathematics education across different grade levels.

However, design thinking alone does not create successful and holistic learning for students. A study by [5] delved into the impact of direct instruction on middle school mathematics. The study emphasized that direct instruction provides clear and explicit guidance to students, helping them build a strong foundation in mathematics and enhancing students' overall mathematical proficiency, especially in geometry. Another study from [21] affirms the benefits of direct instruction in a classroom setup.

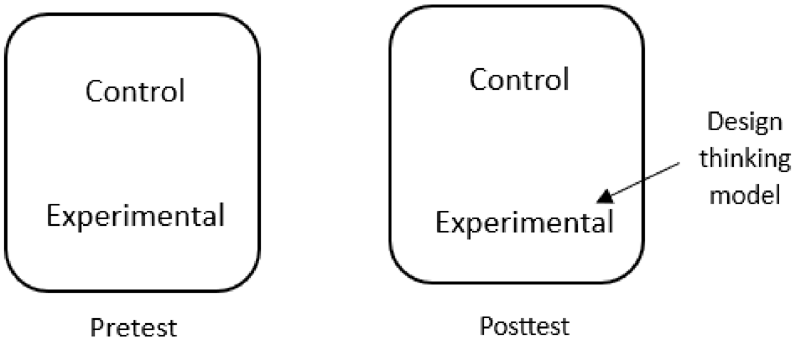
This study illuminates the promising impact of both direct instruction and design thinking in the realm of mathematics education.

3 Methods

3.1 Research Design

The study employed both quantitative and qualitative methods; specifically, a quasi-experimental design was utilized, employing a two-group pretest-posttest design. One group was established as the experimental group, which was exposed to teaching geometry with the design thinking model intervention, and the other group served as the control group, receiving instruction in geometry through the conventional teaching approach as presented in the research design diagram.

Diagram 3.1



3.2 Research Participants

The participants of the study consisted of thirty-seven (37) Grade 7 public high school students who were enrolled in the school year 2022-2023. Of these students, nineteen (19) were assigned to the experimental group, while the remaining eighteen (18) formed the control group. In terms of their understanding of geometry-related mathematical concepts, the researcher ensured that the two groups were randomly distributed.

The request for the assent of the students and the consent of the parents to be part of the study was made to meet the ethical requirements for research. It was emphasized that the students could withdraw their participation anytime if the reflection and the focus-group discussion would affect their performance. Pseudonyms were used in this study to protect the privacy of the students.

3.3 Research Instrument

The study employed a range of instruments to thoroughly investigate the influence of integrating design thinking principles into geometry education. Before data collection, a meticulous pilot test was conducted in a public high school. The students who participated in the test had already undergone discussions involving solid figures in their mathematics class. This facilitated an assessment of the appropriateness and effectiveness of research tools, with the feedback obtained used to enhance clarity, comprehensibility, and alignment with the study's objectives.

After the pilot testing stage, data collection was initiated among the participants. The 40-item test questionnaire underwent an item analysis aimed at evaluating the difficulty and discrimination indices of each question, contributing to the refinement of measurement properties. As a result, eight items were removed due to low discrimination values.

3.4 Data Collection and Analysis

The test questionnaire was developed by the researcher and subsequently subjected to scrutiny by three mathematics experts to ensure its validity and reliability. Two statistical tests were used to check the reliability of the test: Cronbach's alpha and Kuder-Richardson Formula 20 (KR-20). A reliability score of 0.72 (Cronbach's alpha) and 0.72 (KR20) shows an acceptable reliability score. Furthermore, a dedicated set of questions is prepared for the focused group discussion, and this set was rigorously reviewed to ensure its appropriateness and relevance.

3.4 Data Collection and Analysis

This study was conducted in five stages: research approval, pilot testing, administration of a pretest, experimentation, and administration of a posttest.

The school principal received and approved the request letter to conduct research with the Grade 7 mathematics class in the 3rd quarter. Assent forms were given to the research participants. Additionally, the parents of the participants received a letter of consent asking for approval for their child's participation in the study, and it was emphasized that participation in the research was voluntary and participants could choose not to attend any research activities. Furthermore, it was clarified that all activities conducted in the research would not affect the 3rd quarter grades of the participants.

Upon addressing all inquiries and obtaining necessary approvals, the researcher proceeded with pilot testing to validate the appropriateness and efficacy of the research instrument. The teacher-made questionnaire underwent validation by three experts. An item analysis was done, and it encompassed the evaluation of each item's performance within the research instrument, assessing indices related to difficulty and discrimination, and gauging the overall quality of the items. This analysis yielded essential insights into the clarity, relevance, and effectiveness of the research instrument, thus facilitating the refinement and enhancement of its measurement attributes.

The researcher sought assistance from two mathematics teachers at a specific special science public school in Cebu to administer a pretest. This pretest aimed to evaluate the academic performance of Grade 7 students before commencing the experiment. The teacher-researcher taught the experimental group, for five hours using the design thinking method, while the control group, also received instruction from the teacher-researcher using the traditional teaching strategy. Following the geometry-concentrated lessons, both groups took the posttest and six selected students participated in a focused group discussion to evaluate their experiences with the application of the design thinking model in learning geometry.

3.4.1 Design Thinking vs Conventional Teaching Approach

In this subsection, we will explore the similarities and differences between the two teaching techniques employed in this study, namely design thinking and conventional teaching. Both methods share the common goal of imparting knowledge to students, but they differ significantly in their classroom teaching approaches, see 3.4.2.

Design thinking involves a more interactive and student-centered approach, emphasizing creativity and critical thinking [1]. It involves real-world scenarios and collaborative activities that engage students actively in the learning process [2].

On the other hand, the conventional teaching approach, or direct instruction, follows a more traditional model where the teacher serves as the primary source of information and students play a more passive role in receiving knowledge [20], [21].

3.4.2 Pedagogical Approach

This study employed two teaching methods: design thinking and conventional teaching. The experimental group received the design thinking approach, while the control group received conventional teaching. The researcher served as the student's teacher during the study and crafted two (2) lesson plans for both teaching methods.

The experimental group completed the geometry pretest during the first meeting. Immediately after the pretest, the papers were checked. In the second meeting, the teacher-researcher established the learning objectives, presented a video about a renowned industrial designer in Cebu City, explained key terminologies relevant to comprehending solid figures using tangible geometric shapes, and addressed the provided worksheet. In their third and fourth meetings, the teacher-researcher divided the students into groups of five members, with each member participating in the creation of their assigned figure. The teacher-researcher distributed various materials for the activity. During the last meeting, the teacher-researcher prepared a series of questions for the group presentation to assess the student's understanding of the lesson. Each group was required to assess their group work, identifying areas they believed they did incorrectly and areas they believed they did well. The teacher-researcher provided comments on the students' work. The experimental group conducted peer and self-evaluations based on the learning objectives established at the beginning of the week. They assessed themselves to determine if they met the success criteria, identified any difficulties they encountered, and addressed them. Then, the posttest was identical to the pretest. This posttest was identical to the pretest. After the posttest, the papers were examined. All of the activities in the experimental group were indicated in the lesson plan created by the teacher-researcher.

The control group was instructed to complete the geometry pretest during the first meeting. Immediately after the pretest, the papers were checked. The control group engaged in a discussion of solid figures following their pretest. The discussion continued during the second and third meetings. In the fourth meeting, the control group was given paper and pencil seatwork, along with board work and practice exercises. The teacher-researcher asked questions related to the lesson, which the students were expected to answer. After the tasks were provided, a posttest was provided to the control group. The papers were reviewed immediately after the posttest. All of the activities in the control group were indicated in the lesson plan created by the teacher-researcher.

3.4.3 Statistical Treatment of Data

The study employed various statistical tools to treat the different variables. One of the statistical methods used in this study is the t-test. It is used to determine if there is a significant difference between the means of the two groups. And the p-value, as a crucial component in t-test interpretation, serves as the indicator of whether the value is significant or not.

- To determine the pretest and posttest performances of the control and experimental groups, the t-test of a single and small sample was used.

Formula:

$$t = \frac{a.m. - h.m.}{\frac{sd}{\sqrt{n}}}, df = n - 1 \tag{1}$$

where,

$h.m.$ = hypothetical mean,
$a.m.$ = actual mean,
df = degree of freedom,
sd = standard deviation, and
n = total number of students.

- To determine the mean gain from the pretest to the posttest performance of both the control and experimental groups, a paired sample t-test was used.

Formula:

$$t = \frac{\overline{d} - d_0}{\frac{sd}{\sqrt{n}}}, df = n - 1 \tag{2}$$

where,

t = t-test result,
df = degree of freedom,
n = total number of students,
sd = standard deviation,
$\overline{d}$ = the summation of the difference between test scores, and
d_0 = hypothesized difference.

- To determine the difference in the mean gain between the control and experimental groups, an independent sample t-test was used.

Formula:

$$t = \frac{(\overline{x_1} - \overline{x_2}) - d_0}{\sqrt{\frac{{s_1}^2}{n_1} + \frac{{s_2}^2}{n_2}}}, df = n_1 + n_2 - 2 \tag{3}$$

where,

t = t-test result,
df = degree of freedom,
n_1 = total number of students for experimental group,
n_2 = total number of students for control group,
s_1 = standard deviation for experimental group,
s_2 = standard deviation for control group,
sd = standard deviation,
$\overline{x_1}$ = the mean score for experimental group,
$\overline{x_2}$ = the mean score for control group, and
d_0 = hypothesized difference.

All tests were conducted at a 5% level of significance.

4 Results and Discussion

This chapter shows the analyses and interpretations of the data gathered to answer the problems of the study.

Table 4.1

Shapiro-Wilk Test of Normality

		W	*df*	*p*-value	Remarks
Control	Pretest	.952	18	.457	Accept Null
	Posttest	.953	18	.474	Accept Null
Experimental	Pretest	.946	19	.341	Accept Null
	Posttest	.953	19	.438	Accept Null

Based on the Shapiro-Wilk test of normality presented in Table 4.1, both the control and experimental groups demonstrated normal distribution in their pretest and posttest scores. In the control group, the pretest and posttest scores exhibited normality with p-values of .457 and .474, respectively. Comparably, the experimental group's pretest and posttest scores showed a normal distribution with p-values of .341 and .438, respectively. These results support the assumption of normality, and thus we fail to reject the null hypothesis. Overall, these findings collectively signify that the data collected from both groups adhere to a normal distribution, providing a good foundation for subsequent appropriate statistical analyses.

4.1 The Performance Level of the Grade 7 Students in Geometry

Table 4.2 reveals the pretest performance level of the Grade 7 students in geometry.

Table 4.2

Pretest Performance in Geometry

Group	*n*	*hm*	*am*	*sd*	Test Statistics		Qualitative Description
					Computed t	*p*-value	
Control	18	16	8.33	2.70	-12.044	<.001*	Below Average
Experimental	19	16	7.21	1.99	-19.2695	<.001*	Below Average

Note: *significant at $\alpha = 0.05$, two-tailed test.
hm or hypothetical mean = 50% of the total number of items.
Performance level is above average when hm <am and H_0 is rejected; below average when hm >am and H_0 is rejected; and average when H_0 is not rejected.

Table 4.2 presents the results of the t-test analysis comparing the pretest performance in geometry between the control and experimental groups. For the control group, with a sample size of 18, the actual mean performance was 8.33, significantly lower than the hypothetical mean of 16, indicating a **below-average** performance level. The experimental group, comprising 19 participants, exhibited an actual mean performance of 7.21, significantly lower than the hypothetical mean of 16, also suggesting a **below-average** performance level. The findings underscore that both groups exhibited pretest scores below the hypothetical mean, signifying challenges in geometry learning. Additionally, the analysis revealed that both groups demonstrated homogeneity, meeting the assumption required for the t-test. The significance level was set at the alpha level (α) of 0.05 for a two-tailed test. It is important to note that the hypothetical mean represents 50% of the total number of items in the assessment.

Table 4.3 presents the posttest performance level of Grade 7 students in geometry.

Table 4.3

Posttest Performance in Geometry

Group	***n***	***hm***	***am***	***sd***	**Test Statistics**		**Qualitative**
					Computed t	***p*-value**	**Description**
Control	18	16	13.39	3.05	-3.631	<.001*	Below Average
Experimental	19	16	12.95	3.29	-4.043	<.001*	Below Average

Note: *significant at $\alpha = 0.05$, two-tailed test.
hm or hypothetical mean = 50% of the total number of items.
Performance level is above average when hm <am and H_0 is rejected; below average when hm >am and H_0 is rejected; and average when H_0 is not rejected.

Table 4.3 presents the posttest performance results in geometry for both the control and experimental groups. The control group, consisting of 18 participants, had a hypothetical mean of 16, while their actual mean was 13.39, with a standard deviation of 3.05. The computed t-test statistics revealed a significant difference with a t-value of -3.631 for 18 degrees of freedom, accompanied by a p-value of less than .001*, signifying **below-average** performance. The experimental group, comprising 19 participants, exhibited a hypothetical mean of 16 and an actual mean of 12.95, accompanied by a standard deviation of 3.29. The computed t-test statistics for this group yielded a significant difference, with a t-value of -4.043 for 19 degrees of freedom, accompanied by a p-value of less than .001*, also representing **below-average** performance. The results suggest that both groups struggled to meet the hypothetical mean, showing a gap in achieving the expected performance level. The asterisk (*) highlights statistical significance at an alpha level (α) of 0.05 in a two-tailed test. It's worth noting that the performance level is interpreted as **below-average** when the hypothetical mean exceeds the actual mean and the null hypothesis H_0 is rejected. Conversely, performance is classified as above average when the actual mean is greater than the hypothetical mean along with a rejection of H_0, and as average when H_0 is accepted.

4.2 Mean Gain of the Grade 7 Students in Geometry from the Pretest to Posttest

Table 4.4 shows the mean gain of the control and experimental groups in their performance in geometry.

Table 4.4

Mean Gains of the Control and Experimental Group in Geometry

4.3 Comparison of the Mean Gains in Geometry of the Control and Experimental Groups

Group	***n***	**Pretest Mean**	**Posttest Mean**	**Mean Gain**	**Test Statistics**	
					Computed t	***p*-value**
Control	18	8.33	13.39	5.06	-7.397	<.001*
Experimental	19	7.21	12.95	5.74	-6.609	<.001*

Note: *significant at $\alpha = 0.05$, two-tailed test.

Table 4.4 presents the mean gains observed in geometry for both the control and experimental groups. Among the control group, composed of 18 participants, there was an observable elevation in mean scores from the pretest of 8.33 to the posttest of 13.39. This change resulted in an average gain of 5.06. The associated test statistics demonstrated a significant difference, as evidenced by a calculated t-value of -7.397 accompanied by a p-value of less than .001*. This outcome signifies a statistically significant gain in the geometry performance of the control group. Similarly, the experimental group, comprising 19 participants, exhibited a parallel increase in mean scores from the pretest of 7.21 to the posttest of 12.95, reflecting an average gain of 5.74. The corresponding test statistics also denoted substantial dissimilarity, with a computed t-value of -6.609 accompanied by a p-value of less than .001*. This finding underscores a statistically significant gain in geometry learning for the experimental group. The asterisk (*) serves to indicate the statistical significance at the alpha level (α) of 0.05, utilizing a two-tailed test. Although both groups displayed significant gains from the pretest to the posttest, it is important to note that the mean gains show that the posttest scores were still below the average level.

4.3 Comparison of the Mean Gains in Geometry of the Control and Experimental Groups

The mean gains in geometry of the control and experimental groups are shown in Table 4.5.

Table 4.5

Mean Difference of the Posttest Scores of the Control and Experimental Group in Geometry

Group	***n***	**Mean Gains**	***sd***	**Absolute Mean Difference**	**Test Statistics**	
					Computed t	***p*-value**
Control	18	5.06	3.05	.68	.707	.406
Experimental	19	5.74	3.29			

Note: *significant at $\alpha = 0.05$, two-tailed test.

The study employed an independent t-test to compare the pretest and posttest scores of the control and experimental groups in learning geometry. In the control group, the pretest mean was 8.33 with a standard deviation of 3.05, resulting in an absolute mean difference of 5.06. In contrast, the experimental group had a pretest mean of 7.21 with a standard deviation of 3.29 and a posttest mean of 12.95 with a standard deviation of 3.29, resulting in a mean difference of 5.74.

The independent t-test results, presented in Table 4.5, revealed no statistically significant difference in the pretest-posttest scores between the control and experimental groups (two-tailed, $p = .687$), indicating that the observed difference was not statistically significant at the alpha level (α) of 0.05. Furthermore, the study met the assumptions required for the t-test, including independence and homogeneity of variances and continuous dependent variables.

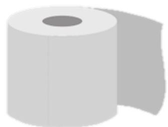
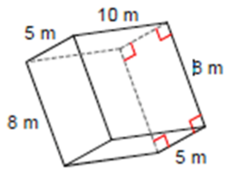
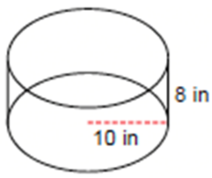
Levene's test for equality of variances yielded a non-significant result of .707 with a p-value of .406, indicating that the variances were equal between the two groups. Additionally, the t-test for independent samples confirmed the equality of means ($p = .544$, $df = 35$, two-tailed), further supporting the findings. In conclusion, the results indicated no significant difference between the control and experimental groups, as well as no difference between the pretest and posttest scores for each group.

4.4 Student Performance on Teacher-made Test Questionnaire

The highest and lowest item classifications in the teacher-made test questionnaire per group are presented in Table 4.6.

Table 4.6

Highest and Lowest Item Classification

<table>
<tr><th>Group</th><th>Item No.</th><th>Question Type</th><th>Question</th><th>Remarks</th></tr>
<tr><td rowspan="3">Control</td><td>1</td><td>Identification</td><td>Write the name of each figure in the space provided.
</td><td>Highest</td></tr>
<tr><td>11</td><td>Problem Solving</td><td>Solve for the volume of each figure and write your solution on the space provided. Answers should be in the nearest hundredths.

</td><td>Lowest</td></tr>
<tr><td>12</td><td>Problem Solving</td><td>Solve for the volume of each figure and write your solution on the space provided. Answers should be in the nearest hundredths.

</td><td>Lowest</td></tr>
</table>

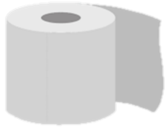
Group	Item No.	Question Type	Question	Remarks
Experimental	1	Identification	Write the name of each figure in the space provided. 	Highest
	20	Multiple Choice	Solve for the lateral area and the surface area of the square pyramid measuring 20 m along the base with a slant height of 17.2 m. a.) lateral area: 688 m^2 surface area: 842 m^2 b.) lateral area: 688 m^2 surface area: 688 m^2 c.) lateral area: 400 m^2 surface area: 688 m^2 d.) lateral area: 688 m^2 surface area: 1088 m^2	Lowest

Table 4.6 displays the performance of students in both control and experimental groups across various questions. The highest proficiency was observed in Item No. 1, focusing on the identification of different types of solid figures. On the other hand, Items Nos. 11 and 12, revolving around problem-solving, posed challenges to the control group of students, resulting in the lowest performance. Furthermore, students in the experimental group encountered difficulty in addressing the multiple-choice question related to solving the lateral surface area and surface area of a given solid figure in Item No. 20.

4.5 Participants' feedback on design thinking integration in geometry class

The ability of the students to respond to the questions and their familiarity with the formulas had an impact on how they perceived their test-taking experiences. Students A and F found the posttest to be manageable because they were able to answer the questions confidently, indicating a sense of accomplishment. They expressed satisfaction with their performance and felt that their knowledge was effectively applied. Student A added, " *"I find it OK since I was able to answer the questions."*. This positive experience can contribute to a sense of self-efficacy and motivation [18].

On the other hand, students C and D struggled with remembering the formulas and expressed difficulty and frustration. Forgetting formulas can hinder performance on math tests and create anxiety for students. Student C mentioned that the formula was not given for the posttest, which added to the challenge. As Student C quoted, " *"I found it hard, Madam, because I forgot the formula. The formula was not given for the posttest."*. The absence of formula references can negatively impact students' problem-solving abilities [11].

Students described their experiences in the design thinking model, emphasizing clear understanding, enjoyment of activities, simultaneous quiz and project engagement, adaptability, and overall positive experiences. The hands-on experience of holding and working with solid figures in the classroom was perceived to enhance understanding, as student A mentioned *"I was able to understand it clearly, miss, because we were able to hold the solid figures, the shapes* *that the teacher-researcher brought inside a classroom."*. Hands-on activities have been shown to promote conceptual understanding, engagement, and knowledge retention in mathematics [3]. Students C and E found the activity-based learning approach in the design thinking model to be enjoyable and interesting, promoting engagement and motivation. Enjoyable learning experiences have a positive impact on student motivation, engagement, and learning outcomes [7].

Students highlighted specific activities within the design thinking model that stood out to them, such as creating solid figures using popsicle sticks, prototyping the faculty room, and working on worksheets explaining volume, surface area, and prototyping of solid figures. Student F mentioned, *"I always loved miniature things. So, it was an exciting experience for me."*. These activities inside the classroom provided opportunities for hands-on exploration, application of geometric concepts, and collaboration, two of the main goals in design thinking mode. Also, hands-on activities and collaborative tasks have been found to enhance students' understanding, problem-solving skills, and mathematical thinking [2].

In summary, the non-significant result in this study suggests that the observed differences in pretest-posttest scores between the control and experimental groups in teaching geometry may be attributed to random variation or other factors that were not accounted for in the study.

Direct instruction in geometry provides a structured and systematic approach to teaching essential geometric concepts, definitions, and procedures. It allows explicit instruction and scaffolding, ensuring that students receive the essential foundational knowledge and skills to navigate the realm of geometry education. A study by [20], found that direct instruction led to improved performance in geometry problem-solving tasks compared to a constructivist approach like design thinking.

While design thinking approaches may have their merits, they are not intended to replace the foundational knowledge and systematic instructions provided by direct instruction in teaching geometry. Rather, design thinking can serve as a supplementary approach, integrating creative and problem-solving elements into geometry instruction. By combining direct instruction with design thinking activities inside the classroom, teachers can provide a balanced instructional approach that fosters both conceptual understanding and creative thinking skills.

5 Conclusion

This study delved into the effectiveness of the design thinking model on students' learning of geometry. Both the control group, exposed to direct instruction, and the experimental group, engaged with design thinking, exhibited below-average scores in the pretest and posttest. Despite notable gains in both groups, posttest scores remained below average. Importantly, there was no significant difference in scores between the two groups, as shown in Table 4.5, indicating that direct instruction effectively promotes geometric understanding. There might be several potential reasons why the design thinking model did not show a significant difference in this study. (1) Learning preferences. The students in the study may have had a preference for more structured and traditional teaching methods [13]. Design thinking requires a more open-ended and exploratory approach, which might not align with the learning preferences of this specific group of participants. (2) Familiarity with conventional methods. The students might have been more familiar with traditional teaching methods [15], making it challenging for them to adapt to the narrative and constructivist aspects of design thinking. The comfort level with the instructional approach might play a significant role in students' learning effectiveness. (3) Limited exposure to design thinking. The study mentions that the contact hours for design thinking were limited to five hours only. It's possible that a more extended exposure of twenty hours to design thinking might have yielded different results and might have created a significant increase in the study's findings. This study also recommended trying design thinking across various subjects, potentially extending beyond mathematics to fields like technology and the sciences. Further studies may use longitudinal design to explore the long-term effects of integrating design thinking in geometry education, assessing the sustainability and transferability of problem-solving skills over time.

Direct instruction has proven effective in promoting geometric understanding and reasoning by providing structured instruction and scaffolding. While design thinking has its strengths, it should be viewed as a supplement rather than a replacement for direct instruction in teaching geometry, ensuring a comprehensive approach that addresses both content mastery and creative problem-solving skills. The study highlights the need for a balanced approach that considers students' perspectives while recognizing the value of direct instruction.

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