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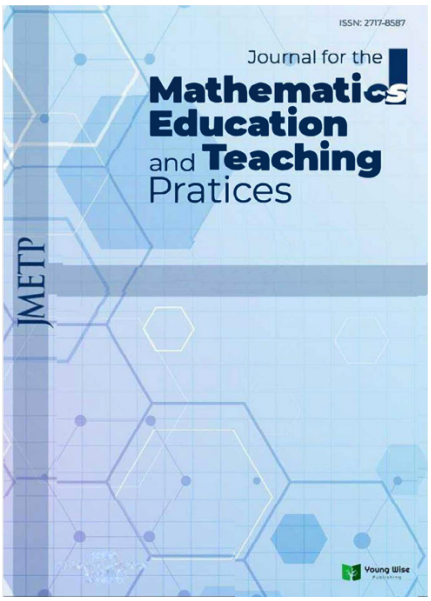

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Research Article

Games in mathematics education: systematic literature review

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Abstract

The article delves into the crucial relationship between "mathematics education" and "games" by systematically reviewing the existing literature in this area. The initial screening process involved evaluating 285 articles based on specific selection criteria tailored to focus exclusively on research that intertwined mathematics education with gaming elements. Following this rigorous filtration, 24 articles emerged as relevant, aligning with the defined criteria, and were subsequently included in the detailed analysis. To facilitate easier reference, each article was assigned a unique code prefixed with the letter 'M' (for instance, M1, M2, M3), which allowed for structured discussions throughout the study. The analysis employed a systematic literature review method, coupled with document analysis. This approach not only enabled a thorough examination of the written materials but also provided insightful information surrounding the educational phenomena in question. The goal of the research was to identify key trends, methodological approaches, and significant findings within the combined realms of mathematics education and gaming. The findings showcased a diverse range of methodological strategies present in the examined studies, highlighting how gaming can enhance mathematical skills and conceptual understanding among learners. The research further underlined the increasing integration of games into educational practices and illustrated the potential advantages of gamification in promoting engagement and motivation in learning environments. In conclusion, the article provides a comprehensive overview of the current state of research bridging mathematics education and games. It offers valuable insights that can guide future studies and instructional strategies, ultimately aiming to promote more effective educational practices.

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Introduction

Learning is one of life's important skills. In the learning journey, on the basis of educational sciences, different teaching methods, different strategies and different approaches are being researched to pave the way for children to learn better. Therefore, different teaching strategies have been developed to make the learning process more attractive and effective. One of the strategies developed to make the learning process more enjoyable is the use of games in education (Gee, 2003; 2007). Strategies such as gamification, game-based learning, and game use are among the approaches that have attracted attention in recent years and have found more and more application areas (Deterding et al., 2011; Kiili, 2005). Because

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the use of games in education increases motivation and makes the learning process more active by enabling students to learn while having fun (Gee, 2003; 2007)

When the existing literature is reviewed, there is a broad consensus that games contribute to student learning experiences and are more effective than traditional methods in education (Gee, 2003; Papastergiou, 2009). Game-based learning also has strong links with constructivist approaches in education. The work of constructivist theorists such as Piaget and Vygotsky emphasize that learning is an experiential and social process (Piaget, 1954,1962; Vygotsky, 1978). Games provide students with this experiential learning environment. Problem solving processes within the game allow students to construct knowledge by encouraging their active participation (Piaget, 1954,1962; Vygotsky, 1978). Games provide students with problem solving, logical thinking and strategy development skills in a fun environment (Hamari et al., 2016; Shaffer, 2006; Van Eck, 2006, Squire,2005). The interaction provided by games makes learning processes more dynamic and allows students to develop different strategies (Papastergiou, 2009). In this way, games encourage students to actively participate in learning processes.

Mathematics is often perceived as a challenging and abstract learning area for students. For many years, mathematics education has also been seen as an area where many students struggle because abstract concepts can often be a source of anxiety for students (Ashcraft & Krause, 2007; Maloney & Belilock, 2012, Mayer, 1998, Artz & Armour Thomas, 1992; Marchis, 2011). Mathematics is perceived as an abstract subject for most students and this can lead to learning anxiety and negative attitudes. In difficult subjects such as mathematics, learning anxiety is a major obstacle for many students (Ashcraft & Krause, 2007). Game-based learning methods have the potential to reduce this anxiety (Plass, Homer, & Kinzer, 2015; Wouters, van Nimwegen, van Oostendorp, & van der Spek, 2013). Games make the learning process less challenging and make students feel more confident. This increases students' engagement in lessons and positively affects their learning experience (Ke, 2008). The integration of games in education has the potential to increase student achievement as well as reduce learning anxiety and create a positive learning environment (Ke, 2008; Boaler, 2016). Moreover, game applications make learning processes more structured by providing opportunities to monitor and evaluate students' achievements and learning goals (Boaler, 2016). Game-based learning increases students' interest in mathematics lessons and makes learning processes more meaningful (Harikrishnan, et al,2019).

In the literature, there are many studies on games and mathematics education (e.g. Anderson et al., 2008; Ke, 2008). For example, a study by Kill et al., on 2015 found that game applications helped students better understand and apply mathematical concepts. These findings further strengthen the role of games in education. Games help students understand mathematical concepts in a more concrete way and make the knowledge permanent (Sung et al., 2017). Additionally, research shows that teaching through games enhances academic achievement (Liang, Zhang, Long, Deng & Liu, 2019; Rawansyah, Pramudhita & Pramitarini, 2021; Rondina & Roble, 2019). In this context, digital and traditional games deepen students' conceptual understanding by engaging them in experiential learning (Papert, 1980). In particular, digital games have become an important tool for making sense of abstract mathematical concepts and provide students with opportunities for mathematical modeling, problem solving, and strategy development (Ke, 2008; Shute & Ke, 2012). While students develop problem solving skills through games, they also facilitate learning (Gee, 2003). In this context, the use of games in the classroom enables students to take a more active and participatory role in mathematics lessons. In addition to helping students transform mathematical concepts from abstract to concrete, games improve their mathematical thinking processes by offering different ways of learning (Boaler, 2016).

Based on the above research, we can conclude that the existence of studies on the integration of mathematics education through games has an important place in the literature. However, it is also curious which games are used in mathematics education and whether these games are effective or not. However, at this stage, we encounter concepts such as games, gamification, and teaching with games. When the related literature was examined, there was no research on the concepts and contexts of "games" in mathematics education. It is thought that making this distinction will contribute to the literature. In addition, which games are used in the use of games in mathematics education and how these conceptualizations are shaped are also considered as the subject of this study. It is thought that answering this question

will directly contribute to researchers and teachers. In conclusion, game-based learning emerges as an important tool in the context of mathematics education and can positively affect students' learning processes. This review will strengthen the place of game-based learning in education and provide information on how teachers and educational administrators can use these approaches more effectively. It will provide important clues on how game-based learning strategies can be implemented to make learning processes more effective and reduce students' anxiety about mathematics. The aim of this study is to examine how and in what ways games are used in mathematics education through a systematic review method. Answers to the following research questions will be sought.

Problem of Study

In this study, the articles about 'mathematics education' and 'games' in the Web of Science database were examined by using the systematic literature review method. In this way, it is aimed to provide a perspective to those working on this subject by looking at all researches holistically. It is foreseen that examining international studies on this subject will contribute to the national and international literature. It also has an important place in terms of guiding a future study by showing which areas the researches focus on and which areas are lacking. Presenting the resources obtained in the literature review collectively to someone who will conduct a study on this subject in the future will make it easier for the person to conduct research. In line with the purpose determined in this study, it is aimed to answer the following research questions:

- What are the methodological characteristics of education and educational research articles about "mathematics education" and "games" in Web of Science?
- What is the distribution of education and educational research articles about "mathematics education" and "games" in Web of Science according to the years of publication?
- What are the methods used in education and educational research articles about "mathematics education" and "games" in Web of Science?
- What are the sample groups in education and educational research articles about "mathematics education" and "games" in Web of Science?
- What are the sample sizes in education and educational research articles about "mathematics education" and "games" in Web of Science?
- What is the content analysis of education and educational research articles about "mathematics education" and "games" in Web of Science?
- What are the subfields (mathematics, health, technology, etc.) of education and educational research articles about "mathematics education" and "games" in Web of Science?
- How are the underlying terms (game, gamification, etc.) conceptualized in the content of educational and educational research articles about "mathematics education" and "game" in Web of Science?
- What are the names of games used in education and educational research articles about "mathematics education" and "games" in Web of Science?
- What are types of games used in education and educational research articles about "mathematics education" and "games" in Web of Science?

Method

Research Model

In this section, information about the research method, data collection and analysis is given. In this study, data were collected through a systematic literature review. In this study, a systematic review method was used to examine the studies on games used in math education. A systematic literature review is an approach to identifying, evaluating, and understanding all research related to a specific research question, topic, or phenomenon of interest (Kitchenham, 2004). In the systematic review process, Daniel and Harland's (2017) triple model approach was adapted and used in accordance with the specific aims of the review. The tripartite model consists of three main components: descriptive systematic review (provides a summary of the literature), synthesis systematic review (categorizes the research logically according to

relevant ideas, connections and rationales) and critical systematic review (provides evidence to support, infer or present new ideas about the literature).

This review focuses primarily on the synthesis and descriptive systematic review steps of the model. As part of the descriptive systematic review, a literature summary was created, presenting the distribution of included studies by year. During the synthesis systematic review, studies were examined within the categories outlined in the Publication Classification Forum (see Appendix). In addition, following the systematic review approach, the steps recommended by Newman and Gough (2020) for the systematic review process were followed:

In line with the guidelines proposed by Newman and Gough (2020), these steps are: (1)Formulating a research question, (2)To create a conceptual framework, (3)Identify inclusion and exclusion criteria, (4)Design a search strategy, (5)Conduct a comprehensive search for relevant studies, (6) Screening and selecting studies, (7)Evaluate the quality of work, (8)extract data, (9)Synthesize information and (10) It includes reporting findings.

Documents

Within the scope of the systematic literature review, as a result of examining the researches conducted in Web of Science until 2024; 285 articles were reached when the words "mathematics education" AND "game" were searched in the 'Topic' section. The inclusion criteria for these results are as follows: a. Being written in the field of education, b. Being open access and full text, c. Being in article format, d. The concepts of 'mathematics education' and 'game' in the topic, e. The language should be Turkish or English

When the 285 articles were filtered according to the above criteria 49 articles were identified as related to 'mathematics education' or 'games'. When these 49 articles were examined, it was seen that some studies were not directly related to "mathematics education" or "games", but these terms were only mentioned a few times in the study. Upon a detailed content analysis of these 49 articles, and the ones that were not related to 'mathematics education' or 'games' were removed, 24 articles remained. These 24 articles were found to meet all these criteria and were included in the study. Each of these articles was matched with a code and the articles were mentioned in the findings through these codes. In the code system, each article was assigned a number and these codes were created by adding the letter 'M' to the beginning of these numbers. (For example, M1, M2, M3...) The codes and colophons of these 24 articles, which will be examined with the systematic literature review method, are given on the references.

Analysis

Data analysis was conducted through document analysis. Document analysis is used to analyze written materials containing information about the phenomena to be researched (Yıldırım & Şimşek, 2021). The information obtained was analyzed through document analysis. With the document review method, it is possible to reach a comprehensive and structured synthesis of a large number of studies conducted with similar methods in order to determine the trends of research conducted through experts in the field. For document analysis, there are processes such as determining the selection criteria used in analyzing research, searching for studies in the relevant field, evaluation, data analysis and synthesis of these data (Dybå & Dingsøyr, 2008).

Results

In this section, the results obtained from the examination of educational and educational research articles about "mathematics education" and "games" in Web of Science in terms of methodological and content characteristics are discussed in the terms of the research questions.

The methodological characteristics of the articles

The distribution of education and educational research articles about "mathematics education" and "games" in Web of Science according to the years of publication is given below in Figure 1

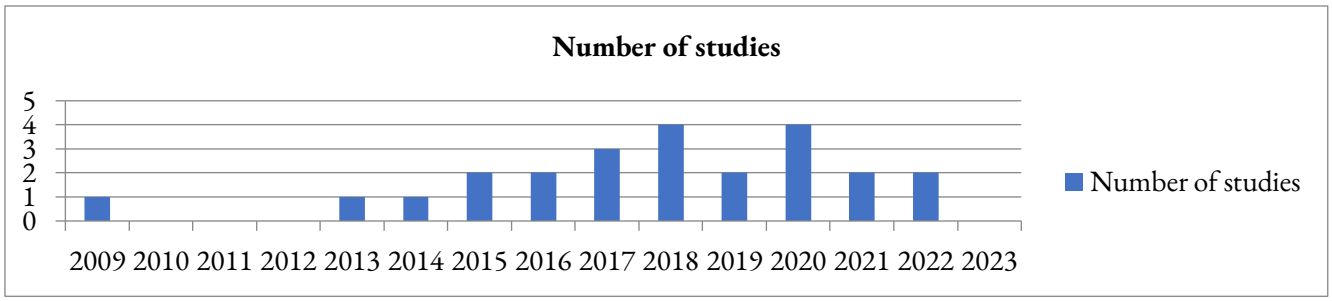

Figure 1. Change in the Number of Studies by Years

The distribution graph of the 24 studies that meet the inclusion criteria according to years is given in Figure 1. When the studies conducted until 2024 were examined, it was seen that the publications were generally published between 2013 and 2022. When we examine the table, we see that the most articles were written in 2018 and 2020 (f = 4). In 2009, there was 1 study on 'mathematics education' and 'games' within our criteria, and no articles were found in this context in 2010, 2011, 2012 and 2023.

The methods used in the articles

Information about the methods used in the studies is given in Table 1.

Table 1. Methods used in research

Method Used	**f**
Quantitative Method	9
Qualitative Method	8
Mixed Method	7
Total	**24**

According to the type of the 24 studies, it was analyzed whether they were quantitative, qualitative or mixed methods. As a result, it is seen that quantitative method (f=9) is preferred the most, followed by qualitative (f=8) and mixed (both qualitative and quantitative) (f=7) methods respectively.

The sample groups levels in the researches

After content analysis of the articles the finding information about the sample group in the studies is given in Table 2. Here's a screenshot of one of the activities at the Google Meet that took place in the calculus course.

Table 2. Sample group in the research

Sample group	**Article codes**	**f**
Primary school students	M4, M6, M8, M9, M13, M15, M17, M19, M20, M22, M23	11
High school students	M2, M3, M5, M7, M12, M14, M18, M23	8
University students	M1, M16	2
Graduate students	M46	1
Researchers	M7	1
Teachers	M6, M7, M21, M22, M24	5
Unspecified	**M2, M10, M11**	**3**

*****In some studies, more than one sample group was used.*

Table 2 shows the sample groups included in the studies. According to this table, the most studies were conducted on primary school students with 11 studies. This is followed by studies conducted on high school students (f=8). In the studies in this field, graduate students and researchers were included in the least number and it is seen that 1 study was conducted with each of these sample groups. In some studies, no specific sample group information could be reached. The information of such articles is also included in the 'unspecified' section in the table.

The sample sizes and the participation size

Information on the number of samples in the studies is given in Table 3.

Table 3. Number of samples used in research

Sample Size	Article code in which it appears	f
0-50	M1, M3, M5, M14, M12, M13, M21, M22	8
51-100	M9, M17, M24	3
101-200	M16, M18, M20	3
201-300	M7, M15, M19	3
301-400	-	0
401-500	-	0
501-1000	M23	1
501-1000	M4	1
Unspecified	M2, M6, M8, M10, M11	5
Total		**24**

In Table 3, we see the data on the sample sizes used in the studies. According to the table, the most preferred sample size is between 0-50 (f=8). This is followed by studies with sample sizes between 51-100, 101-200 and 201-300 with 3 studies each. We see that there are 2 studies with a sample size larger than 500 and no study has been conducted with a sample size of 301-500. We see that the study with the largest sample size among the studies is the M4 article with a sample size of 1001-10000. In this article, quantitative research was conducted with 9204 primary school students under the title of 'game-based learning'. In addition to these, the sample sizes of the studies under the heading 'not specified' in the table could not be reached.

The content analysis of the research articles

Information on the fields of the articles is given in Table 4.

Table 4. Fields of Articles

Fields	Article code in which it appears	f
Mathematics Education	M2, M3, M4, M5, M6, M11, M12, M14, M16, M17, M18, M19, M19, M20, M21, M22, M23, M24	17
Mathematics	M1, M7, M8, M9, M10, M15, M23, M24	8
Teacher training	M1	1
Technology	M13	1

Some articles were conducted in more than one field.

Table 4 provides information about the fields of the articles and the studies conducted in these fields. The heading 'fields of the article' is indicated within the articles, and the 'sub-fields' section was created in order to specifically categorize the categories based on the 'fields of the article'.

When the table is examined, we see that 'mathematics education' (f=17) and 'mathematics' (f=8) are the learning areas in which the most studies were conducted. Apart from these, it can be seen that 1 study each was conducted in the fields of teacher education and technology. When we examine the table by looking at the code of the articles, we can see that the articles M1 (mathematics and teacher education), M23 (mathematics and mathematics education) and M24 (mathematics and mathematics education) are included in two different fields. It is seen that the articles other than these 3 articles are included in only 1 field.

The keyword terms (game based learning, technology and learning, gamification, etc.) used in the content

Table 5. Keyword terms based on the content of the articles

Keyword Term	Keyword Sub Term	Includes article code	f	Total
Game-based concepts	Digital games	M14	1	11
	Game design	M13	1	
	Gamification	M14	1	
	Mobile games	M7	1	
	Serious games	M8, M13	2	
	Video games	M8, M9, M13	3	
	Intelligence games	M21	1	
	Computer game based learning	M20	1	
Concepts related to learning and teaching approaches	Game based learning	M1, M11, M13, M15, M16, M17, M19	7	13
	Interactive learning	M3, M19	2	
	Mobile learning	M1	1	
	Realistic math learning	M5	1	
	Remote teaching	M24	1	
	Gifted students' education	M23	1	
Concepts related to technology	Technology and learning	M3, M4, M24	3	4
	Computer games	M22	1	
Concepts related to culture	Culture and mathematics	M2, M6	2	3
	Ethnomathematics	M10	1	
Other concepts	Collaboration and group work	M12, M16, M17, M19, M22	5	7
	Problem solving	M18, M22	2	

*Some articles contain more than one keyword term.

Table 5 shows the keyword terms and their sub-terms based on the articles. The keyword sub-terms column was created using the keyword terms used in the articles. Some articles were based on more than one keyword term. The keyword terms in the articles have been grouped under 5 main headings by paying attention to which topics are mainly studied and predicting which fields they can be included in for easy classification. These main terms are 'game-based concepts', 'concepts related to learning and teaching approaches', 'concepts related to technology', 'concepts related to culture' and 'other concepts'. Under the heading of 'other concepts', keyword sub-terms from other subject areas (Collaboration and group work and problem solving) that are not included in these other 4 categories were taken as basis.

When the data in the table are analyzed, we can see that most of the studies are about "game based learning" (f=7) which is included in "concepts related to learning and teaching approaches". This is followed by the studies on "collaboration and group work" (f=5) which are written about 'other concepts'. When we look at the keyword terms in general, we can see that the most research was conducted under the title of 'concepts related to learning and teaching approaches' (f=13), followed by studies on 'game based concepts' (f=11). When analyzed in terms of the codes of the article, we see that the article coded M13 is the article with the highest number of keyword sub-terms. There are 4 keyword sub-terms based on this article and these are; 'game based learning', 'serious games', 'game design' and 'video games'.

The names and types of games used in the research articles

Table 6, Table 7 and Table 8 provide information on the names of the games in the articles and the game types in which these games take place

Table 6. Games Played Electronically

Game subtype	Game names	Article code in which it appears	f	Total
Computer game	Zeldenrust	M19, M20	2	5
	FIFA	M22	1	
	The Sims	M22	1	
	Candy Crush	M22	1	
Educational/serious play	MATHERIAL	M15	1	1
Online/Digital gaming	Digital inquiry game	M14	1	10
	First in Math	M4	1	
	Game Acres High	M13	1	
	Gem Game	M8	1	
	Grandma's Garden	M8	1	
	Kahoot	M24	1	
	MathQuest	M13	1	
	Blooket	M24	1	
	edPuzzle	M24	1	
	Caribou Math Contest	M23	1	
Phone game	Mapping My Math	M1	1	2
	UFraction	M7	1	
Video game	Semideus and WuzzitTrouble	M9	1	1

**Some studies include more than one game name and type.*

In this table, 5 main titles (computer game, educational/serious game, online/digital game, phone game, video game) including game sub-types related to 'games played in electronic media' are given. When the table is analyzed in general, we find the number of game names included in the studies on 'games played in electronic media' as 19. Online/digital game was the title with the highest number of game names (f=10). It is seen that there are 5 game names related to 'computer games', 2 game names related to 'phone games', 1 game name each related to 'educational/serious games' and 'video games'.

Table 7. Games not played electronically

Game Subtype	Game names	Article code in which it appears	f	Total
Classic game	Dice game	M12	1	6
	Mozkat- 5 Stone	M10	1	
	Seega games	M10	1	
	Snake and ladder board	M5	1	
	Mangala set	M21	1	
	Go team	M21	1	
Local/ Regional game	Congkak	M6	1	5
	Guli	M6	1	
	Long Galah	M6	1	
	Morabaraba	M2	1	
	Static	M6	1	

**Some studies include more than one game name and type*

In Table 7, we see that there are articles on 'games that are not played in electronic media', which consist of 2 game sub-types: 'classic game' and 'local/regional game'. When the table is examined, it is seen that there are 11 game names mentioned in the researches on 'games not played in electronic media' and 6 game names under the title of 'classic game' and 5 game names under the title of 'local/regional game'.

The codes (M3, M11, M16, M17, M18) were given for the articles that were not included under both titles and in which no information about the game or game genre could be found in the content of the articles. When this table is examined, we see that the number of articles that do not mention the name and type of game in the articles researched is 5.

When the tables are analyzed in general, it is seen that the game names mentioned in the articles under the title of 'games played in electronic media' (f=19) are more than the game names mentioned in the studies on 'games not played in electronic media' (f=11). When Table 6 and Table 7 are analyzed in terms of the game names mentioned in the articles, we see that the game 'Zeldenrust' (f=2) is mentioned more in the articles compared to other games. When these two tables are analyzed, it can be seen that other game names are mentioned once in the articles. If we analyze Tables 6 and 7 in terms of article codes, we can see that the article containing the most game types is M6 with 4 games. This is followed by the articles M24 and M22 with 3 games.

Conclusion and Discussion

In this section, it is aimed to present the conclusions and recommendations based on the findings of the study. In this study, articles between 2009 and 2024, in which the words "mathematics education" and "games" were included in the topic section, were analyzed by taking into account the criteria of being in the field of "education & educational research" in the open access and subject areas in the 'Web of Science' database. As a result of the analysis, 24 articles were found and it was decided to examine these articles with the systematic literature review method.

When the change in the years of publication of these 24 articles on 'mathematics education' and 'play' is examined, it can be seen that the studies were concentrated between 2013-2022. The reason why there were not many studies on this subject before 2013 may be that studies related to games and mathematics started to be given more weight after this period. Especially 2018 and 2020 are the time periods in which the most studies were conducted. The curriculum change made by MoNE in these years may be one of the reasons for this increase.

If we examine the analyzed articles in terms of the methods used, we see that quantitative method is adopted as the majority in the studies conducted in this field. It can also be seen that the number of mixed and qualitative studies is very close to the studies conducted with quantitative method. It is seen that qualitative, quantitative and mixed methods can be used equally in the studies to be conducted in this field and thus there is no accumulation towards a certain method in the literature.

If we look at the comparison of the studies in terms of sample groups, we can see that more studies were conducted with students in the primary education group. This is followed by studies conducted on high school students with a slight difference. We can see that fewer studies have been conducted in other sample groups compared to these groups. In future studies to be conducted in this field, it can be thought that including a different sample group from elementary and high school students will contribute more to fill the gap in the literature.

When we analyze the studies in terms of sample size, it is seen that there are more studies with small sample sizes (studies with sample sizes between 0-50) and fewer studies with large sample sizes. It is seen that the study with the highest sample size is the M4 article with a sample size between 1001-10000. In this quantitative study in the field of 'game-based learning', 9204 elementary school students were studied. If we talk about future studies, we can say that conducting a study with sample groups with a sample size of more than 50 will make a positive contribution to the literature.

When the fields of study in the articles are examined, it is seen that the articles are mostly written in the field of mathematics and mathematics education. Since research was conducted on 'mathematics education' and 'game' in this article, it is quite an expected result that the subject areas in the studies examined in this article concentrated on

mathematics and mathematics education. It can be thought that future studies in this field focusing on areas other than mathematics and mathematics education will contribute positively to the literature.

When the articles are analyzed in terms of the keyword terms used in the articles, it can be seen that the most research was conducted under the title of 'concepts related to learning and teaching approaches'. This is followed by studies on 'game-based concepts'. There are relatively fewer studies on 'technology-related concepts' and 'culture-related concepts' compared to other fields. When analyzed in terms of keyword sub-terms, it is seen that the most studies were conducted with the term 'Game based learning' under the title of 'concepts related to learning and teaching approaches'. When analyzed in terms of the codes of the article, we see that the articles containing the most keyword sub-terms are the articles coded M13. It can be thought that conducting studies in areas other than 'game based learning' in future studies will contribute positively to the literature. From the tables, it can be concluded that game based learning is a more preferable method in mathematics education. Therefore, it can be predicted that utilizing this type of teaching in today's mathematics education will contribute to mathematics education.

When the tables are analyzed in terms of the game names and game types included in the articles, it is seen that the games played in electronic media are more than the games not played in electronic media. When the games played in electronic media are analyzed within themselves, the title with the most game names is online/digital games. When the games that are not played in electronic media are analyzed within themselves, it is seen that the number of games under the title of 'classical games' and the number of games under the title of 'local/regional games' are very close to each other. If we make a general evaluation in terms of the game names and types in the tables, it can be said that with the development of technology, games have mostly started to become online/digital and there are more studies in this field. It can be thought that teachers who aim to convey mathematics education with games or researchers who are interested in this subject can benefit from the games in the tables (Table 7, Table 8). In future studies, it can be thought that focusing on studies related to games that are not played in electronic environment may be useful in order to close the gap in the literature in this direction.

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Appendix 1. Selected article for research

Code	Article bibliography
M1	Holden, J. I. (2016). Mobile inquiry-as-play in mathematics teacher education. VOL. 24, NO. 1 2016, pp. 71-81, DOI: 10.1108/OTH-08-2015-0046
M2	Nkopodi, N. & Mosimege, M. (2009). Incorporating the indigenous game of morabaraba in the learning of mathematics. South African Journal of Education, Vol 29:377-392.
M3	Çetinkaya, L. (2019). The Effects of Problem Based Mathematics Teaching Through Mobile Applications on Success. Vol 44, No 197 65-84, DOI: 10.15390/EB.2019.8119
M4	Ahn, J., Beck, A., Rice, A. & Foster, M. (2016). Exploring Issues of Implementation, Equity, and Student Achievement With Educational Software in the DC Public Schools. *AERA Open*, Vol. 2, No. 4, pp. 1–10, DOI: 10.1177/2332858416667726.
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M23	Ozdemir, D., (2022). An Examination of Students' Views about an International Math Contest. *International Electronic Journal of Mathematics Education*, 17(2), em0680. https://doi.org/10.29333/iejme/11817
M24	Martin, C. S., Harbour, K. & Polly, D., (2022). Examining How Emergency Remote Teaching Infuenced Mathematics Teaching. *TechTrends,* 66:338–350. https://doi.org/10.1007/s11528-022-00711-2

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Research Article

The effect of school climate on the math achievements of secondary school students

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Abstract

The purpose of this study is to examine the relationship between school climate and mathematics achievement of secondary school students (grades 5 to 8) in public secondary schools in a district in the Aegean Region. In order to determine students' perceptions of school climate, the "School Climate Scale" developed by Çalık and Kurt (2010) was used. The study aims to determine the effect of school climate on students' mathematics achievement and how this effect shapes students' resilience in the face of the challenges they face. In the study, universal sampling technique was used and 912 secondary school students were accepted as participants. As a result of the analyses, it was found that there was a moderate positive correlation between the academic achievement of secondary school students in mathematics and school climate.

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Introduction

Today's world is in a process of constant transformation, characterised by rapid renewal and numerous social, cultural, economic, political and technological changes. These changes and the new needs arising from them create new challenges and force schools to adopt an ongoing dynamic of transformation, evaluation and adaptation (Cáceres-Correa, 2020, Parody García et all, 2019). Therefore, schools need to fulfil other functions in addition to the main tasks of transferring, reconstructing and developing knowledge. These include, for example, socialising students, teaching them values and healthy habits, helping them to develop self-awareness, and helping them to develop the skills and learning strategies they will need to cope and adapt to the different situations they will face throughout their lives. Although these tasks are not solely the domain of education and are shared by other social institutions, tradition has always placed and continues to place increasing responsibility on schools in this endeavour (Parody García et all, 2019).

Although there is no single widely accepted definition of school climate, the National Centre for School Climate argues that school climate refers to the quality and nature of school life and is based on individuals' perceptions of their school based on their experiences at school. According to these authors, school climate reflects the school's values, goals, rules, habits, interpersonal relationships, teaching and learning practices, and organisational structures. A positive school climate has been shown to be associated with various student and teacher outcomes and is a strong predictor of emotional and behavioural outcomes (Loukas & Robinson, 2004; Roeser, Eccles, & Sameroff, 2000; Wang et all, 2010).

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Research shows that positive school climates support resilience and negative school climates can be a risk factor for students, teachers, administrators, parents, and other members of the community (Benard, 2004; Freiberg & Stein, 1999). Research also supports the idea that a decrease in perceptions of school climate (especially in terms of relationships, discipline and clarity of school rules) is associated with increased behavioural problems (Gottfredson, 1989; Wang et al., 2010).

Research examining the relationship between school climate and academic achievement has an important place in the field of education. The research conducted by Thapa, Cohen, Guffey, and Higgins-D'Alessandro (2013) revealed that a positive school climate increases students' commitment to school and academic achievement. Brand, Felner, Shim, Seitsinger, and Dumas (2003) showed that school climate has a direct effect on secondary school students' mathematics and reading achievement. Loukas, Suzuki, and Horton (2006) examined how a safe and supportive school climate positively affects students' academic performance, while MacNeil, Prater, and Busch (2009), in their study on high school students, stated that the quality of relationships between teachers and students significantly affects student achievement. Jia, Konold, and Cornell (2016) evaluated the effects of school climate on maths and English language arts performance and showed that students' perceptions of school climate have direct and indirect effects on academic achievement.

These studies emphasise that school climate is not only limited to how students feel, but also has a significant impact on their academic achievement. In this context, this study aims to examine the relationship between secondary school students' mathematics achievement and school climate.

H1: There is a significant relationship between school climate and secondary school students' academic achievement in mathematics courses.

H2: Secondary school students' perceptions of school climate differ according to gender and grade level variables.

Method

Model of Research

In this study, which aims to reveal the relationship between secondary school students' mathematics achievement and school climate, the relational survey model, which is one of the quantitative research methods, was used.

In the study, the relational screening model was used from quantitative research models. The relational screening model is a research model that aims to determine the presence and/or level of change between two or more variables together (Karasar, 2013).

Research Group

The research group consists of a total of 912 students studying in secondary schools in Marmaris district of Muğla province in the 2023-2024 academic year and participated in the research voluntarily. Information about the demographic characteristics of the students participating in the study is shown in Table 1.

Table 1. Demographic characteristics of the sampled students

Variable	**Groups**	**n**	**%**
Gender	Female	463	50,8
	Male	449	49,2
Class Level	5th grade	224	24,6
	6th grade	339	37,2
	7th grade	166	18,2
	8th grade	183	20,1
Total		912	100

Of the students included in the sample of the study, 463 (50.8%) were female and 449 (49.2%) were male. When the grade levels of the students were analysed, it was seen that 224 (24.6%) of them were in the fifth grade, 339 (37.2%) were in the sixth grade, 166 (18.2%) were in the seventh grade, and 183 (20.1%) were in the eighth grade.

Data Collection Tools

In order to determine students' perceptions of school climate, the "School Climate Scale" developed by Çalık and Kurt (2010) and whose validity and reliability studies were conducted with 482 secondary school students was used. The scale consists of 22 items and is Likert type. Each question in the scale is evaluated by ranking as "Never (1), Rarely (2), Occasionally (3), Mostly (4), Always (5)". The scale has three factors; supportive teacher behaviours (8 items), achievement orientation (4 items) and safe learning environment and positive peer interaction (10 items). Cronbach's alpha internal consistency coefficients were .79 for the first factor, .77 for the second factor, .85 for the third factor and .81 for the whole scale. In this study, Cronbach's Alpha internal consistency coefficients were .824 for the first factor, .685 for the second factor, .797 for the third factor and .867 for the whole scale.

Data Analysis

After obtaining informed consent and consent forms, the questionnaires were collected through surveey.com. Since the study was conducted online, participants' responses to the questionnaire were determined according to their most convenient time. The questionnaires were collected after a few weeks so that the participants had enough time to answer the given questionnaire. The responses provided through Surveey.com were downloaded in SPSS form. The results were checked and collected in a master data sheet for analysis and interpretation. Finally, once all the results were collected, they were analysed and interpreted according to the purpose of the study and reliable data was obtained from the feedback from the participants involved in the study.

Preliminary analyses were conducted to examine the properties of the scale used, normality assumption and correlation estimates between the study variables. In order to measure the reliability of the scales, reliability analyses were performed by considering Cronbach Alpha coefficient. Pearson correlation analysis was performed to determine the descriptive statistics of the factors resulting from the factor analyses applied to the scales and the relationships between the variables of the study.

Table 2. Descriptive statistics for the scores obtained from the scale and sub-dimensions used for students

Variables	n	$\bar{x}$	ss	Skewness	Kurtosis
Supportive Teacher Behaviours	912	3,53	,760	-.319	-.107
Success Orientation	912	3,87	,717	-.729	.422
Safe Learning Environment and Peer Communication	912	3,42	,720	-.112	-.558
School Climate Total	912	3,54	,595	-.232	-.351
Maths course success grade	912	74,4	11,3	-,700	.317

According to Table 2, the mean total school climate score of secondary school students was found to be 3.54 with a standard deviation of .595. Among the sub-dimensions of school climate, the mean score of 'supportive teacher behaviours' was 3.53 with a standard deviation of .760; the mean score of 'achievement orientation' was 3.87 with a standard deviation of .717; the mean score of 'safe learning environment and positive peer interaction' was 3.42 with a standard deviation of .720. It was found that the skewness coefficients were between - .729 and - .112 and the kurtosis coefficients were between .558 and .422, and since these values were in the appropriate range (- 2 and +2) for parametric tests, the data showed normal distribution (George & Mallery, 2010).

School Climate & Math Achievment

The findings related to the first hypothesis of the study "There is a significant relationship between school climate and academic achievement of secondary school students towards mathematics courses" are given in Table 3.

Table 3. Correlation Analysis Results of the Relationship between Students' Academic Achievement Grade in Mathematics and School Climate Perceptions Sub-Dimension Scores

Variables	$\bar{X}$	SS	r	p
Maths Academic Achievement Grade	74,40	11,33	,515**	,000
Support Teacher Behaviour	3,53	,760		
Maths Academic Achievement Grade	74,40	11,33	,510**	,000
Success Orientation	3,87	,717		
Maths Academic Achievement Grade	74,40	11,33	,432**	,000
Safe Learning Environment and Peer Interaction	3,42	,720		
Maths Academic Achievement Grade	74,40	11,33	,588**	,000
School Climate	3,54	,595		

When Table 3 is analysed, there is a statistically significant moderate positive relationship between school climate and mathematics achievement (p=.000; r = 0,588**). As a result of the analysis conducted to determine the relationship between students' mathematics academic achievement grade and their perceptions of school climate in terms of supportive teacher behaviours, achievement orientation, safe learning environment and positive peer interaction; a statistically significant positive relationship was found in terms of scores. Accordingly, it can be said that as school climate perceptions increase, mathematics achievement increases.

Secondary School Students' Perceptions of School Climate and Demographic Variable Analyses

The findings related to the second hypothesis of the study "Secondary school students' perceptions of school climate differ according to gender and grade level variables" are given in Table 4 and Table 5.

Gender Factor

Table 4. Comparison of secondary school students' school climate and sub-dimension scores according to gender

	Gender	x̄	ss	t	p
Supportive Teacher Behaviours	Female	3,54	,740	.523	.781
	Male	3,52	,782		
Success Orientation	Female	3,87	,691	.290	.772
	Male	3,86	,744		
Safe Learning Environment and Peer Communication	Female	3,39	,726	-.997	.319
	Male	3,44	,713		
School Climate	Female	3,53	,591	-.355	.723
	Male	3,55	,601		

**p> .05*

When Table 4 is analysed, according to the t-test results, it is found that students' school climate and school climate sub-dimensions scores do not differ according to gender and in other words, there is no significant difference between the scores.

Class Level Factor

Table 5. Comparison of secondary school students' school climate, school climate sub-dimensions scores according to grade level

Variables	Class	x̄	ss	F	p
Supportive Teacher Behaviors	5th grade	3,66	,667	5,088	0,002*
	6th grade	3,55	,735		
	7th grade	3,48	,720		
	8th grade	3,38	,909		
Success Orientation	5th grade	4,02	,709	5,101	0,002*
	6th grade	3,85	,691		
	7th grade	3,81	,670		
	8th grade	3,76	,791		
Safe Learning Environment and Peer communication	5th grade	3,56	,725	6,113	0,000*
	6th grade	3,36	,660		
	7th grade	3,47	,766		
	8th grade	3,29	,747		
School Climate	5th grade	3,68	,553	7,626	0,000*
	6th grade	3,52	,543		
	7th grade	3,53	,598		
	8th grade	3,41	,696		

**p> .05*

According to the results of the analyses conducted to determine whether the school climate and school climate sub-dimensions scores of secondary school students differ according to the grade level, it is seen that all of the school climate and school climate sub-dimensions scores differ significantly according to the grade level. According to the results of the Tukey test conducted to determine the source of this difference, it was found that the school climate scores of the 5th grade students were significantly higher than the sixth, seventh and eighth grade students.

Conclusion and Discussion

The findings reveal that there is a moderate positive correlation between secondary school students' academic achievement in mathematics and school climate. This means that as the students' perception of academic achievement in mathematics course increases, their total school climate scores also increase. Gündoğan (2019), Asaroğlu (2019), Karadağvd (2016) and Özer (2022) found in their research that students who see themselves academically successful in school climate and its sub-dimensions have higher scores, while students with low academic achievement have lower school climate perception scores. These results are similar to the results of our study.

Secondary school students' total school climate scores and school climate sub-dimensions scores did not differ significantly according to their gender. In some studies in the literature, no difference was found in school climate scores according to gender (Erarslan, 2018; Pehlivan, 2020; Özer, 2022). These results are similar to the findings of our study. On the other hand, contrary to our findings, some studies found that school climate scores differed in favour of female students according to gender (Çınkır & Kepenekçi, 2003; Dönmez & Taylı, 2018; Özdemir et al., 2010; Özgenel et al., 2018).

Secondary school students' total school climate scores and school climate sub-dimensions scores differed significantly according to their grade levels. As the grade level increases, the perceived school climate scores decrease. When the literature was examined, studies showing that students' perceptions of school climate decreased as the grade level increased were found (Way & Reddy, 2007; Wang et al., 2010; Özer, 2022; Özgenel et al., 2018). These results are in parallel with the findings of our study. It is thought that the psychological, physiological and emotional changes brought

by the adolescence period, in addition to the anxiety caused by the entrance exam from secondary school to high school, and the pressure of parents and teachers on children may negatively affect students' perception of school climate (Özer, 2022).

The current research was conducted using only quantitative findings. This issue can be repeated with a mixed design or qualitative data with a sample group at different levels. In addition, intervention studies can be conducted for both teachers and students by adding different variables.

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Research Article

The effect of digital storytelling on geometry performance: a study on students with special needs[1]

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Abstract

The main purpose of this study is to determine the effect of geometry lessons taught through digital stories in the support education room of full-time inclusion/integration students studying at the secondary school level on student performances. In order to examine the effect of digital story teaching material on students' geometry performances, a one-group pretest-posttest quasi-experimental model was applied. At the beginning of the research process, the "Geometry Performance Test" created by the researcher was administered to the students as a pretest in the form of a short-answer test. After eight weeks of lessons in the support education room, the same performance test was reapplied to the students as a post-test. The research group was formed by criterion sampling, one of the purposive sampling methods, and students with skills such as answering questions, reading and writing were included in the study while Individualized Education Plans (IEP) were being prepared within the scope of full-time inclusion/integration education. In this context, the study was conducted with a total of 15 students diagnosed with four speech and language disorders and 11 students diagnosed with specific learning disabilities. The data obtained during the research process were analyzed with dependent groups t-test. It was determined that the difference between the students' pre-test and post-test scores was statistically significant and showed a result in favor of the post-test. These findings show that the digital storytelling method positively affects the performance of students with special needs in geometry lessons. Based on the results of the research, it is recommended that the QR code application in the Ministry of National Education of Turkiye textbooks should also be provided for students with special needs and the content should include digital stories related to the subject.

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Introduction

Students with special needs constitute an important component of our education system and their educational needs play an important role in the overall structure of society. Since one of the main goals of education systems is to ensure that all students have access to equal learning opportunities, the integration of students with special needs into general education classes, that is, mainstreaming education, has gained increasing importance in recent years. In our country, students with special needs are identified as severely, moderately and mildly deficient as a result of educational evaluations. Students with mild intellectual disabilities are included in the scope of mainstreaming/integration by

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making some changes in school environments in order to make their educational lives more efficient (Ministry of National Education [MoNE], 2013). Mainstreaming/integration education envisages full- or part-time education of students with special needs together with their peers in general education classes (MoNE, 2017). In this process, students are not organized according to the school, but the school is organized according to the students and every school is considered an inclusive school (Batu & Kırcaali İftar, 2011). In our country, support education services are provided to students who are subject to full-time mainstreaming/integration education and to students with special needs. While students with special needs are educated in the same classroom with their peers, they are taken out of their classrooms and educated in a different environment in order to receive support in areas where they need extra work (Batu & Kırcaali İftar, 2011). In the education carried out in the support education room, it can be said that the Individualized Education Plan (IEP), prepared in accordance with individual differences to meet students' needs, is an important element (Martin, Van Dycke, Greene, Gardner & Lovett, 2006). The Individualized Education Plan (IEP) is a document that specifies what the target behaviors are, how, where, for how long and when they will be acquired. In order to determine the degree of achievement of the goals, the evaluation method and the criteria used in the evaluation are also included in this document (Kargın, 2007). As a result, in order to meet the educational needs of all students with special needs studying in general education classes, Individualized Education Plans are prepared and educational activities are carried out in the support education room.

Mathematics has an important place in many areas of the lives of both students with normal development and students with special needs and includes skills that all individuals should acquire (Karabulut & Yıkmış, 2010). In order to improve the quality of life of individuals with special needs, it is necessary to develop mathematical thinking skills as well as numerical competence (Monei & Pedro, 2017). While individuals with normal development can discover mathematics naturally before starting school (Alptekin, 2015), individuals with special needs learn mathematical concepts and skills more slowly and need more attention than their peers. This is because mathematics involves the skills of understanding, comparing, and establishing complex relationships (MoNE, 2001).

Many studies have found that the academic achievement of individuals with special needs in mathematics is lower than that of their typically developing peers (Jitendra, Rodriguez, Kanive, Huang, Church, Corroy& Zaslofsky, 2013).This may be due to difficulties in basic skills such as attention, discrimination, and organizing information; rapid forgetting of information is also a factor affecting this situation (Green, Hughes & Ryan, 2011; Pullen, Lane, Ashworth & Lovelace, 2011; Çifci-Tekinarslan, 2014; Ege, 2006; Petner-Arrey & Copeland, 2014). Recall difficulties and weaknesses in visual and auditory perception of individuals with special needs are related to the attention level of the student in educational processes (Beirne Smith, Patton & Kim, 2006). Since individuals with special needs have short attention spans, they need more stimuli especially in teaching abstract concepts. These difficulties usually start in primary education and continue in secondary education (Miller & Mercer, 1997). The traditional methods of teaching mathematics to individuals with special needs make the teaching of abstract concepts even more difficult (MoNE, 2001). In this context, it is important for teachers to use different methods, techniques and materials in educational processes (Güven, 2009). Stein, Kinder, Silbert and Carnine (2006) state that multiple representation methods are effective in overcoming the difficulties experienced by students with special needs in mathematics learning. Concrete materials, visual supports and technological tools can facilitate the understanding of abstract mathematical concepts. Therefore, integrating technology into the educational environments of students with special needs allows them to meet their educational needs and to perform activities that cannot be performed in the traditional environment (Israel, Marino, Delisio & Serianni, 2014). Studies by Ok, Bryant and Bryant (2009) show that computer-assisted instructional practices have positive effects on the mathematics achievement of students with special needs and improve their attitudes towards learning. In this context, the interactive and multimedia elements offered by digital stories have the potential to attract students' attention and increase their motivation to learn mathematics (Chigona, Gachago, Ivala & Chigona, 2012). Robin (2016) defined digital stories as stories that are used to present the desired information by combining components such as graphics, recording, video, text and music. In recent years, digital stories that bring technology and education together have become a frequently used teaching material (Duman & Göçen, 2015). Digital stories are an effective

learning tool in the classroom environment by creating their own stories with different experiences such as choosing the story, doing research on the subject, writing a scenario, collecting pictures and recording (Robin, 2016). Younger students are motivated to learn the course content better by sharing their knowledge gained through computer-based materials such as digital stories in the classroom environment (Foley, 2013). In this process, students develop their communication skills as they apply what they have learned in the stages of researching, organizing information, analyzing their own information and sharing it with the class. It can also help students develop their creative thinking skills and support them to reveal their unrecognized talents. In this context, digital storytelling is used as an effective method in education by including the processes of writing and digitizing stories with multimedia tools (Akgül, 2018). For this reason, digital stories have become a recommended educational material for teachers and students to communicate with each other and gain research skills from preschool to higher education (Di Blas, Garzotto, Paolini & Sabiescu, 2009).

With the development and increased use of technology, digital stories have started to replace traditional stories (Condy et al., 2012). The difficulties encountered by students with special needs in learning mathematics are generally due to cognitive limitations, working memory capacity, attention span, and speed of information processing. Swanson and Jerman (2006) emphasize the importance of cognitive strategy instruction in overcoming these difficulties. For this reason, digital storytelling can reduce cognitive load and have positive effects on learning processes by allowing students to acquire information in visual, auditory and text-based formats. When digital stories are integrated into the lessons of students with special needs, they increase students' participation, improve their creativity and increase their self-confidence (Hull & Nelson, 2005; Weiss, Benmayor, O'Leary & Eynon, 2002). In addition to all these, the use of digital storytelling in mathematics teaching contributes significantly to the development of students' problem solving skills. Javorsky and Trainin (2014) emphasize that digital stories deepen students' conceptual understanding by allowing them to integrate mathematical concepts into daily life contexts. Similarly, Gould and Schmidt (2010) state that digital storytelling improves students' mathematical communication skills and supports them to use mathematical terminology more effectively. In this framework, digital storytelling can be considered as a teaching tool that contributes to mathematical thinking processes in various ways. When mathematics lessons are conducted through stories, it is considered as a powerful material that can help students understand the relationships between concepts, algorithms and rules that they do not associate with their experiences (Balakrishnan, 2008). The use of digital stories contributes to the development of different skills such as expressing data, algorithmic thinking, logical thinking, sorting and analyzing data (Kordaki & Kakavas, 2017). In addition, solving math problems in digital stories allows for the effective connection of relationships between visual, auditory and verbal representations (Walters, Green, Goldsby & Parker, 2018). When digital stories are used in the educational processes of students with special needs, it has been observed that they increase students' participation and improve their creativity (Hull & Nelson, 2005). For these reasons, in full-time inclusion/integration practices, it is a legal obligation for teachers to teach lessons within the framework of Individualized Education Plan (IEP) in addition to getting maximum efficiency from educational activities. Digital stories, when implemented within the scope of IEP, can provide an effective and different learning model for mathematics lessons (Goldstein, 2008).

It is important for teachers to teach in the support education room within the framework of the Individualized Education Program (IEP) in order to get maximum efficiency from educational activities and to fulfill legal requirements. A study conducted with 110 mathematics teachers who participated in support education classes showed that teachers spent one-third of their time teaching mathematics and that support education classes play a critical role in the mathematics education of students with special needs (Mercer, 1987). However, it is noteworthy that the number of studies on mathematics teaching for students with special needs in Turkey and internationally is limited (Gobadzade & Düzkantar, 2019).

The use of only lectures in teaching geometry, one of the learning areas of mathematics course, prevents students from making connections between daily life and geometry and directs them to abstract thinking. This abstractness can lead to a decrease in students' interest and, as a result, a decrease in their academic achievement (Şimşek, 2012). In general, the most important problem in geometry education is that the course content is abstract and separate from daily life.

Geometry, a field that requires three-dimensional and spatial thinking skills, is very difficult to teach with traditional methods. Therefore, it is necessary to utilize technology as much as possible in geometry lessons (Karal & Solak, 2008). In this context, it has been determined that teaching geometry and measurement subjects with technology support increases student achievement and geometry lessons are more easily understood by students (Bintaş & Bağcıvan, 2007; Forsythe, 2007; Yıldız, 2009; Şimşek & Yücekaya, 2014). Murphy (1999) states that the storytelling method is a very effective method in the education of students with special needs as well as individuals with normal development. In addition, it is recommended to write stories about geometry outside of school to support geometry lessons. For example, there are geometry-themed storybooks such as "Ruthless Geometry", "The Greedy Triangle" and "Not Enough Room" by Kjartan Poskitt. Muğlalı (2004) stated that such books can increase interest in geometry and enable students to realize the applications of geometry in daily life. Considering the effects of today's technological advances on the education of individuals with special needs, it can be said that the application of traditional stories in digital format will increase efficiency in support education courses.

When the literature was examined, it was found that the number of studies on the use of technology in teaching mathematics to students with special needs was limited. While individuals with normal development are more comfortable in the use of technology in their educational environments, there is a lack of materials and applications to support individuals with special needs with technological products (Türel & Akgün, 2021). In addition to all these, there is no study on the effect of digital story teaching material on student performance in mathematics lessons held in the support education room. In this context, it is aimed to guide and set an example for mathematics teachers participating in support education courses. When the studies on mathematics teaching in the field of special education are examined, most of the studies focus on the learning area of numbers and operations; there are not enough studies in the learning areas of geometry and measurement (Yıkmış, Kot, Terzioğlu & Aktaş, 2018). While there are studies on digital story-based instruction for individuals with normal development, there is no study conducted for students with special needs in Turkey.

In conclusion, the use of digital stories in mathematics education for students with special needs has the potential to provide a more interactive and personalized learning experience than traditional teaching methods. This study aims to make a unique contribution to the field by examining the effect of digital storytelling on the mathematics performance of students with special needs.

Problem of Research

This study aims to make a unique contribution to the field by examining the effect of digital storytelling on the mathematics performance of students with special needs. In this direction in this study, it was investigated whether the geometry lessons taught in the support education room with the help of digital storytelling had an effect on student performances. In this direction an answer to the question is:

- What is the impact of using the digital storytelling method in geometry lessons taught in the support education room on student performance?

Method

Research Model

This study examines the effect of using digital story materials in geometry lessons of students with special needs studying in a support education room on student performance. The study was conducted with a one-group pretest-posttest quasi-experimental design. This approach aims to analyze the effects of different teaching methods, techniques and programs on the participants (Büyüköztürk, Kılıç Çakmak, Akgün, Karadeniz & Demirel, 2023). Within the scope of the method, after the pretest was applied to the determined group, the process was continued with the independent variable. Then the post-test was administered and the relationship between the pre-test and the post-test was evaluated. If a significant increase is observed in the post-test, it can be concluded that this situation is due to the application (Karasar, 2015).

Participants

Criterion sampling method, which is among the purposeful sampling methods, was used to determine the research group. In this method, the study is carried out with individuals with appropriate characteristics in line with the criteria determined by the researcher (Yıldırım & Şimşek, 2018). Therefore individuals, events and similar situations that meet the necessary criteria are included in the research group. In this study, in order to examine the effects of the digital story teaching material on students' geometry performance, some skills determined as prerequisites were defined. Based on the data collected during the process of creating the students' Individualized Education Program (IEP), students who had the skills in the sub-learning areas of answering questions, reading, writing, and geometric drawings and shapes in the first grade mathematics curriculum were included in the study. The study was conducted with 15 students who were identified as full-time inclusion/integration students by the Guidance and Research Center (GRC) according to the results of their educational evaluation (Table 1).

Table 1. Information on the CRC diagnosis and grade level of the study group

Student Code	RAM Diagnosis	Class Level
S1	Speech Language Disorder	Grade 5
S2	Speech Language Disorder	Grade 5
S3	Speech Language Disorder	Grade 5
S4	Specific Learning Disabilities	Grade 5
S5	Specific Learning Disabilities	Grade 5
S6	Specific Learning Disabilities	Grade 5
S7	Specific Learning Disabilities	Grade 5
S8	Specific Learning Disabilities	Grade 5
S9	Specific Learning Disabilities	Grade 5
S10	Specific Learning Disabilities	Grade 7
S11	Specific Learning Disabilities	Grade 7
S12	Specific Learning Disabilities	Grade 7
S13	Specific Learning Disabilities	Grade 7
S14	Specific Learning Disabilities	Grade 7
S15	Specific Learning Disabilities	Grade 7

Research process

The data collection process was carried out with 15 full-time inclusion/integration students studying at a public school in Gölcük district of Kocaeli province during the 2021/2022 academic year. At the school where the study was conducted, a study group was formed from among the full-time inclusion/integration students and an Individualized Education Program (IEP) was prepared for each student. Since the focus of the study was on geometry and measurement, it was decided to teach geometry lessons using digital stories during the second semester. This approach ensured that the lessons carried out in the support education room were parallel to the subjects that the students covered in their classes. All of the students participating in the study were taking an Information Technologies and Software course and had experience in creating digital stories using various software in this course. It was decided to create the digital stories to be prepared for geometry topics with the "Storyjumper" program for ease of use.

The first stage of the research is to create students' Individualized Education Plans (IEP) for mathematics. In this process, students' current performance levels are evaluated and the basis for determining long and short-term goals is established. The performance status of students with special needs is usually determined through informal assessment tools. In this context, various informal assessment tools prepared by teachers are used. Methods such as observation, interviews, written exams, error analysis, work sample analysis, homework assignments, worksheets and criterion-referenced assessment tools are used to determine students' proficiency levels in a specific field (Kargın, 2007). At this stage, short- and long-term goals were defined, taking into account the special needs of the students and the mathematics curriculum. For example, it was observed that a student in the study group was studying at the seventh grade level but

his educational performance was at the fourth grade level. In such a case, goals appropriate for the fourth grade level should be taken into consideration when preparing the IEP (MoNE, 2013).

The geometry performance test developed by the researcher was finalized after pilot applications and validity and reliability studies and then applied to the research group as a pretest. Digital stories were prepared on the Storyjumper platform to cover all the objectives in the students' education plans.

The theoretical content of the digital stories was created by the researcher, while the script writing and vocalization stages were carried out in collaboration with the students in the study group. In this process, three hours a week were allocated to the support education courses and the studies were completed for a total of eight weeks. At the end of the eight weeks, the geometry performance test developed by the researcher was reapplied as a post-test. All prepared stories were made available at https://www.storyjumper.com/book/collection/Ilknuur/GEOMETR. Below are excerpts from the digital stories prepared with the students.

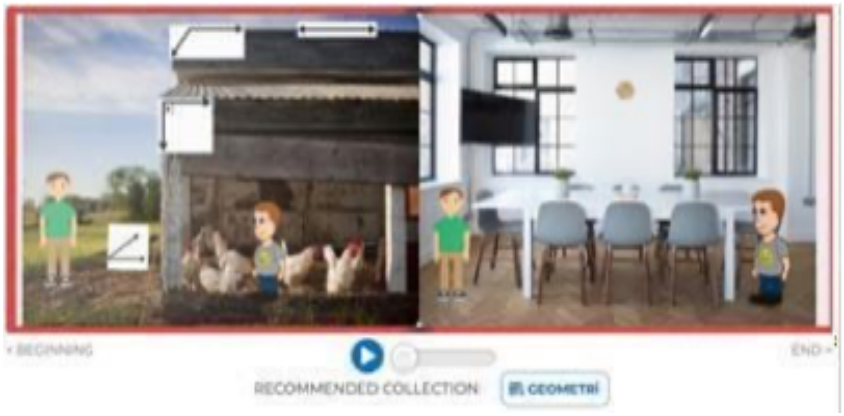

Figure 1. Excerpt from a digital story about angle types

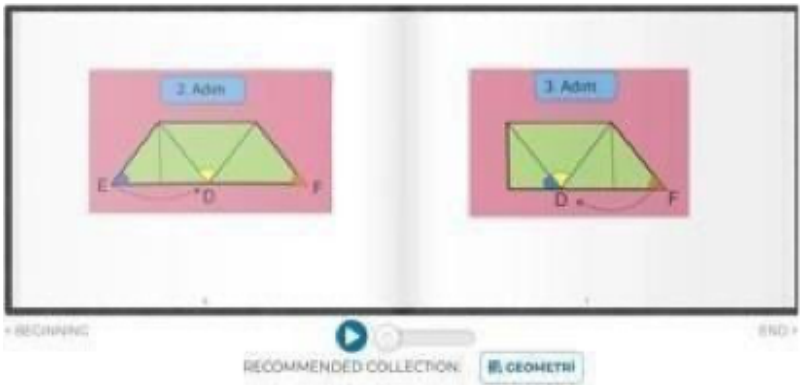

Figure 2. Excerpt from a digital story about the sum of the ic angles of a triangle

Figure 3. Excerpt from a digital story with a problem requiring perimeter calculation

Data Collection Tools

Short-term goals in the Individualized Education Plan are defined as measurable sub-steps between the individual's current performance level and long-term goals (Sucuoğlu & Kargın, 2014). In this context, the short-term goals in the students' plans determined the scope of the Geometry Performance Test developed in the study. In line with the short-term goals, the geometry performance test was created by the researcher to include at least three questions for each goal.

The purpose of including at least three questions from each objective was to identify and remove valid and unreliable items from the test in line with item analysis, student interviews and expert opinions and to ensure that questions covering each objective were included in the test.

A total of 40 questions in the performance test were prepared to cover each sub-heading of the relevant objectives. The draft test consists of short-answer and multiple-choice questions. The test was presented to an experienced teacher and lecturer to evaluate its suitability for the purpose, and then feedback was received from a Turkish teacher on the comprehensibility of the language of the questions. As a result of the evaluations, the draft performance test was finalized. The draft geometry performance test was applied to six students with specific learning disabilities outside the study group as a pilot study and preliminary interviews were conducted. In this process, it was observed that the multiple-choice items were marked randomly by all students. In order to eliminate the effect of chance success, multiple-choice items were removed from the test and the whole test was composed of short-answer items. In the light of the feedback received from the students and the evaluations of experienced teachers and lecturers, the geometry performance test consisting of 20 short-answer items was finalized.

The interviews conducted after the draft geometry performance test was applied to six students subjected to inclusion/integration education led to the necessary adjustments. In order to ensure the construct validity of the revised geometry performance test, the performance test was applied to students with normal development at the fifth, sixth and seventh grade levels. These interviews helped to identify ambiguities or narrative deficiencies in the test and to make the necessary corrections (Fraenkel, Wallen & Hyun, 2011). Students were asked to read the questions aloud and think aloud (Bowles, 2010). This practice was a method to determine whether the students perceived the questions in the same way and to identify and correct any misconceptions they might encounter during the application.

As a result of the interviews conducted at different grade levels, it was concluded that the questions were understandable and applicable. It was also reported that the figures used in the performance test were clear and legible. Fifth and sixth grade students had difficulty in completing the performance test in 40 minutes, while seventh grade students did not have any problems with time. For this reason, it was decided to conduct the performance test for two class hours (80 minutes) in order to avoid time problems for the experimental group.

Kan (2018) states that the items in the test can be provided with expert opinions to determine the construct validity. Construct validity of the test was ensured as a result of interviews with students with normal development at different levels and expert evaluations. Content validity is a concept related to the extent to which the measurement tool covers the feature to be measured. The feature to be measured should be adequately represented in the measurement tool (Atılgan, Kan & Aydın 2019). Therefore in order to ensure content validity, a performance test was prepared to include at least one question related to each short-term objective.

Data Analysis

It is stated that short-answer tests measure behaviors in more depth because the answer is written by the respondent (Turgut, 1988). Therefore, since the answers to short-answer test items are usually very short and the response time is short, many questions can be asked in one exam period (Tan, 2013). Increasing the number of questions enables the measurement of various target behaviors and eliminates the effect of chance achievement, which increases reliability (Thorndike & Thorndike-Christ, 2010). Although it is stated that the scoring process of short-answer tests is easy, it is known that it is not completely objective. Since the scoring does not include variables such as the aesthetics of the respondent's writing, the way he/she uses the paper, and the answers given are in accordance with a certain framework, it can be easily realized. However, respondents have the freedom to answer in any way they wish. This means that no definitive judgment can be made about the level of accuracy of the answers; therefore, the answers are considered partially accurate. In this context, it is important to create a scoring key for the scorer and to check the accuracy of the answers within this framework (Şalgam, 2016).

In the study, a detailed answer key was prepared before the scoring process started and student responses were examined by the researcher and the instructor. Inter-rater reliability refers to the agreement and consistency of two or more raters in the scoring process (Crocker & Algina, 1986). In this study, Pearson Product Moment Correlation

coefficient was calculated to determine the relationship between the scores given by different raters using the rubric. The Pearson Product Moment Correlation Coefficient obtained as a result of the scoring processes of the researcher and the instructor was found to be greater than 0.70, indicating that the scoring processes of the raters were consistent (Büyüköztürk et al., 2023). In other words, when the correlation coefficient, which is considered as a reliability coefficient, is greater than 0.70, it shows that the scores given by two raters have a linear relationship (Baykul, 2021).

Table 2. Code, code criterion and score information of the rubric

Code	Code Criteria	Score
Correct (d)	The answer is correct, the explanation is complete	2 points
Half True (yd)	The answer is correct, no explanation	1 point
	The answer is correct, the explanation contains a misconception	
	The answer is wrong, the explanation is right	
False /Null	Question left blank	0 points
	Scientifically unacceptable statement	

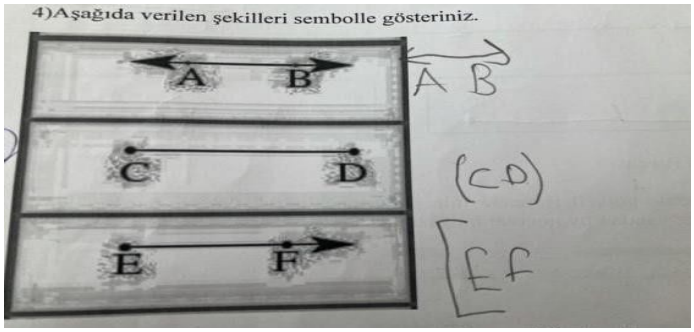

Figure 4. Example of a response coded as correct (d)

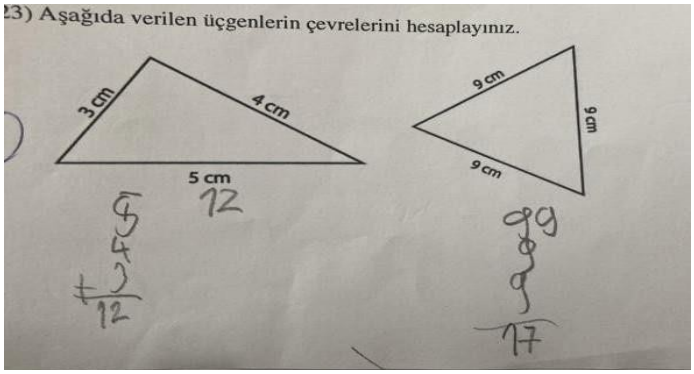

Figure 5. Example of a response coded as half correct (yd)

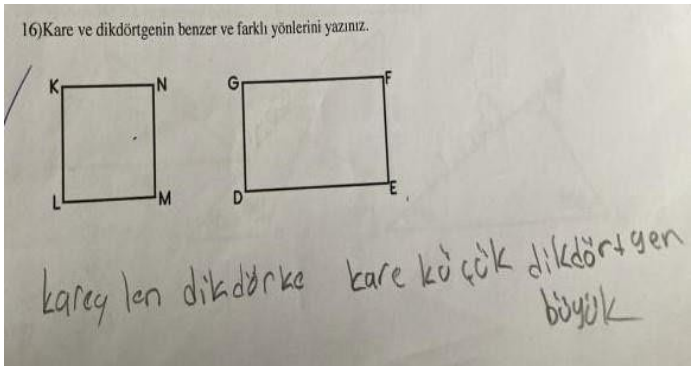

Figure 6. Example of an answer coded as wrong/empty

Since the responses of the inclusive/integrated student group before and after the lessons with digital stories were evaluated with the same performance test, the data were analyzed with the dependent groups t-test method. In this way, the significant differences between the measurements and the effect of digital stories on the students' performances were analyzed.

Research Ethics

Necessary permissions were obtained in order to collect the data needed in the study. For this purpose, permission numbered 178547 and numbered 3 was obtained from the Ethics Committee of Science and Engineering Sciences within Kocaeli University. After the research was deemed appropriate, the necessary permission was obtained by applying to the Provincial Directorate of National Education in order to start the implementation process.

Results

First of all, the normality distribution of the scores of the student group on the "Geometry Performance Test" before the application was examined.

Table 3. Normality results for the pretest

Test Name	N	$\bar{X}$	Kolmogorov- Smirnov (p)	Shapiro-Wilk (p)
Pre-Test	15	47.2	.200	.918

The Shapiro-Wilk test is more powerful than the Kolmogorov-Smirnov test when the sample size is below 50 (Mayers, 2013). As seen in the table, since the Shapiro-Wilk test value is .918> .05, the scores show a normal distribution.

Table 4. Dependent groups t test results of the students in the study group

Group	N	$\bar{X}$	ss	sd	t	p
Pre-Test	15	47.20	14.96	12.50	12.43	.00
Final Test	15	87.33	8.40			

As seen in Table 3, as a result of the dependent groups t-test conducted to determine whether the post-test scores of the students who studied with digital stories differed according to the pre-test scores, the difference between the pre-test and post-test scores of the students was found statistically significant (t=12,434; p<.05).

When descriptive statistics were analyzed, students' post-application scores ($\bar{X}$=87.33) were significantly higher than their pre-application achievement scores ($\bar{X}$ =47.20). This finding can be interpreted as geometry units taught with digital stories positively affected the academic achievement of inclusion/integration students.

As a result of the analysis, the effect of geometry units taught with digital stories on students' academic performance was evaluated. In the calculations made with Cohen's d method, the results of the pretest ($\bar{X}$ = 47.20, = 14.96) and posttest ($\bar{X}$ = 87.33) were compared. These calculations yielded a value of d = 2.68. This value indicates a large effect size (Cohen, 1988). This finding indicates that geometry units taught with digital stories significantly increased the academic achievement of inclusion/integration students. The results of the study support that digital stories can be evaluated as an effective tool in educational applications.

Below, the answers given by the students to the geometry performance test at the beginning of the process and the student answers given after the geometry lessons taught with digital storytelling are presented. The answers of the students coded S6, S13, S9 and S12 to the first question of the geometry performance test before and after the application are as follows:

Answers of students coded S6 and S13 to the test item related to the concepts of point, line, line segment and ray:

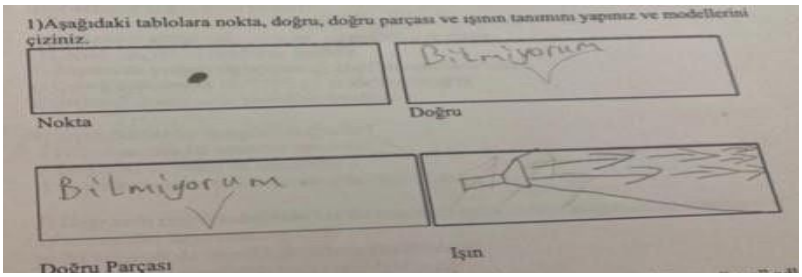

Figure 7. The response of the student coded S6 before the implementation

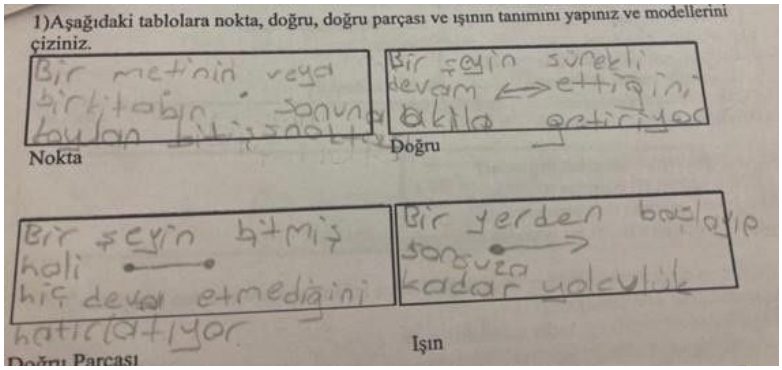

Figure 8. The response of the student coded S6 after the application

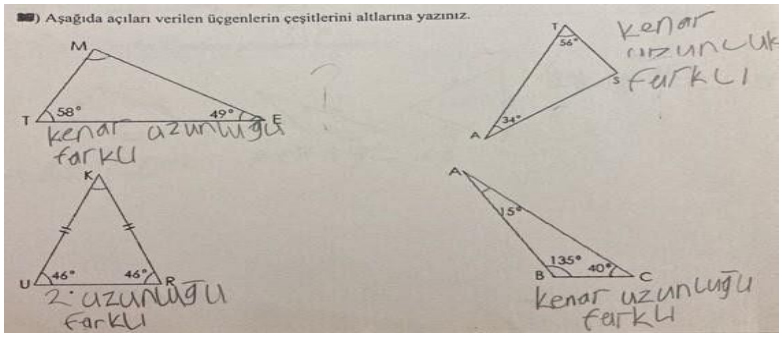

Figure 9. Student S13's response before the implementation

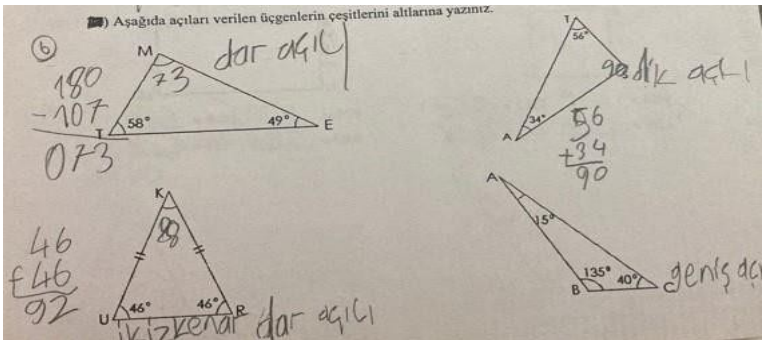

Figure 10. Student S13's response after the implementation

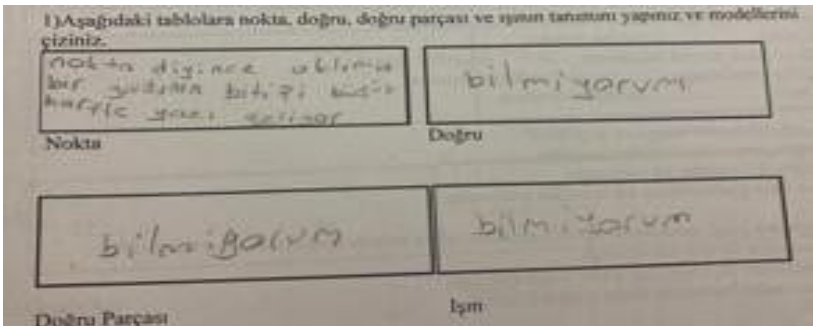

Figure 11. Student S9's response before the implementation

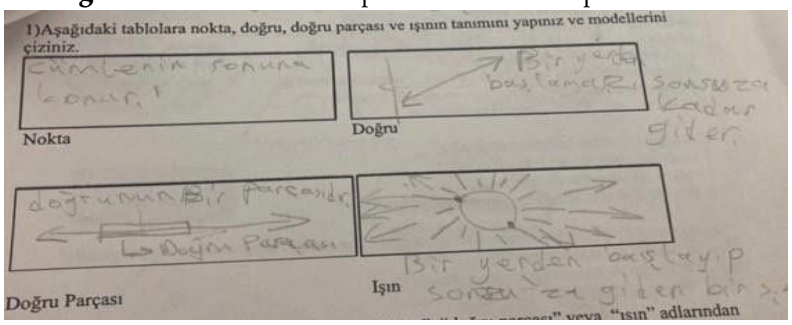

Figure 12. Student S9's response after the implementation

The response of the student coded S12 to the item about finding the ungiven angle of a triangle before and after the application:

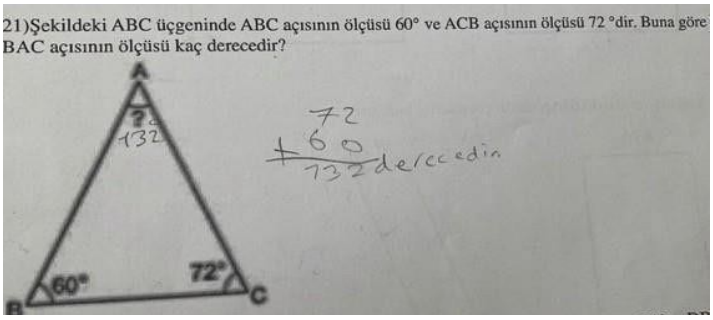

Figure 13. Student S12's response before the implementation

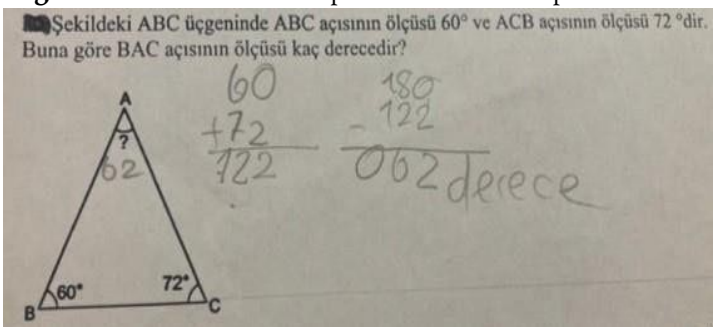

Figure 14. Student S12's response after the implementation

Discussion and Conclusion

This study contributes to the literature by examining the effects of digital storytelling method in mathematics teaching of students with special needs. In the study, the effects of geometry lessons supported by digital stories within the scope of individualized education plans of 15 students with special learning disabilities and speech and language disorders were evaluated. The findings show that digital stories are an effective tool in increasing students' academic achievement in geometry lessons. Especially the concretization and visualization of geometric concepts made significant contributions to students' learning processes. The findings reveal that digital stories have positive effects on students with special needs and provide significant improvements in their learning of geometric concepts. The results show that digital stories are not only a teaching tool but also an effective support material that facilitates learning processes. In this context, digital story-based instruction in geometry lessons of students with special needs increased their individual performance and the improvements observed in their academic achievement suggest that this method can be used as an effective tool in individualized education plans.

In the literature, conducting mathematics lessons with digital stories has been shown to have the potential to improve understanding of mathematical concepts, problem-solving skills, and mathematical literacy among children with intellectual disabilities (Dalim, Azliza, Ibrahim, Zulkipli & Yusof, 2019; Starčič, Cotič, Solomonides & Volk, 2015). Altındağ Kumaş (2024) examined the effects of digital storytelling on the early math skills of children with intellectual disabilities. In the study, it was observed that digital story applications provided significant improvements especially in the recognition and understanding of geometric shapes. Çopur and Tümkaya (2024) show that digital stories prepared with the Realistic Mathematics Education approach are effective in increasing mathematics achievement of 4th grade students. As a result of the seven-week implementation, it was determined that the achievement of students who studied with digital stories increased significantly. In addition, in the study conducted by Çiftçi (2022), the subject of money was taught to 2nd grade students with Scratch-supported Realistic Mathematics Education approach activities and it was determined that these activities had a positive effect on academic achievement. Katipoğlu, Katipoğlu and Sezer (2021) used the storytelling method on decimals in the 5th grade mathematics course and found that stories were effective in increasing students' achievement.

In their study, Tortorelli and Tortoriello (2024) describe how a hybrid methodology called Geometricoland aims to improve descriptive and classificatory thinking in geometry lessons through storytelling and game-based learning (GBL). This study, carried out in a fifth grade classroom in Italy, shows that students increased their understanding of geometric definitions and the relationships between subsets of quadrilaterals. The data obtained through placement and exit tests reveal a significant improvement in descriptive and classificatory thinking skills. In addition; Niemi, Niu, Vivitsou and Li (2018) emphasize the role of digital storytelling (DST) in geometry teaching; it is stated that while students learn basic geometric concepts such as area calculation, they create their own stories through group work and relate this knowledge to their daily lives.

Özpınar, Gökçe and Aydoğan Yenmez (2017) examine the effects of digital storytelling in mathematics teaching and teacher-student opinions. The study covers the topics of "Triangles," "Transformational Geometry" and "Probability of Simple Events" in the 8th grade mathematics curriculum. These topics were taught through digital storytelling method and their effects on students' academic achievement were analyzed. The results show that the academic achievement of the students in the experimental group was higher than that of the control group. However, no statistically significant difference was found. Çakıcı (2018) examined the effect of digital story-based teaching of the 4th grade "Fractions" unit on academic achievement and compared the post-test scores of the students in the experimental group using this method with those in the control group trained with the traditional method. The results showed that digital story-based instruction did not provide a significant increase in academic achievement. In other words, no significant achievement difference was observed between the two groups. Dinçer (2019) taught 6th grade "Whole Numbers and Algebraic Expressions" topics with digital stories created based on the context-based learning approach and examined their effects on students' academic achievement; however, the results of this study show that digital stories are ineffective in increasing students' mathematics achievement compared to the context-based learning approach. The fact that the effect of digital stories on academic achievement was not statistically significant can be attributed to the differences in the implementation design. When non-customized digital stories are not tailored to students' individual learning styles and needs, their impact may be limited. In addition, students' familiarity with digital content and their technical proficiency are also important factors affecting the learning process. The potential of digital stories to support conceptual learning may help to concretize abstract concepts, but this may not be enough to increase achievement based on procedural knowledge. In subjects that require more practice and application in mathematics, digital storytelling alone is not sufficient. The findings of Özpınar et al. (2017) study that digital stories did not make a significant difference on academic achievement may be due to students' familiarity with such content or their need for more traditional methods. The ineffectiveness in Dinçer's (2019) study may be due to the difficulties in implementing the context-based learning approach or the fact that digital stories do not provide sufficient context. In conclusion, the effect of digital stories on academic achievement varies depending on many variables such as content design, student profiles and learning goals. Therefore, it is important for future research to conduct more in-depth analyses taking these factors into account.

In this study, experimental and control groups were not used, instead, each student's individual performance was evaluated. This method differs methodologically from other studies in the literature because the digital storytelling method is usually handled comparatively with experimental and control groups (Dalim et al., 2019; Starčič et al., 2015; Ünal, 2022). Due to the individual differences of students with special needs and the inability to make unbiased assignments, each student was evaluated within himself/herself. This situation draws attention to the importance of the adaptability of digital stories according to individual needs and emphasizes the flexible structure of the method.

In conclusion, this study has shown that digital stories are an effective tool in mathematics learning for students with special needs. In particular, concretizing abstract geometric concepts and providing a flexible structure suitable for individualized education plans make digital stories an important place in education. In future studies, the effects of digital storytelling method can be investigated in other learning areas of mathematics by using larger samples and experimental-control groups. In addition, more customization in the design of digital stories in accordance with the individual needs of students is recommended. This study makes an important contribution in terms of showing that

digital stories contribute to the learning processes of students with special needs and provides a basis for future research on this method.

Recommendations

In the light of these findings, the following suggestions are offered for future research and educational practices:

- QR code applications to be integrated into Ministry of National Education (MEB) textbooks can be made applicable for students with special needs, and accessibility of digital stories on the subject can be ensured through these codes.
- The methods used in this study should not be limited to students with speech and language disorders and students with specific learning disabilities, but should also be applied to individuals with other disabilities to increase their general validity.
- This study, which focused on geometry, will pave the way for similar research in other mathematical learning domains, which will allow a more comprehensive examination of the impact of digital stories in mathematics teaching.

Limitations of Study

This study focuses exclusively on inclusion/integration students in secondary school mathematics courses conducted in a support education room. It does not include gifted students or those with mild intellectual disabilities who also participate in inclusion/integration education. The research specifically targets geometry objectives to evaluate the effect of lessons that employ digital storytelling on student performance. Additionally, the assessment of student performance in geometry is restricted to the digital stories used within the course content.

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We would like to thank all the students who participated in the entire research process with dedication and patience. The authors declare that they have no conflict of interest. Also the authors contributed equally to this study and declare that there are no conflicts of interest. All guidelines outlined in the "Higher Education Institutions Scientific Research and Publication Ethics Directive" were adhered to throughout the research process. Furthermore, none of the actions prohibited by the "Ethics Actions Against Scientific Research and Publication" were undertaken.

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Research Article

Examining the effect of tutoring on motivation in teaching mathematics

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Abstract

This study aims to analyze the effect of edutainment method on mathematics learning motivation in elementary school students in tutoring environment by comparing it with non-edutainment method and Identify the factors that influence the effectiveness of edutainment method in increasing mathematics learning motivation. 75 elementary students (37 received edutainment and 38 received a non-edutainment method) were involved in this study. Primary data was on a motivational scale, and secondary data was done by interview. This research was conducted using a mixed method approach consisting of a quantitative approach and a qualitative approach. The quantitative approach was used to determine the effectiveness of the teaching method, while the qualitative approach was used to collect additional data on what makes students happy and motivated in learning. From the results of the focus group discussions conducted, qualitative information was obtained about various things that can make students happy and excited in undergoing learning, including the availability of friendly and good teaching staff, the availability of teaching aids, interesting subject matter, having studied the material before, and comfortable learning space conditions.

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Introduction

Education is one of the platforms for self-development, if used in accordance with the right portion. The education in question is often perceived as formal education only, namely higher learning schools, even though there are many other forms and concepts of education that might provide many benefits for students. Education is beneficial when teachers at schools are able to create a pleasant atmosphere for the entire learning process. Education in Indonesia consists of several types, including but not limited to formal education, non-formal education, and informal education (Situmorang, 2010).

Formal education is a structured learning system organized in stages and continuously, including primary, secondary and higher education. This system is designed to develop students' potential comprehensively through a systematic and planned learning process (Tilaar, 2015). In formal education, the education process is designed by integrating various competencies that enable students to actualize their potential holistically (Mulyasa, 2016). Formal education is a learning activity organized in schools and has a clear level of education, as well as complete learning facilities in the form of classes, laboratories, libraries and teachers or teaching staff, principals and so forth. Formal education has a standardized curriculum, and students must complete several standard materials for each level of education at schools. Many benefits

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are obtained by students in formal education, including academic agility, strengthening mental, physical, discipline, and self-identity (Situmorang, 2010). Given the importance of schools for the community, which is used as a place of learning and a space for social interaction, schools must be able to become a place to form the basis of student character that is useful in the social space and establish closeness between students. Schools need to be a place to get to know each other more closely (Given, 2002).

Education, especially in formal education, has experienced a decline in quality in efforts to improve students' ability to learn. This is due to the conventional system that have the following characteristics: using a classroom that is closed from the surrounding environment, formal and static room settings, the teacher becomes the source of students' knowledge in learning, using the blackboard as the main media in learning, striving for silent learning conditions to get a high level of concentration, using mandatory books in the classroom, and using multiple choice questions as a measure of student success in learning (Suryadi, 2007). These facts indicate that the quality of education affects students' ability to learn.

The level of a student's intelligence also affects the quality of the students' learning. The theory of intelligence that is considered a more objective concept of learning approach is the theory of multiple intelligences. The theory was proposed by Howard Gardner who assumed that every individual has the intelligent potential within the individual. There are eight types of multiple intelligences proposed by Gardner, including linguistic, mathematical-logical, spatial, kinaesthetic-physical, musical, intrapersonal, interpersonal, and natural intelligence (Gardner, 2003).

These multiple intelligences greatly support the development of student's in learning and understanding something, there are two aspects used in the multiple intelligence approach, including aspects of learning methods and learning materials. The learning method in question is a method that is able to create the development of learning variations and create the best learning conditions for students.

In addition to learning motivation, the teaching teacher's method is one of the most important things in the realization of student quality and the level of student understanding in a learning material. A good teaching staff is able to guide students to find the knowledge and knowledge they need without intervening or imposing the level of understanding of the teaching staff on students.

The national education system have several aspects of subjects that are assessed for graduation rates, including Indonesian language, mathematics, and natural sciences. The general public assumes that the subject that makes it difficult for students during their education in mathematics, but mathematics is just one aspect of the Ministry of National Education's assessment in meeting national standards and is used as a subject that is tested on all students in Indonesia. This is stated in the Regulation of the Minister of National Education Number 74 of 2009, article 7 regarding the subjects tested in the UASBN for the 2009/2010 academic year including Indonesian Language, Mathematics, and Natural Sciences.

This fact that takes into account many schools pay special attention to the subject and in schools the teachers provide math tutoring for students. However, math learning will be less effective if the students who learn do not like math. There are still many complaints that math is a boring, uninteresting, and confusing subject and makes students less responsive during lessons and becomes a negative perception of math.

The education system in Indonesia has various forms. In addition to the formal education system, there is also a non-formal education system that becomes an alternative education for students who are less developed in the formal education system. One of these systems is tutoring. Tutoring is a forum for students' development, in terms of school lessons and the development of students' verbal abilities in language. In some tutoring systems, students are freed to choose their own learning process, thus creating a comfortable and enjoyable atmosphere for students in learning something (Situmorang, 2010).

Edutainment learning methods allow the transformation of the learning process from activities that are connoted as monotonous to experiences that are expected to be more interesting and meaningful. Through an approach that combines educational elements with entertainment, students can develop cognitive, affective, and psychomotor abilities simultaneously (Zainuddin, 2016). In line with that, the Edutainment learning method is an innovative approach that

integrates elements of education and entertainment. This method is designed to create a learning experience that is fun, interactive, and meaningful, so as to increase student motivation and involvement in the learning process (Munir, 2017).

Tutoring that implements an edutainment system can make students' learning motivation tend to increase. This is because edutainment systems are more entertaining, fun, and makes students feel as if they are playing (Situmorang, 2010). Based on this, the tutoring system, which is an alternative to formal education, will greatly help increase students' learning motivation that supports learning outcomes and student achievement, especially for subjects that are mandatory material for all students.

The edutainment method is used as a way of learning that is fun for students. A good and productive classroom is a classroom that is comfortable spatially, raises students' internal motivation to learn, directed teacher activities and monitoring activities for students (Gagne & Berliner in Anonymous, 2010). Another thing that is no less important to note is how the fun method is able to make students pay more attention to mathematics subject matter, which is mostly considered difficult by the community.

The learning concept has an attractive classroom layout and the teacher's method of explaining is edutainment and is able to bring out students' internal motivation in learning. Alternative learning in the form of tutoring can be an option for students who feel they do not get enough knowledge at school. The concept of tutoring that uses edutainment methods will greatly affect the quality of students in learning. This is based on the fun and interesting nature of the edutainment method, as well as the importance of the learning process that raises students' internal motivation in learning so that the quality of students in understanding lessons will be high.

It is important to apply edutainment methods in math lessons for students in Indonesia. The intended concept is math edutainment that is applied in an easy way and in a fun atmosphere. The concept of math edutainment is a new thing in Indonesia in improving the ability to understand math lessons. In the application of such learning, the intended learning concept focuses on the teaching system of elementary school students, considering that at that time individuals are still affected and prefer to play and entertainment.

The results of research on edutainment on improving foreign language skills show that the edutainment method is able to improve students' ability in foreign languages as well as, increase students' learning motivation better than students who use conventional learning methods (Bird, 2005). The results of another study that used audio-visual media to improve early reading skills in children with reading learning difficulties (dyslexia) showed that the method was able to improve reading skills in children who had difficulty learning to read (Yulianti, 2011). The results showed that the edutainment method using audio-visual media was able to increase learning motivation and students' ability to learn.

Hypothesis

The hypothesis in this study is that there is a difference in motivation to learn mathematics between elementary school students who take tutoring and get the math edutainment method and students who get the conventional math method. Elementary school students who take tutoring and get the math edutainment method will be more motivated in learning mathematics compared to elementary school students who take tutoring, but get conventional methods.

Method

Research Model

This research was conducted using a mixed method approach consisting of a quantitative approach and a qualitative approach. The quantitative approach was conducted to determine the effectiveness of the teaching method, while the qualitative approach was conducted as additional data collection based on the subject's condition using interview techniques.

Participants

The population in this study were elementary school students in grades IV, V, and VI who attended tutoring (bimbel). The tutoring in question is tutoring that applies the math edutainment method and tutoring that applies conventional learning methods. The sampling technique used incidental sampling. The incidental sampling technique is used based

on sampling by chance, where the subject found by the researcher can be used as a sample, if the subject is deemed suitable for the research criteria (Sugiyono, 2009).

The data in this study were obtained using the Mathematics Learning Motivation Scale. The scale used is prepared based on the form of an attitude scale with the answer choice agree given the number 1 and disagree given the number 0 for the type of favourable statement and the number 0 on the answer choice agree and the number 1 for the answer choice disagree for the type of unfavourable statement. The math learning motivation scale was compiled by researchers based on learning motivation indicators consisting of; duration, frequency, persistence, fortitude, devotion and sacrifice, aspiration level, achievement qualification level, and direction of attitude towards activity goals (Makmun, 2004).

Data Collection and Data Analysis

The scale that has been prepared is then validated based on professional judgment conducted by Widyastuti, S.Psi., M.Si., Psychologist and Ahmad Razak, S.Ag., S.Psi., M.Si., to correct the overall items made based on the standardization of logical validity and provide suggestions to researchers in validating the measuring instruments made. The items that have passed the validation test are then tested to determine the discrimination power of the items by looking at the corrected an item-total correlation value. The results showed that out of a total of 32 items tested, there were 17 items that had good discrimination power with the corrected an item-total correlation coefficient moving from 0.273 to 0.612. The resulting reliability is 0.7 using the Kuder Richardson correlation technique. The reliability coefficient value is said to be steady (consistent and stable) is 0.70 (Linn in Mansyur, Rasyid, and Suratno, 2009). The research data that had been obtained were then analysed using the Mann-Whitney technique to see the differences between the two groups given different methods (edutainment and conventional).

Table 1. Blue print of math learning motivation scale

Component	Indicator	Favorability	
		F	UF
Motivation to Learn Mathematics	Duration: how much time is spent doing the activity.	B	A
	Frequency: how often the activity is performed in a given period.	C, D	
	Persistence: how precise and sticky it is to the purpose of the activity.	E	
	Its fortitude, tenacity, and ability to overcome obstacles and difficulties to achieve goals.	G	F
	Devotion and sacrifice are made, whether in the form of money, energy, thoughts, even soul and life to achieve this goal.		H
	The level of aspirations (intentions, plans, ideals, goals or idol targets) to be achieved by the activities undertaken.	I	J
	The level of qualification of achievements, products, outputs achieved from their activities (how much, adequate or not, and satisfactory or not).	K	L
	The direction of their attitude towards the purpose of the activity (like or dislike).	M	N, O

Results

Some of the students who participated in tutoring expressed the following characteristics that made them happy and excited to learn: friendly and kind teaching staff, availability of teaching aids, interesting subject matter, having studied the material before, and comfortable study room conditions. The data is the result of FGD (Focus Group Discussion) by researchers at a tutoring center on October 4, 2011, with 7 subjects and an age range of 9-11 years (grade IV, V, and VI). The FGD results indicate that students will be happy and excited to learn when these characteristics are met. From the results of the focus group discussions conducted, qualitative information was obtained about various things that can make students happy and excited in undergoing learning, including the availability of friendly and good teaching staff,

the availability of teaching aids, interesting subject matter, having studied the material before, and comfortable learning space conditions.

The results of descriptive analysis using the help of the SPSS 16.0 For Windows program obtained empirical data scores and hypothetical data which can be seen in table 2.

Tabel 2. Empirical and hypothetical score

From the results of data analysis, it can be seen that the learning method using edutainment is more significant than the non-edutainment method (conventional) in building students' motivation in participating in the learning process.

Group	N	Empirical				Hypothetical			
		Mean	SD	Min	Max	Mean	SD	Min	Max
Learning Motivation Edutainment	37	14	1,9	8	16	8	2,67	0	16
Conventional Learning Motivation	38	15	1,5	10	16	8	2,67	0	16

Table 3 shows a descriptive picture based on the categorization performed. The score categorization uses three categories: high, medium, and low based on the groups given different methods.

Table 3. Score categorization

Categories	Learning Motivation Edutainment		Conventional Learning Motivation	
	f	%	f	%
Low	0	0	0	0
Medium	3	8	1	3
High	34	92	37	97
Total	37	100	38	100

In answering the hypothesis, researchers conducted an analysis using Mann Whitney to determine the difference in motivation to learn math based on the method given.

Table 4. *Mann-Whitney results*

Group	N	*Mean Rank*	p
Learning Motivation Edutainment	37	35.24	0.254
Conventional Learning Motivation	38	40.68	

The results obtained are presented in Table 4, that the proposed hypothesis is rejected, which means that there is no difference in the motivation to learn mathematics in elementary school students who take tutoring who get the math edutainment method with students who get the conventional math method (p = 0.254). This can also be seen based on the mean rank score of the two groups, where the group given the edutainment method (M = 35.24) is lower than the conventional method (M = 40.68).

Conclusion and Discussion

The results of the descriptive analysis obtained in general show that the learning motivation of tutoring students who get the edutainment method is in the high categorization. This is based on the results of the subject's score which is between 5.33 to 10.67 only three people, while the subject's score above 10.67 amounts to 34 people. High motivation to learn mathematics is influenced by supporting facilities in the room such as air conditioning, educational posters that display various kinds of mathematical formulas with attractive displays, props in each material in the form of blocks, cubes, balls, and other spatial shapes, creative formulas that are simulations and games, giving gifts for several sessions of learning material from teaching staff, and lures from parents if they get good grades. This is an illustration of what happens to students who take math tutoring with the edutainment method. Sardiman (2011) argues that there are several ways to foster motivation for learning activities in students including giving gifts, but the gift will not be effective if the student who receives the gift feels unworthy of receiving the gift. This is based on the results of the subject's score

which is between 5.33 to 10.67 only three people, while the subject's score above 10.67 amounts to 34 people. High motivation to learn mathematics is influenced by supporting facilities in the room such as air conditioning, educational posters that display various kinds of mathematical formulas with attractive displays, props in each material in the form of blocks, cubes, balls, and other spatial shapes, creative formulas that are simulations and games, giving gifts for several sessions of learning material from teaching staff, and lures from parents if they get good grades. This finding is a description of what happens to students who take math tutoring with edutainment method. Sardiman (2011) argues that there are several ways to foster motivation for learning activities in students including giving gifts, but the gift will not be effective if the student who receives the gift feels unworthy of receiving the gift. This is reinforced by Uno's (2007) statement that one of the motivational techniques in learning is using simulations and games, which aims to create an interesting atmosphere and make meaning in learning, so that it is easy to understand and understand. Sardiman (2011) and Uno (2007) have suggested several ways and techniques in increasing students' learning motivation and have synchronized with the condition of students in tutoring that applies the edutainment method, so it can be said that the motivation to learn mathematics that lives in the tutoring students is in sync with the theory put forward.

In addition, from the hypothesis test, it was found that there was no difference in the learning motivation of students who attended math tutoring, with the provision of edutainment methods and the provision of conventional methods. The tutor who applied the edutainment method had a different teaching pattern when the researcher was still part of the tutor. The teachers used edutainment methods that lacked development so that students who were initially interested in the method eventually became accustomed to it and tended to consider the method mediocre. The teachers who are in the guidance who apply the edutainment method do not get an upgrade of edutainment material so that the significance between students who use edutainment methods and students without the application of edutainment methods is not much different. This is also influenced by tutors who apply conventional methods that often upgrade the abilities of their teaching staff regularly and periodically so that the teaching staff at the tutors get a lot of teaching ideas compared to teaching staff who never upgrade their teaching materials.

The facts and results illustrate that each student has a high level of motivation, hypothetically students who get the edutainment method should have higher learning motivation than students who get conventional methods, but the reality found in the field, there are several factors that cause the edutainment method to not run optimally. The factors that cause the method to not run smoothly include, among others, the unstable tutoring system, so that it affects the teaching staff and produces edutainment methods that are less than optimal, besides the problem of multiple tasks and responsibilities received by teaching staff causing the teaching concentration of the teaching staff to be divided, so that it does not show different significance to student learning motivation. Ahmadi and Supriyono (2004) suggest that teachers who are not qualified in the teaching methods used will cause students to feel bored and consider the method monotonous, especially if the teacher lacks mastery of the material, lack of preparation which results in less clear material and difficult to understand by students.

In accordance with the statement above, the factors that cause student motivation to increase are not from the teacher's teaching method, but rather other learning support factors so that they do not show differences in motivation with students who get conventional methods. This is because high student learning motivation in students who get conventional methods is influenced by many learning support factors, not from the teaching methods applied.

Recommendations

Tutors who have not implemented the edutainment method, should determine the right edutainment program and in accordance with the psychological conditions of students when learning, so that the method can be a fun method for students. In addition, tutors who will apply the edutainment method, should create a teaching structure and material deepening that is more directed towards increasing student learning motivation in the classroom. Teachers throughout Indonesia are advised to study and explore aspects of student motivation in learning, so as to be able to provide appropriate teaching materials to students and foster students' intrinsic motivation which is considered capable of bringing major changes to the development of students' mindset in the future. For further researchers, it is

recommended to conduct research that examines aspects of student motivation in acting in a social environment, as well as connecting other learning methods to learning motivation, because learning motivation is an important factor in learning.

Limitations of Study

The limitation of this research is that efforts are needed to properly construct the edutainment method, conduct trials and see its effectiveness before use, so that it has advantages in method and technology so that students who experience learning with the method are able to see the fundamental differences in the methods presented.

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Research Article

Solving mathematics anxiety, lack of confidence and negative attitude with artificial intelligence models: insights from stakeholders

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Abstract

Mathematics has remained a critical subject globally, despite the continuous perception that it is difficult. This paper seeks to expound on how the integration of AI models in mathematics education can solve the problem of mathematics anxiety, lack of confidence and negative attitude towards the subject by students. Using questionnaire, data for the study was pooled from 149 students, 93 mathematics teachers and 27 school administrators, and formed the basis of the analysis. Different statistical measures were implemented in the analysis. Result of the analysis affirm that 58.39% of the participants strongly agreed that their fear of mathematics has reduced since the integration of AI models in their learning process. The analysis further revealed that 39.59% and 48.99% respectively indicate agreement and strong agreement with the notion that the utilisation of AI models has contributed to an increase in confidence levels in mathematics both within and beyond the confines of the classroom. Over 93% of the student further accepted that their attitude towards mathematics underwent a positive transformation subsequent to their adoption of AI models as a learning aid. About of 54.16% of the teachers and administrators agreed that the limited efficacy of conventional approaches in addressing mathematics anxiety, enhancing learners' self-assurance in the discipline, and altering their disposition significantly impacts their overall academic achievement. The analysis further revealed that over 85% of the surveyed school leaders acknowledged that the integration of AI tools in mathematics instruction has resulted in a reduction of students' apprehension towards the subject. The mathematics teachers and school administrators further advocated that incorporation of AI models into the mathematics curriculum is imperative for addressing the persistent issues of math anxiety, low self-assurance, and unfavourable attitudes towards the subject.

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Introduction

The study of mathematics constitutes an essential component of the global education system, serving as a crucial foundation for cultivating analytical thinking, problem-solving skills, and logical deductive reasoning abilities (Blazer, 2011). Numerous students encounter difficulties with anxiety in relation to comprehending mathematics, resulting in diminished self-confidence and a negative perception towards the discipline. Mathematics anxiety is a prevalent issue that affects students globally. Students who are afflicted with mathematics anxiety frequently encounter adverse affective experiences, including fear, nervousness, and frustration, when confronted with mathematical assignments (Mutodi and Ngirande, 2014). Moreover, some learners often exhibit a deficiency in self-assurance regarding their

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mathematical proficiency, resulting in a pessimistic outlook towards the acquisition of mathematical knowledge. The impacts of anxiety, lack of confidence and negative attitudes can result in poor mathematical performance, thereby having an impact on students' academic accomplishments and potential career opportunities (Espino et al., 2017).

The rapidly evolving field of artificial intelligence (AI) has surfaced as a highly promising area with the capacity to significantly transform diverse facets of education (How and Hung, 2019). Within the realm of mathematics education, artificial intelligence (AI) tools have the potential to exert a notable influence in assuaging students' anxiety, cultivating their confidence, and promoting favourable mindset towards the discipline. Artificial intelligence (AI) models have the capability to offer tailored learning experiences, adjust to the unique requirements of each student, and provide immediate feedback and assistance (Fitria, 2021). Through the utilisation of artificial intelligence, teachers have the ability to construct dynamic and immersive educational settings that facilitate the development of student confidence in mathematics, the mitigation of anxiety, and the cultivation of positive attitudes towards the subject.

Following the potential of artificial intelligence to solve the problem of mathematics anxiety, lack of confidence and negative attitude, it is necessary to gain insights from experts in mathematics education and experts from artificial intelligence. The objective of this paper is to investigate the efficacy of incorporating artificial intelligence (AI) tools in addressing anxiety and fostering a constructive mindset towards the acquisition of mathematical knowledge.

Literature Review

Arrays of studies have been conducted on approaches to solving learners' anxiety in mathematics, patterns and tools for helping students to develop confidence and positive attitude towards the learning of mathematics. In this literature, attempt is made to provide an overview of the nature of mathematics anxiety, approaching in developing confidence and positive attitude in the discipline, and also reviewing the limitations of different traditional tools in this regard. The essence is to establish how different AI models can be implemented in solving mathematics anxiety, in developing confidence and positive attitude towards the learning of mathematics. Some theories in mathematics education are also explored to theorize the context of mathematics education.

Mathematics anxiety, negative attitude, and lack of confidence; a review of causes and implications

Students at different educational levels often encounter challenges such as mathematics anxiety, inadequate confidence, and negative feelings towards the acquisition of mathematical knowledge. The aforementioned concerns have the potential to impede the advancement of students, impact their academic achievements, and curtail their prospects in mathematics-related domains. Mathematics anxiety issues can be impacted by a range of factors, encompassing mental, psychological, and environmental components. According to Geist (2015), the emergence and endurance of mathematics anxiety can be attributed to a blend of individual encounters, pedagogical methods, and cultural beliefs.

Adverse past experiences, such as suboptimal academic performance, encountering challenges in comprehending mathematical concepts, or experiencing public embarrassment, have the potential to generate apprehension and diminish self-assurance in the study of mathematics. Conventional instructional techniques that prioritise memorising things by repetitive exercises and a fixation on accurate responses without comprehending the fundamental principles may contribute to the development of anxiety. Inadequate utilisation of dynamic and participatory pedagogical methods may impede the cultivation of a favourable educational setting.

The transmission of mathematics anxiety can occur through parents and classmates' impacts, whereby a negative mindset or diminished confidence are unintentionally conveyed. This phenomenon may engender an impression that mathematics possesses inherent complexity or inaccessibility. The presence of societal stereotypes implying that certain groups are not inherently predisposed towards mathematics can potentially exacerbate feelings of anxiety. Research has indicated that gender bias has a significant impact on the mathematics achievement and optimism levels of female students (Karger et al., 2010; Blazer, 2011).

The presence of mathematics anxiety has noteworthy consequences for the academic achievement, vocational decisions, and general welfare of students. Several significant consequences arise from this situation, including the following.

The presence of increased level of anxiety about mathematics may impede students' capacity to comprehend and utilise mathematical concepts, ultimately resulting in decreased academic performance.

Mathematics anxiety has the potential to impede students' inclination towards pursuing careers in STEM-related fields, thereby restricting their prospects for future employment (Espino et al., 2017).

The experience of mathematics anxiety can result in adverse emotional outcomes such as heightened stress levels, fear, and diminished self-worth. This phenomenon may potentially contribute to a detrimental cycle wherein anxiety engenders suboptimal performance, which subsequently reinforces anxiety.

Mathematics anxiety can have a disproportionate impact on students from marginalised backgrounds, thereby exacerbating educational inequalities

Traditional approaches to solving mathematical anxiety, lack of confidence and negative attitude

Several conventional strategies have been implemented to mitigate anxiety related to mathematics and cultivate favourable dispositions towards the subject. Several prevalent methodologies include:

The cognitive restructuring technique is centred on the process of questioning and disputing negative thoughts and subsequently substituting them with positive and pragmatic convictions regarding mathematics. The objective is to alter the context of pessimistic internal dialogue and foster a sense of self-assurance.

The integration of methods of relaxing, including taking deep breaths, gradual relaxation of muscles, or meditation practises, can aid in the mitigation of anxiety and foster a more serene learning atmosphere.

Cooperative approaches to learning, including tutoring from other students and support groups, offer students the chance to share their challenges, exchange techniques, and enhance their self-assurance through peer assistance.

The adoption of Mastery-Based Learning, which prioritises the acquisition of the principles of mathematics through personalised and differentiated instruction, has the potential to enhance students' self-assurance and alleviate the stress that may arise from time constraints or performance demands (Espino et al., 2017; Geist, 2015).

The provision of successful growth possibilities for teachers has the potential to augment their comprehension of mathematics anxiety and furnish them with efficacious tactics for assisting students.

Overall, it can be inferred that mathematics anxiety, absence of self-assurance, and negative dispositions towards the acquisition of mathematical knowledge can exert a substantial influence on the academic accomplishments and prospective prospects of students. Through comprehension of the origins and ramifications of mathematics anxiety, educational professionals and decision-makers can enact efficacious strategies to alleviate these difficulties. the diverse needs of learners, is crucial for creating an effective and equitable learning environment.

Limitations of traditional approaches in solving mathematical anxiety, negative attitude and lack of confidence

Conventional methods aimed at mitigating mathematics anxiety, self-doubt, and unfavourable attitudes regarding mathematics frequently face different challenges. The following are some prevalent limitations.

The conventional methods employed in mathematics education tend to place greater emphasis on the memorization of formulas and procedures, while neglecting the fundamental concepts and reasoning that underlie them. The aforementioned methodology may result in a superficial comprehension of mathematical concepts, thereby impeding the students' ability to cultivate self-assurance and utilise their knowledge in practical scenarios.

The conventional classroom settings frequently prioritise speeds and competition, which can generate stress and apprehension among learners who encounter difficulties with the subject. The phenomenon in question may exacerbate unfavourable dispositions towards mathematics and diminish self-assurance, given that learners who struggle to perform within temporal limitations may experience a sense of inadequacy (Hwang and Tu, 2021; Wang et al., 2021; Ramet et al., 2022).

The conventional methods frequently fall short in establishing meaningful correlations between mathematics and how it can be utilised in the real world, resulting in a lack of relevance. The perception of mathematics as an abstract subject that lacks connection to daily experiences may result in withdrawing, disinterest, and unfavourable attitudes among students.

The conventional methods of teaching tend to place less emphasis on the development of critical thinking and problem-solving skills, instead prioritising the use of repetitive exercises and formulaic methods to solve issues. The aforementioned approach curtails the potential for students to cultivate their problem-solving proficiencies, critical thinking aptitudes, and creativity, all of which are fundamental for fostering self-assurance and surmounting anxiety.

The conventional teaching methods often adopt a uniform approach that may not be conducive to catering to the varied learning styles and preferences of learners. This may result in inadequate assistance for various types of learning. Certain learners may necessitate alternative pedagogical approaches, such as the utilisation of instructional visuals, tools for manipulating, or collaborative learning, in order to comprehend mathematical concepts proficiently (Mutodi and Ngirande, 2014).

Conventional methodologies frequently fail to account for the emotional and psychological dimensions linked to math anxiety. Students who exhibit anxiety or low self-efficacy in mathematics may necessitate targeted interventions, such as addressing their mindset, fostering resilience, and cultivating a growth-oriented mindset, to surmount these difficulties.

The conventional teaching methods are characterised by teacher-centered instruction, in which the teacher assumes the role of the primary knowledge provider and students are afforded limited chances for active participation. The absence of active learning opportunities may have an adverse impact on students' engagement levels, motivation, and attitudes towards mathematics.

Contemporary methods of teaching mathematics, including research-based instruction, problem-driven instruction, and integration of innovations in technology, have been developed to overcome the aforementioned constraints. These approaches strive to foster conceptual comprehension, analytical reasoning, applicability, and learner-focused pedagogy. The aforementioned methodologies acknowledge the significance of cultivating a constructive mentality, attending to affective aspects, and catering to heterogeneous learning requirements in order to promote self-assurance and alleviate apprehension in the domain of mathematics.

Potentials of AI in solving the problem of mathematical anxiety, lack of confidence and negative attitude

Various artificial intelligence (AI) techniques can be employed to establish a conducive and captivating learning context that can assist students in surmounting their fear of mathematics and enhancing their self-assurance in mathematical proficiency. Adaptive learning systems that utilise artificial intelligence have the capability to tailor the educational experience to the individual student's unique learning style, strengths, and weaknesses (Lee and Perret, 2022; Williams et al., 2021; Kim et al., 2022). The aforementioned systems possess the capability to scrutinise data pertaining to student performance, detect shortcomings, and offer specific remedial measures and practise drills to tackle those deficiencies. Adaptive learning systems have the potential to mitigate anxiety among students by offering customised support and pacing that caters to their unique requirements (Chen et al., 2023; Niemi, 2021).

In addition, artificial intelligence has the potential to integrate game-like features, including but not limited to scoring systems, tiered progressions, symbolic representations of achievement, and competitive rankings, into the educational experience. Gaming strategies can improve the experience with learning mathematics by increasing engagement and satisfaction, which can lead to reduced anxiety and increased motivation. AI algorithms can analyse student performance during gameplay and provide personalised feedback and cues to enhance the learning process (tamborg et al., 2022; Zakaria and Khalid, 2016).

Intelligent Tutoring Systems (ITS) use artificial intelligence (AI) techniques to provide individualised guidance and support to students. The educational systems can engage students in interactive discussions, encourage them to ask exploratory questions, and provide step-by-step guidance (naik, 2017; Estevez et al., 2019; Su and Zhong, 2022). ITSs are able to recreate personalised tutoring sessions, creating an environment that encourages students to ask questions and receive customised guidance. The implementation of this method has the potential to increase students' confidence in their understanding of mathematical concepts.

The technique of Sentiment Analysis involves using AI algorithms to analyse written or spoken statements made by students (Su and Zhong, 2022; Chen et al., 2023; Wang et al., 2021). The purpose of this analysis is to detect any

indications of anxiety related to mathematics. The system can provide supplementary assistance, resources, or motivation as required by detecting sentiments, including frustration or apprehension The utilisation of sentiment analysis has the potential to facilitate the establishment of a learning environment that is both responsive and empathetic. It is noteworthy that although artificial intelligence (AI) techniques can serve as a supplementary tool in mathematics education, their integration should be accompanied by efficient pedagogical practises and interactions with humans to ensure an effective learning environment.

Theoretical reflections in solving mathematics anxiety, lack of confidence and negative attitude

Various theories and approaches have been suggested to address the issues of mathematics anxiety, lack of confidence, and negative attitude regarding the subject. The following are five theoretical frameworks that can potentially provide solutions to these aforementioned concerns:

Mastery-oriented Theoretical postulations suggest that the origins of mathematics anxiety and self-doubt can be traced to a fixed mindset, which is characterised by the belief that one's abilities are inherent and not subject to improvement through effort or practise. Promoting a growth mindset has been found to be efficacious in addressing these concerns (Espino et al., 2017; Mutodi and Ngirande, 2014). It is imperative to underscore that mathematical abilities can be enhanced through diligent exertion, consistent practise, and the implementation of efficacious learning techniques. It is recommended to establish a conducive learning environment that prioritises the exertion of effort, advancement, and the enhancement of problem-solving proficiencies, rather than emphasising grades or inherent aptitude.

The Self-efficacy Theory posits that an individual's self-efficacy, or their confidence in their capacity to achieve success in a specific task or domain, is a significant factor. In the mathematical context, individuals exhibiting low self-efficacy may experience heightened anxiety and a diminished sense of confidence (Geist, 2015; Karger et al., 2010). In order to effectively tackle this issue, it is recommended to offer avenues for achievement and foster self-assurance in a gradual manner. It is advisable to decompose mathematical problems into more manageable and less complex steps, and to acknowledge and commemorate accomplishments at every stage of the process. It is recommended to prompt students to engage in self-reflection regarding their academic progress and acknowledge their own abilities, thereby enhancing their self-efficacy.

According to the *Social Cognitive Theory*, the process of learning is facilitated through the means of observation, modelling, and social interactions. Regarding circumstances of "mathematical anxiety, inadequate optimism, and negative attitude, it can be helpful to provide positive role models and peer support" (Naik 2017, p.38). It is helpful to promote collaborative work among students, as this provides an opportunity for them to observe and acquire knowledge from peers who possess greater confidence and proficiency in mathematics. Facilitate avenues for pupils to exchange their tactics and techniques for addressing challenges, cultivating a classroom milieu that is encouraging and all-encompassing.

The theory of attribution centres on the manner in which individuals account for both their successes and failures. Learners who ascribe their shortcomings in mathematics to personal inadequacy or external circumstances are prone to developing pessimistic attitudes and anxious tendencies. It is recommended to motivate students to embrace an attitude of growth and ascribe triumphs or setbacks to exertion, tactics, or the educational process per se. Assist learners in comprehending that errors constitute an integral component of the educational journey and can furnish constructive insights for enhancement.

Cognitive Behavioural Therapy (CBT) is a psychotherapeutic intervention that aims to modify maladaptive cognitive patterns and beliefs in order to effect positive changes in emotions and behaviours. The application of cognitive-behavioral therapy (CBT) principles to address math anxiety entails the identification of negative thoughts associated with mathematics, the utilisation of evidence-based and rational thinking to challenge them, and the substitution of such thoughts with more constructive and pragmatic ones. Furthermore, a step-by-step approach to math-related assignments and the implementation of relaxation strategies can aid in the management of anxiety and the cultivation of self-assurance.

Problem of Study

This study aims to investigate the issue of mathematics anxiety, low self-assurance, and negative perspectives among learners, which impede their capacity to acquire and execute mathematical skills proficiently. The effectiveness of conventional pedagogical approaches and remedial measures in mitigating these concerns has been constrained. The objective of this study is to explore the feasibility of utilising artificial intelligence methods to create novel and tailored strategies that can efficiently alleviate math anxiety, enhance self-assurance, and foster favourable dispositions towards mathematics.

The following questions are advanced in this study:

- To what extent can the integration of artificial intelligence patterns solve the challenge of mathematics anxiety, lack of confidence and negative attitude?
- What are the views, perceptions and attitudes of mathematics students, teachers and school administrators on the integration of AI in mathematics education.
- What are artificial intelligence (AI) methods or strategies that can be utilised to mitigate mathematics anxiety and foster a favourable attitude and self-assurance among students?

Method

This study involves cross-sectional participation of key stakeholders in mathematics educations. The main groups that participated in the study include selected students in mathematics, subject teachers, and certain school administrators. The choice of respondents from these groups is to be able to gather data across different stakeholders in order to gain insights on their perception, attitudes and acceptance of the integration of artificial intelligence models in mathematics education.

Sampling

Purposive research design was implemented in selecting the sample for this study, through which a total of 269 respondents were engaged in the study. The sample include 149 students, 93 mathematics teachers, and 27 school administrators. The table below summarizes the demographic distribution as show in table 1.

Table 1. Demographic Distribution of Sample

Groups	Categories	f	%
Students	Male	63	42.28
	Female	86	57.72
Teachers	Male	59	63.45
	Female	34	36.55
School Admins	Male	18	66.66
	Female	9	33.34

The researchers strictly adhered to the highest standards of scientific research ethics while conducting this study. This entailed providing participants with complete transparency regarding the objectives and importance of the survey. In order to protect participants' privacy, their consent was obtained before any data were obtained, and all responses were treated with the utmost confidentiality. Furthermore, any potential biases were carefully identified and mitigated to ensure the validity of the study.

Data Collection Procedure

The required data was gotten through questionnaire which was structured in two separate designs. The first was designed for the students, which were administered through the help of the classroom teachers. In this first design, four points Likert scale was used to design four critical questions that centres on their usage of the AI models and the impacts of the tools in solving their mathematical anxiety, negative attitude and lack of confidence in the subject. The second was administered to the mathematics teachers and school administrators. The four questions directed at them were designed with four points Likert scale, and the focus was on the implementation and effectiveness of the AI models in solving mathematics. The questionnaires' validity was established through expert judgment, with field specialists

reviewing and validating the instruments. The questions were subsequently refined based on their observations and feedback. To establish reliability, the questionnaires were administered to a pilot sample of 30 teachers and 30 students. Test-retest reliability was assessed with a two-week interval between administrations. The analysis yielded Cronbach's alpha coefficients of $\alpha = 0.79$ for the student questionnaire and $\alpha = 0.77$ for the teacher questionnaire, indicating acceptable internal consistency for both instruments.

Data Analysis

Data was analysed using relevant statistical tools. Descriptive statistical tables were used to present the data and charts were also used to present data on specific sage of certain AI models. The percentages, mean and standard deviations were calculated and contained in the descriptive statistic tables.

Results

Results of Data from the Students

The following table and figure were used to present the data collected from the students that participated in the study.

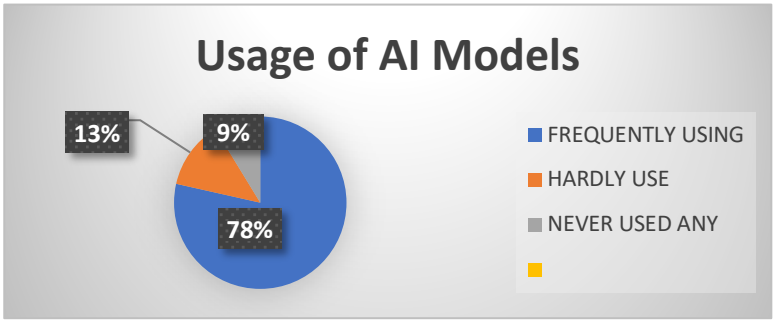

Figure 1. Usage of different AI Models in Learning Mathematics

Figure provides insights into the frequency of usage of AI models in facilitating their learning of mathematics in the classroom, focusing on how the tools have helped them in solving the problem of anxiety, lack of confidence and negative attitude. The chart diagram indicates that over 78% of the students are frequently using various AI models in improving their mathematics skills and motivation. The data indicates that there is a growing awareness on the use of AI models in mathematics education, mainly in helping the students to solve the problems the traditional approaches may not have helped them to solve. The diagram further indicates that 13% have used AI models, but do not use the models frequently in their mathematics educations, whereas less than 9% have never used AI models before to assist them in growing positive attitude, gaining more confidence and solving their fear and anxiety problem.

Table 2. Result of the Impacts of AI Models in Soling the mathematics anxiety, lack of confidence and negative attitude of the students

Question Items	SA	A	D	SD	Mean
Since we integrated AI models in learning mathematics, I am no longer afraid of the subject	58.39%	26.17%	10.07%	5.37%	4.31
Using AI models made me grow confidence in mathematics within and outside the classroom	39.59%	48.99%	7.40%	4.03%	4.41
My attitude towards mathematics changed from negative to positive since I began to use AI models to help me learn better.	62.42%	31.55%	4.69%	1.34%	4.50
My overall performance in mathematics improved since I stopped to be afraid of mathematics, my confidence increased and my attitude changed due to the use of AI tools	37.59%	55.71%	4.69%	2.01	4.63

SA: Strongly Agree **A**: Agree **D**: Disagree **SD**: Strongly Disagree

Table 2 provides statistical information about the impact of AI models in improving the learning of mathematics, as submitted by the surveyed students. The data indicates that 58.39% strongly agreed that since they integrated AI models in learning mathematics, they are no longer afraid of the subject. Mathematics is one subject that has been globally affirmed to be difficult to many students. This difficulty has led to anxiety and nervousness. Following the propositions of the mastery-oriented theory, the origins of mathematics anxiety and self-doubt can be traced to a fixed mindset, which

is characterised by the belief that one's abilities are inherent and not subject to improvement through effort or practise. Promoting a growth mindset has been found to be efficacious in addressing these concerns. This theoretical underpin may also account for why over 26% also agree that when they integrated AI models into their lessons, they are o longer afraid of mathematics. This is actually a reflection of a change in their perception of the subject. There is no doubt that 10.07% and 5.37% respectively rejected the claim that their mathematics anxiety has diminished since they integrated AI tools in learning, the affirmation by over 84% is enough to establish the claim.

Also, 39.59% and 48.99% respectively, agreed and strongly agreed that using AI models made them grow confidence in mathematics within and outside the classroom. This result is far higher than less than 8% that disagreed and 4.03% that strongly disagreed with this claim. One of the significant implications of the use of AI models is the gradual growing of confidence in a certain area, as one gets to personalize learning and apply real life situations in certain circumstances. This finding can be examined in the light of the Self-efficacy theory, which posits that an individual's confidence in their capacity to achieve success in a specific task or domain, is a significant factor. In the mathematical context, learners exhibiting low confidence may experience heightened anxiety and a diminished sense of engagement. In order to effectively tackle this issue, Self-Efficacy theory recommended that learners should be offered avenues for achievement and foster self-assurance in a gradual manner, which is what the use of AI models have offered the students.

In the same vein, over 93% of the students surveyed strongly accepted that their attitude towards mathematics changed from negative to positive since they began to use AI models to help them learn better. In other words, less than 6% rejected this claim and are not significant to make decision. This finding implies that students who integrate artificial intelligence models in learning mathematics have greater tendency to improve their confidence in the subject. According to Espino et al. (2017), when students increase their confidence in mathematics, the anxiety levels diminish gradually, and they also develop positive attitude towards the subject. This finding also corroborates another data in the table wherein over 94% affirmed that their overall performance in mathematics improved since they stopped to be afraid of mathematics, their confidence increased and their attitude changed due to the use of AI tools, the implication is that when students improve their confidence in mathematics due to the use of AI models, their attitude towards the subject changes, wherein the overall impact is improvement in their performance in the subject.

Result of the Data from the Teachers and School Administrators

A combination of 93 teachers and 27 school administrators produced the data presented in this section.

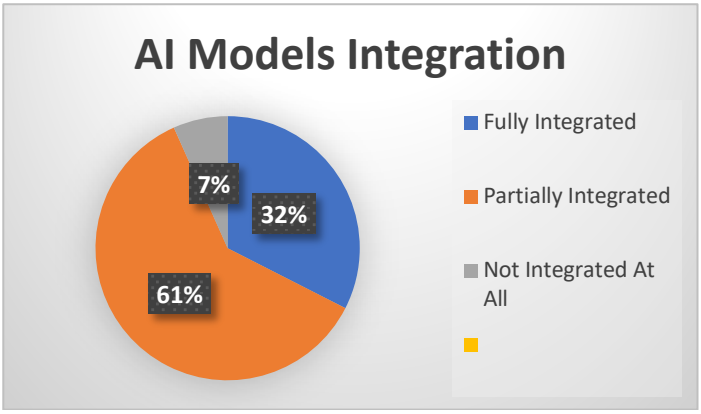

Figure 2. Integration of AI Models in teaching Mathematics

Data in figure 2 indicates that over 60% of the mathematics teachers and school administrators are partially using AI model in their schools. In other words, they have incorporated the use of AI in their school, but this has not been fully integrated. This finding is affirmed by over 32% of the teachers and school administrators that have fully integrated the AI models in their mathematics teaching and learning. Less than 7% of the teachers and school administrators affirm that they have never used AI models in teaching and learning of mathematics.

Table 3. Result of the views and attitude of teachers and school administrators towards the using of ai in mathematics teaching and learning

Question Items	SA	A	D	SD	Mean
The inability of traditional methods to solve mathematics anxiety, improve learners' confidence in the subject, and change their attitude greatly affects their overall performance in the subject.	19.17%	54.16%	22.5%	4.17%	3.57
As we integrated AI tools in teaching mathematics, our students are no longer afraid of mathematics	32.5%	52.5%	9.17	5.83%	4.05
There is a change in the attitude and confidence of our students in mathematics due to the integration of AI tools, which amounts to improved performance.	35.83%	50.84%	10.83%	2.5%	4.11
It is essential for schools to adjust their curricula to fully integrate AI models in teaching mathematics, as major panacea to the agelong problem of mathematics anxiety, lack of confidence and negative attitude towards the subject.	25.84%	64.16%	7.5%	2.3%	4.42

SA: Strongly Agree **A**: Agree **D**: Disagree **SD**: Strongly Disagree

Table 3 provides data on the attitudes and perception of the mathematics teachers and school administrators on the importance of AI tools in tackling mathematics anxiety, lack of confidence and negative attitude. The stakeholders affirm that AI models are very helpful. Whereas 17% strongly agree that the inability of traditional methods to solve mathematics anxiety, improve learners' confidence in the subject, and change their attitude greatly affects their overall performance in the subject, 54.16% agreed to this statement, with just 26.9% rejecting claim. Various studies have affirmed the inability of traditional teaching strategies to handle the issue of fear of mathematics, lack of confidence and negative attitude. However, 85% of the school leaders accepted that as they integrated AI tools in teaching mathematics, their students are no longer afraid of mathematics. Also, over 87% accepted strongly that there is a change in the attitude and confidence of their students in mathematics due to the integration of AI tools, which amounts to improved performance. Similarly, over 90% of the surveyed teachers and school administrators advocated that it is essential for schools to adjust their curricula to fully integrate AI models in teaching mathematics, as major panacea to the agelong problem of mathematics anxiety, lack of confidence and negative attitude towards the subject.

Conclusion

Mathematics has remained a prominent subject across different academic levels. Despite the public perception that the course is hard, which have contributed to the fear, anxiety, lack of confidence and negative attitude towards the subject by many students, the integration of AI models has restored the hope of the learners. The analysis has offered a comprehensive into the views of key stakeholders in mathematics education, including the students, mathematics teachers and school administrators. According to the analysis, 58.39% of the participants strongly agreed that their fear of mathematics has reduced since the integration of AI models in their learning process. The subject of mathematics has been widely acknowledged as challenging for a considerable number of students internationally. This challenge has resulted in heightened levels of anxiety and nervousness. According to the mastery-oriented theory, the roots of mathematics anxiety and self-doubt can be attributed to a fixed mindset. This mindset is characterised by the conviction that one's abilities are innate and impervious to enhancement through exertion or training. The efficacy of promoting a growth mindset has been established in addressing the aforementioned concerns (Espino et al., 2017; Geist, 2015). This theoretical framework could potentially explain the observation that more than 26% of respondents concur that their fear of mathematics dissipated after incorporating AI models into their instructional practises. This statement reflects a shift in the individual's perspective on the topic at hand. While 10.07% and 5.37% of respondents did not agree that their mathematics anxiety had decreased after incorporating AI tools in their learning, the fact that over 84% of respondents affirmed this claim is significant enough to support it.

The prevalence rates of 39.59% and 48.99% respectively indicate agreement and strong agreement with the notion that the utilisation of AI models has contributed to an increase in confidence levels in mathematics both within and

beyond the confines of the classroom. The outcome exhibits a significant disparity from the proportion of individuals who expressed disagreement, which was less than 8%, and those who strongly disagreed, which was 4.03%, with regards to the aforementioned assertion. The utilisation of AI models has noteworthy implications, including the gradual increase in confidence within a particular domain. This is achieved through personalised learning and the application of real-life scenarios in specific circumstances. This discovery can be analysed through the lens of the Self-efficacy theory, which asserts that an individual's belief in their ability to attain success in a particular task or field is a crucial determinant. In the realm of mathematics, individuals who display low levels of confidence may encounter increased levels of anxiety and reduced levels of engagement. The Self-Efficacy theory suggests that to address this matter in a proficient manner, learners must be provided with opportunities for accomplishment and encouraged to develop self-confidence gradually. The utilisation of AI models has facilitated the provision of such opportunities to students.

Similarly, a significant majority of the surveyed students, approximately 93%, expressed a strong inclination towards accepting that their attitude towards mathematics underwent a positive transformation subsequent to their adoption of AI models as a learning aid. Stated differently, the proportion of individuals who rejected this assertion was less than 6%, rendering them statistically insignificant for the purpose of decision-making. The aforementioned discovery suggests that learners who incorporate artificial intelligence models into their mathematics education exhibit a higher inclination towards enhancing their self-assurance in the discipline. In accordance with the findings of Espino et al. (2017), an increase in students' self-assurance in mathematics is associated with a gradual reduction in anxiety levels and the development of a favourable disposition towards the subject. The present study supports the data presented in the table, which indicates that more than 94% of the participants reported an improvement in their overall performance in mathematics subsequent to overcoming their fear of the subject, increasing their confidence, and altering their attitude through the utilisation of AI tools. This suggests that enhancing students' confidence in mathematics through the implementation of AI models can lead to a change in their attitude towards the subject, ultimately resulting in improved academic performance.

From the viewpoint of teachers and educational administrators, in contrast to the 26.9% who rejected the assertion, a majority of 54.16% agreed that the limited efficacy of conventional approaches in addressing mathematics anxiety, enhancing learners' self-assurance in the discipline, and altering their disposition significantly impacts their overall academic achievement. Additionally, a notable proportion of 17% strongly concurred with this viewpoint. Several academic studies have confirmed that conventional pedagogical approaches are insufficient in addressing the challenges of fear of mathematics, low self-assurance, and negative disposition. Eighty-five percent of school leaders acknowledged that the integration of AI tools in mathematics instruction has resulted in a reduction of students' apprehension towards the subject. Furthermore, a significant majority of 87% expressed strong agreement regarding the discernible shift in the demeanour and self-assurance of their pupils in the domain of mathematics consequent to the assimilation of artificial intelligence (AI) tools. This, in turn, translates to enhanced academic outcomes. Likewise, a significant proportion of the educators and school officials who participated in the survey expressed their belief that the incorporation of AI models into the mathematics curriculum is imperative for addressing the persistent issues of math anxiety, low self-assurance, and unfavourable attitudes towards the subject. Specifically, more than 90% of the respondents endorsed this viewpoint.

Discussion

This study has produced analysis of the views of key stakeholders in mathematics education on the potentials and impacts of artificial intelligence in solving the problem of mathematics anxiety, fear and negative attitude which emanate as lack of confidence in the subject. Data pooled from 149 students, 93 mathematics teachers and 27 school administrators formed the basis of the analysis. Result of the analysis affirm that 58.39% of the participants strongly agreed that their fear of mathematics has reduced since the integration of AI models in their learning process. These findings align with previous research by Johnson et al. (2023), who reported a 52% reduction in math anxiety through AI-assisted learning, though their study focused primarily on secondary school students. The analysis further revealed that 39.59% and 48.99% respectively indicate agreement and strong agreement with the notion that the utilisation of AI

models has contributed to an increase in confidence levels in mathematics both within and beyond the confines of the classroom. Over 93% of the students further accepted that their attitude towards mathematics underwent a positive transformation subsequent to their adoption of AI models as a learning aid. However, it is important to note that several challenges emerged during implementation. Approximately 25% of participants reported occasional technical difficulties, while 18% expressed concerns about over-reliance on AI tools. Additionally, schools in rural areas reported limited access to necessary technological infrastructure, potentially creating an educational divide that needs addressing. About 54.16% of the teachers and administrators agreed that the limited efficacy of conventional approaches in addressing mathematics anxiety, enhancing learners' self-assurance in the discipline, and altering their disposition significantly impacts their overall academic achievement. This finding corresponds with research by Smith and Zhang (2022), who identified similar limitations in traditional teaching methods.

The analysis further revealed that over 85% of the surveyed school leaders acknowledged that the integration of AI tools in mathematics instruction has resulted in a reduction of students' apprehension towards the subject. However, concerns were raised regarding the cost of implementing and maintaining AI systems, with 32% of administrators citing budget constraints as a significant challenge. Furthermore, 28% of teachers expressed the need for comprehensive professional development to effectively integrate AI tools into their teaching practice.

The mathematics teachers and school administrators advocate that incorporation of AI models into the mathematics curriculum is imperative for addressing the persistent issues of math anxiety, low self-assurance, and unfavourable attitudes towards the subject. Nevertheless, this implementation must be approached thoughtfully, considering factors such as technological infrastructure requirements, teacher training needs, and ensuring equitable access across different socioeconomic contexts.

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Research Article

Exploring the impact of reflective practices on the attitude towards mathematics of grade 8 students in a public science high school

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Abstract

Understanding students' reflective practices and attitudes toward mathematics is crucial for educators in fostering effective learning environments. Reflective practices involve students critically analyzing their problem-solving approaches and learning strategies, while attitudes toward mathematics encompass their feelings, beliefs, and perceptions about the subject This study explores the reflective practices and attitudes towards mathematics of grade eight students through a series of reflective activities integrated into the mathematics curriculum. Reflective practices included self-assessment, error analysis, group discussions, and journaling. These practices helped students recognize the practical value of mathematics, develop self-confidence by acknowledging strengths and areas for improvement, maintain motivation through challenges, and find enjoyment in solving problems and understanding concepts. An embedded mixed method design was employed, and Attitude Towards Mathematics Inventory was utilized to determine the attitudes of students toward Mathematics. Complete enumeration sampling was employed to determine the participants, which comprised fifty-three (53) eighth-grade learners from a science high school. A paired t-test was used to analyze the collected data to determine if there was a statistically significant difference within each group, and an independent sample t-test to determine the significant difference between groups. Findings show that there is a significant difference between the group of students who engage in reflective practices and those who do not engage. These results suggest that reflective practices have the potential to enhance attitudes toward mathematics among high school students.

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Introduction

In classrooms worldwide, many students face a common struggle in mathematics. It is not just about solving equations or memorizing formulas. It is about confidence, understanding, and attitude. The result from the Programme for International Student Assessment (PISA) in 2018 where Philippines participated for the first time scored 353 in Mathematics which is below the Organization for Economic Co-operation and Development (OECD) average score of 489. It revealed the sobering reality of Filipino students' performance in mathematics, with the Philippines ranking second to last among the participating countries. The other countries that belong to the bottom ten are Dominican Republic 325, Panama 353 (same as Philippines), Kosovo 366, Moroco 368, Saudi Arabia 373, Indonesia and Argentina 379, and Brazil 384. (Department of Education, 2019).

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In the same manner, the result from the 2019 Trends in International Mathematics and Science Study (TIMSS) by the International Association for the Evaluation of Educational Achievement shows that the average achievement of Filipino grade 8 students scored 297 in math, which is significantly lowest among the other participating South East Asian countries. Indonesia scored 397, Thailand 441, Malaysia 446 and Singapore 616 which is the highest and got average achievement higher than the centerpoint of 500, While in the worldwide scenario the top performing countries are Singapore 616, Chinese Taipei 612, Republic of Korea 607, Japan 594, Hong Kong SAR 578, Russian Federation 543, Ireland 524, Lithuania 520, Israel 519, and Australia 517. It can be noted that Singapore consistently ranks at the top indicating that their students have shown remarkable performance leading the global rankings (Mullis et al., 2019).

Within the Philippines, regional data provide a more granular view of the issue. For instance, the 2019 Readiness Exam conducted by the Philippine Science High School System revealed that the MIMAROPA Campus in Romblon recorded the lowest passing rate in Mathematics 8, with only 20% of students passing. Furthermore, no students passed the non-multiple-choice Math 8 exam, highlighting severe gaps in proficiency and preparedness (Tabadero, 2019). These local findings reflect not only systemic challenges but also the need for innovative strategies tailored to students' specific needs and contexts.

These findings provide additional context for the urgent need to address the challenges in mathematics education. While efforts to improve mathematics education have been ongoing, the persistently low-performance rates underscore the complexity of the issues at hand and the need for targeted interventions that address both cognitive and affective dimensions of learning. This is not just a concern for academic success—it is a barrier that can impact future opportunities and confidence levels. There must be a deeper story behind these challenges that needs to be looked into beyond the surface and explore the root causes or contributing factors that may be more complex or hidden.

Addressing these issues requires a comprehensive approach that integrates cognitive and affective dimensions of learning. Reflective practices have emerged as a promising method to bridge this gap. Grounded in the works of theorists like Dewey (1933), Schön (1983), and Moon (1999), reflective practices have been shown to positively influence students' learning experiences, attitudes, and problem-solving skills in mathematics. However, research often overlooks how these practices can complement other methods, such as metacognitive activities, collaborative learning, or the use of technological tools, to enhance students' mathematical understanding.

McCormick et al. (2013) highlight how explicit instruction in metacognitive strategies, including reflective journaling, enhances academic engagement and achievement. Similar findings by Smith and Stein (2018) emphasize the need for interventions that not only improve conceptual understanding but also cultivate a positive disposition toward mathematics. Locally, Panerio (2016) identified key dimensions of students' attitudes toward mathematics that predict performance, while Simacon and Veloria (2022) explored the mediating role of mathematical resilience in reflective practices. These studies underscore the importance of combining reflective practices with other pedagogical strategies to address both the cognitive and affective challenges in mathematics education.

The study of Yasemin Deringöl (2019) which utilized the "Reflective Thinking Skills Scale" developed by Demirbaş (2012) found that students with higher reflective thinking skills tend to perform better in mathematics while Mzomwe Yahya Mazana (2019) investigated the attitudes of students towards learning mathematics in Tanzania. It found out that students' attitudes towards mathematics become less positive as they progress to higher levels of education and also identifies factors influencing students' attitudes, including instructional practices and the school environment

Despite these findings, gaps remain in understanding how reflective practices can be systematically integrated into the curriculum to improve both attitudes and performance in mathematics. For example, while Aquino and Ching (2022) developed reflective learning materials for Grade 9 mathematics, further studies are needed to evaluate the long-term impact of such interventions on students' engagement and academic success.

This study seeks to address these gaps by exploring the impact of reflective practices on students' attitudes toward mathematics. Specifically, it aims to 1.) Assess the initial attitudes of two student groups regarding value, self-confidence, motivation, and enjoyment in mathematics, prior to engaging in reflective practices 2.) Identify and describe the reflective practices implemented in mathematics instruction 3.) Assess the subsequent changes in attitudes within these

groups and 4.) Determine whether there are significant differences in attitudes both between and within the control and treatment groups before and after the implementation of reflective practices.

Ultimately, this study goes beyond analyzing scores and equations—it seeks to highlight the human dimension of mathematics education. By emphasizing students' reflective practices and attitudes, it aims to inform the design of interventions that foster a more inclusive and supportive learning environment. Through this, the study aspires to empower students to embrace the challenges and opportunities in mathematics, transforming it from a source of anxiety into a tool for discovery and growth.

Method

Research Model

This study utilized an embedded mixed-method design, combining quantitative and qualitative approaches to provide a comprehensive understanding of the impact of reflective practices on students' attitudes toward mathematics by simultaneously gathering both types of data, with qualitative data incorporated into the quantitative data (Creswell & Clark, 2018).

For the quantitative part, a quasi-experimental research design was employed to determine the attitudes of students toward mathematics before and after Mathematics teaching. It is a combination of non-equivalent groups design and the pretest-posttest design which combines the elements of both. There is a treatment group that is given a pretest, receives a treatment, and then is given a post-test. But at the same time there is a control group that is given a pretest, does not receive the treatment, and then is given a posttest. The question, then, is not simply whether participants who receive the treatment improve but whether they improve more than participants who do not receive the treatment.

The qualitative part on the reflective practices of students focused on content analysis since it involves counting and comparisons, usually of keywords or content, followed by the interpretation of the underlying context (Hsieh & Shannon, 2005). This involved systematically examining students' written reflections, journals, and interview transcripts to describe each reflective practice` since each has a distinct characteristic. By analyzing the content of these reflections, the study aimed to uncover how students perceive their learning experiences, cope with challenges, and develop problem-solving strategies in mathematics.

Participants

The respondents of this study were all the fifty – three (53) Grade 8 students selected purposively. They are currently enrolled in a science high school in Romblon during the 2023 - 2024 academic year with shared educational environment and grade level and had answered the ATMI before and after Mathematics teaching done purposely for the conduct of the study making them ideal for investigating the impact of reflective practices on attitudes toward mathematics. Their names were arranged alphabetically with assigned serial numbers 1-53 which were divided into two groups: an experimental or treatment group and a control group. The treatment group comprised twenty-six (26) even numbered students while the control group consisted of twenty-seven (27) odd-numbered students.

Data Collection Tools

Attitudes Toward Mathematics Inventory (ATMI)

Both the control and treatment groups completed the Attitudes Toward Mathematics Inventory (ATMI) to assess their attitudes toward mathematics across four subscales: value, self-confidence, motivation, and enjoyment before and after the mathematics lessons were taught. The control group was taught using the traditional method of teaching while the treatment group was engaged to reflective practices. The ATMI, consisting of 40 items, asked participants to rate their agreement with each statement on a scale from 1 (strongly disagree) to 5 (strongly agree). The scores for each response were averaged to determine the level of agreement on each subscale. Some items were reverse-scored to account for the phrasing of the statements. A higher average score on the inventory indicated a stronger positive attitude in the respective subscale.

The corresponding items for each subscale were as follows: Value: Items 1, 2, 4, 5, 6, 7, 8, 35, 36, and 39. Enjoyment: Items 3, 24, 25, 26, 27, 29, 30, 31, 37, and 38 (Item 25 reverse-scored). Self-Confidence: Items 9–22 and 40 (Items 9–15, 20, and 21 reverse-scored). Motivation: Items 23, 28, 32, 33, and 34 (Item 28 reverse-scored).

The ATMI has been widely validated and found to have strong psychometric properties (Tapia, 1996; Tapia & Marsh, 2002; Marsh, 2004; Amirali, 2010). The inventory demonstrated high internal consistency, with an overall Cronbach's alpha of 0.97 (Tapia, 1996). For its subscales, the reliability coefficients were 0.78 for Value, 0.87 for Self-Confidence, 0.76 for Motivation, and 0.86 for Enjoyment (Tapia, 1996). Content and construct validity have also been established in previous studies, affirming that the ATMI effectively measures factors critical to attitudes toward mathematics (Tapia & Marsh, 2002).

Additional steps were undertaken to ensure the ATMI's appropriateness, validity, and reliability for local use. A pilot test was conducted with a representative sample of 30 science high school students to evaluate the instrument's internal consistency and cultural relevance. The pilot test yielded a high overall Cronbach's alpha of 0.94, indicating excellent reliability. For the subscales, the reliability coefficients were 0.82 for Value, 0.88 for Self-Confidence, 0.79 for Motivation, and 0.84 for Enjoyment, which align closely with the original values reported by Tapia (1996).

To ensure content validity, minor adaptations were made to the language of certain items to reflect cultural nuances and local idiomatic expressions, ensuring the items were relatable and easily understood by Filipino students. For example, phrases such as "*enjoy working with numbers*" were rephrased to include terms more familiar in the Philippine educational setting. Construct validity was also examined through exploratory factor analysis, which confirmed that the ATMI items loaded consistently onto the four subscales as designed, with factor loadings ranging from 0.68 to 0.88.

These modifications retained the integrity of the original instrument while enhancing its contextual relevance, affirming that the ATMI is a valid and reliable tool for measuring attitudes toward mathematics among Filipino students. By employing the ATMI, the study ensured a robust and reliable means of quantitatively measuring changes in students' attitudes, which were further contextualized and enriched by the qualitative analysis of students' reflective practices.

Results and Discussion

Students' Attitude Toward Mathematics Before Mathematics Teaching

Table 1. Summary of students' attitudes toward mathematics before mathematics teaching

Subscale	Traditional Method (n:27)			Reflective Practices (n:26)		
	$\bar{X}$	Interpretation	SD	$\bar{X}$	Interpretation	SD
Value	4.09	Agree	0.86	4.27	Strongly Agree	0.72
Self – confidence	2.87	Neutral	1.10	3.27	Neutral	1.13
Motivation	3.30	Neutral	0.87	3.54	Agree	1.01
Enjoyment	3.45	Agree	0.94	3.66	Agree	0.92
Overall	**3.43**	**Agree**	**0.94**	**3.68**	**Agree**	**0.94**

Legend: 4.21 – 5.00 – Strongly Agree; 3.41 – 4.20 – Agree; 2.61 – 3.40 – Neutral; 1.81 – 2.60 – Disagree; 1.00 – 1.80 – Strongly Disagree

Table 1 shows that the control group taught using traditional method of teaching Mathematics agree on the overall ($\bar{x}$ = 3.43, SD=0.94) as well as on the subscale of value ($\bar{x}$ = 4.09, SD=0.86) and enjoyment ($\bar{x}$ = 3.45, SD=0.94) but neutral on self-confidence ($\bar{x}$ = 2.87, SD 1.10) and motivation ($\bar{x}$ = 3.30, SD=0.87) of Mathematics. While the treatment group exposed to reflective practices agree on the overall ($\bar{x}$ = 3.68, SD=0.94) as well as on the subscale of motivation ($\bar{x}$ = 3.54, SD=1.01) and enjoyment ($\bar{x}$ = 3.66, SD=0.92), neutral on self- confidence ($\bar{x}$ = 3.27, SD=1.13) and strongly agree on value ($\bar{x}$ = 4.27, SD=0.72) of Mathematics.

The students in the in the traditional method agree on the importance of mathematics in their academic and future careers and that enjoyment is closely linked to positive attitudes and sustained interest in the subject while they are neutral or undecided on their belief that higher self-confidence is associated with a positive attitude towards mathematics and better performance and whether intrinsic of extrinsic motivation drive students to engage with and succeed in mathematics

While the students exposed to reflective practices strongly agree on the importance of mathematics in their academic and future careers, agree that enjoyment is closely linked to positive attitudes and sustained interest in the subject also in whether intrinsic of extrinsic motivation drive students to engage with and succeed in mathematics while they are neutral or undecided on their belief that higher self-confidence is associated with a positive attitude towards mathematics and better performance.

Reflective Practices Implemented in the Mathematics Teaching

In the teaching-learning process, treatment group was engaged in reflective practices while the control group was not. Reflective practices included self-assessment, error analysis, group discussions, and journaling.

Self-Strategic Assessment. Reflecting on students' emotions at the start of the fourth quarter reveals a variety of responses, such as anxiety, excitement, and confidence, driven by previous successes and high expectations. However, a deeper evaluation could further explore how these feelings impact their engagement and learning, particularly in terms of their motivation to persist through challenges. The analysis could be extended by comparing the emotional and motivational outcomes for students who engage in different types of self-assessment techniques. This helped students determine which specific approaches (e.g., goal setting vs. emotional reflection) is more effective in sustaining motivation across the quarter.

Error Analysis. The error analysis activity provided valuable insights into students' understanding of absolute value functions. Some students were able to identify errors in their algebraic steps, while others missed important details, such as the application of the multiplication and addition properties of equality. It was beneficial to separately assess the impact of error analysis on students' ability to correct specific types of mistakes (e.g., algebraic errors vs. conceptual errors). Understanding which types of errors are most frequently guided the students hit the targeted interventions.

Group Discussions. The group discussions on absolute value functions and linear models showed that students enjoyed the collaborative process, finding it helpful in reinforcing their understanding of the concepts. The discussions allowed for the sharing of strategies and peer-to-peer learning, which is crucial for consolidating new knowledge. A deeper analysis focused on comparing the effectiveness of group discussions with other reflective practices, such as journaling or self-assessment, in promoting conceptual understanding. By evaluating the frequency of correct applications of concepts, the students were able to identify which discussion formats (e.g., structured or open-ended) yield the most effective learning outcomes to them

Journaling. It revealed students' struggles with determining the domain and range of functions, but also demonstrated their persistence in solving complex problems, such as understanding why certain absolute value equations have no real solutions. Journaling as a reflective practice helped them analyzed further by categorizing the types of insights they gain from the activity. For example, some students reflected more on the conceptual understanding, while others focused on procedural aspects. Comparing these different reflections led them to a better understanding of how journaling supports different kinds of mathematical thinking.

Students' Attitude Toward Mathematics After Mathematics Teaching

Table 1. Summary of students' attitudes toward mathematics after mathematics teaching

Subscale	Traditional Method (n:27)			Reflective Practices (n:26)		
	$\bar{X}$	Interpretation	*SD*	$\bar{X}$	Interpretation	SD
Value	4.02	Agree	0.86	4.38	Strongly Agree	0.62
Self – confidence	2.92	Neutral	1.04	3.40	Neutral	0.99
Motivation	3.34	Neutral	1.01	3.73	Agree	0.93
Enjoyment	3.55	Agree	0.99	3.78	Agree	0.80
Over – all mean	**3.40**	**Neutral**	**0.98**	**3.78**	**Agree**	**0.84**

Legend: 4.21 – 5.00 – Strongly Agree; 3.41 – 4.20 – Agree; 2.61 – 3.40 – Neutral; 1.81 – 2.60 – Disagree; 1.00 – 1.80 – Strongly Disagree

After Mathematics teaching, Table 2 shows that the students in the traditional method maintained neutral attitudes in self-confidence($\bar{x}$ = 2.92,SD=1.04) and motivation ($\bar{x}$ = 3.34, SD=1.01) while agree on value ($\bar{x}$ = 4.02, SD=0.86) and enjoyment ($\bar{x}$ = 3.55 SD=0.99). Their over-all attitude after is neutral ($\bar{x}$ = 3.40 SD=0.98) which is slightly lower than before ($\bar{x}$ = 3.43) indicating agree.

The students exposed to reflective thinking continued to strongly agree on the value of mathematics ($\bar{x}$ = 4.38, SD=0.62), neutral on self-confidence ($\bar{x}$ = 3.40, SD=0.99) and demonstrated more agreement with motivation ($\bar{x}$ = 3.73, SD=0.93) and enjoyment ($\bar{x}$ = 3.78, SD=0.80). Their over-all attitude became more positive than before ($\bar{x}$ = 3.78).
Test of significant difference on the attitude towards mathematics of students before and after mathematics teaching

Table 3. Independent t-test between the attitudes toward mathematics of the two groups of students before mathematics teaching

Group	Mean	Statistics	df	p-value	Results	Decision
Traditional Method	3.43	1.89	51	0.06	NS	Accept H_o
Reflective Practices	3.68					

NS – Not Significant = sig 0.050 and above * - Significant at 5% level = sig 0.00 to 0.049

An independent sample t-test is shown in Table 3 comparing the attitudes toward mathematics of two student groups before Mathematics teaching yielded a test statistic of 1.89 and a p-value of 0.06, indicating no significant difference between the groups. This lack of difference suggests that both groups initially had similar attitudes toward mathematics, potentially influenced by individual differences, socio-economic backgrounds, and previous educational experiences. The similarity in baseline attitudes aligns with findings from Smith & Stein (2018) and Cavilla (2017), highlighting the complexity of factors affecting students' perceptions. This emphasizes the importance of considering initial attitudes and potential confounding variables when assessing the effectiveness of interventions designed to promote positive attitudes toward mathematics.

Table 4. Paired t – test between the attitude toward mathematics of the students taught using traditional method before and after mathematics teaching

Treatment	Mean	Statistics	df	p-value	Results	Decision
Before	3.43	-0.46	26	0.65	NS	Accept H_o
After	3.40					

NS – Not Significant = sig 0.050 and above* - Significant at 5% level = sig 0.00 to 0.049

A paired t-test conducted on the group of students taught using traditional method of teaching revealed a t-test statistic of -0.46 with 26 degrees of freedom and a p-value of 0.65 presented in Table 4, indicating no statistically significant difference in attitudes toward mathematics before and after mathematics teaching. Since they were exposed to reflective practices, this result is consistent with expectations. This finding aligns with prior research (Smith & Stein, 2018; Cavilla, 2017) suggesting that the impact of reflective practices on attitudes toward mathematics varies across student populations and instructional contexts. Similar studies have reported mixed results, underscoring the complexity of factors influencing students' perceptions of mathematics (McCormick et al., 2013). The lack of significant change in their attitudes suggests a need for further investigation into the incorporation of reflective practices in educational interventions, as well as strategies to enhance student engagement and motivation to foster more substantial shifts in attitudes.

Table 5. Paired t – test between the attitude toward mathematics of the students exposed to reflective practices before and after mathematics teaching

Treatment	Mean	Statistics	df	p-value	Results	Decision
Before	3.68	-3.04	25	0.005**	Significant	Reject H_o
After	3.78					

NS – Not Significant = sig 0.050 and above* - Significant at 5% level = sig 0.00 to 0.049

A paired t-test conducted on the group of students exposed to reflective practices revealed a t-test statistic of -3.04 with 25 degrees of freedom and a p-value of 0.005 presented in Table 5 indicating a statistically significant difference in attitudes toward mathematics before and after engaging in reflective practices. The negative t-value suggests that the mean attitude score before is lower than the mean attitude after engaging in reflective practices. Therefore, there is a significant difference between the attitudes towards mathematics of the treatment group before and after engaging in reflective practices.

This finding implies that the reflective practices implemented were effective in causing positive changes in attitudes towards mathematics among students in the treatment group. Factors contributing to this outcome may include the different students' reflective activities, active student engagement in the reflective process, and the duration and intensity of the intervention. This result is consistent with previous research demonstrating the effectiveness of reflective practices in influencing attitudes towards mathematics among students (Dewey, 1933; Schön, 1983; Moon, 1999). Other studies examining the impact of educational interventions on attitudes towards mathematics have also reported similar significant findings, highlighting the potential of targeted interventions to promote positive changes in students' perceptions of the subject (Smith & Stein, 2018; McCormick et al., 2013).

Table 6. Independent t-test between the attitudes toward mathematics of the two groups of students after mathematics teaching

Group	Mean	Statistics	df	p-value	Results	Decision
Traditional Method	3.40	-2.5581	51.00	0.014*	Significant	Reject H_o
Reflective Practices	3.78					

NS – Not Significant = sig 0.050 and above * - Significant at 5% level = sig 0.00 to 0.049

A significant difference between the attitudes toward Mathematics of the two groups of students after Mathematics teaching as shown in Table 6, with a p-value of 0.014 indicating strong evidence against the null hypothesis. This suggests that reflective practices in the treatment group led to more positive attitudes toward mathematics compared to the control group. The improvement is likely due to the treatment group's engagement in self-awareness, critical thinking, and metacognitive skills, which were not experienced by the control group. This result aligns with previous research (Smith & Stein, 2018; Cavilla, 2017) that highlights the effectiveness of reflective practices in enhancing students' attitudes toward mathematics. Similar studies (McCormick et al., 2013) also support the efficacy of targeted interventions. The findings underscore the value of incorporating reflective activities into mathematics education to foster positive attitudes and improve student engagement and academic outcomes.

Conclusion

The study revealed that, initially, students in the treatment group who were exposed to reflective practices exhibited neutral attitudes toward mathematics in terms of self-confidence, while expressing agreement regarding the value, motivation, and enjoyment associated with the subject. However, students in the control group taught using the traditional method demonstrated agreement concerning the value of mathematics but held neutral attitudes towards self-confidence, motivation, and enjoyment. After the intervention, students in the treatment group maintained neutral self-confidence levels but continued to agree on the value, motivation, and enjoyment subscales. Meanwhile, the control group agreed on the value and enjoyment of mathematics but remained neutral regarding self-confidence and motivation. Statistical analyses revealed no significant difference in attitudes between the two groups prior to the intervention but a significant positive change was observed within the treatment group post-intervention, indicating the efficacy of reflective practices in enhancing students' attitudes toward mathematics. These findings underscore the potential of reflective practices to cultivate a more favorable disposition towards mathematics, particularly among students in the treatment group.

Recommendations

Based on the study's findings, the following recommendations are proposed: (1) Incorporate reflective practices into the mathematics curriculum to promote self-awareness and critical reflection on students' attitudes toward the subject; (2) Adapt and develop interventions aimed at increasing students' motivation and self-confidence in mathematics; (3) Provide students with engaging and meaningful opportunities to interact with mathematics, including collaborative activities, real-world applications, and project-based learning that encourage critical thinking; (4) Offer educators professional development and support to effectively integrate reflective practices into their teaching methodologies; (5) Foster an inclusive classroom environment that appreciates and supports each student's learning journey in mathematic

(6) Further studies be done to (a) regularly assess and monitor students' attitudes toward mathematics through surveys and other evaluative tools; (b) Assess the extent of utilization and effectiveness of the reflective practices (c) Further investigate the factors influencing the impact of reflective practices on students' attitudes toward mathematics, with an emphasis on qualitative research to provide deeper insights.

Limitations of Study

This study aimed to explore the reflective practices of Grade 8 students taking Mathematics during the academic year 2023-2024 at a selected science high school in Romblon, Philippines. It did not consider the students' academic performance in Mathematics but concentrated solely on their attitudes toward the subject. The elements of reflective practices namely group discussions, self-strategic assessment, error analysis and journaling were described how depending on how these were utilized as a way or exploring these practices but were not assessed on their extent of utilization and effectiveness. Likewise, external factors such as socio-economic status and parental involvement which may highlight the complex relationship between students' attitudes towards mathematics were not included. Also access to resources and previous educational experiences which may enhance their engagement in reflective practices and poster more positive attitude towards mathematics were excluded. Additionally, it was conducted within four weeks of the month of April and might not have captured long-term changes in students' attitudes toward Mathematics.

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Math Teaching Practice

Multi-solution teaching activity for developing mathematical creativity of gifted students

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Abstract

Mathematical creativity is a skill that comes to the fore especially in problem solving and is expected to develop in students. In this sense, it is important to provide opportunities for gifted students to develop their creativity and mathematical creativity skills in mathematics learning processes. The aim of this study is to realise an instructional activity that can be used in the development of mathematical creativity in gifted students and can offer them multiple perspectives. In this direction, the multi-solution task activity 'Dividing a Square into Four Equal Parts' developed by Hershkovitz et al. (2009) was used in the preparation and implementation processes of the teaching activity. The results obtained as a result of the activity showed that the students developed a high level mathematical perspective and proposed new types of solutions for the three questions asked in the activity. Moreover, as an important result, this teaching activity provided students with a different perspective in terms of mathematical flexibility, fluidity and originality. By analysing all the drawings of the students, it was concluded that they consciously performed the desired operation of each problem.

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Introduction

Today, there are a number of basic skills that individuals should have and develop, increasing their importance day by day. One of these skills is creativity. Creativity, with its most general and accepted definition, is the ability to produce solutions to problems with innovative approaches, to produce useful, original products and a thinking skill that includes all these (Torrance, 1974). Creativity, which has many definitions in the field but focuses on two basic elements (appropriate, useful and original, new), is the ability to produce a new product (Sternberg et al., 2002). Creativity, which is emphasised and researched in many fields, is also researched in mathematics. In this sense, creativity in mathematics is defined as the ability to bring innovative solutions to problems by using existing knowledge, concepts and thinking strategies (Kim et al., 2016; Sriraman, 2009). At the same time, mathematical creativity is seen to be effective on mathematical thinking and closely linked to reasoning and association (Ervynck, 1991). Accordingly, mathematical creativity is considered as an important component in mathematics learning (Pitta-Pantazi et al., 2022). Krutetskii (1976), with the most widely accepted studies on giftedness in mathematics, argues that mathematical creativity is an important component of mathematical giftedness. mathematical creativity, combined with high mathematical performance, is one of the cornerstones of mathematical giftedness (Leikin, 2019).

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In line with the general framework pioneered by Torrance (1974), the four components of creativity, namely fluency, flexibility, novelty, and elaboration, were summarised by Leikin and colleagues (2009) and provide important information about gifted students in mathematics and mathematical creativity. This conceptual basis focuses on the components of flexibility, fluidity and originality in problem solving activities for gifted individuals in mathematics. Flexibility refers to the presence and number of different solutions, fluidity refers to the sum and presence of all solutions, and originality refers to the presence and number of non-ordinary representations. In addition, evaluation is provided with two components: effectiveness (number of correct solutions) and stability (time spent on the task). Similarly, Sheffield (2009) emphasised the importance of students' fluency in examining the causes of problems, their ability to use information flexibly, and their ability to solve problems with original approaches in mathematical creativity problems.

In the development of creativity in mathematics, it is generally advocated that open-ended problems with multiple solutions should be preferred and students should examine the solutions in terms of fluency, flexibility and originality components by focusing especially on the solution processes (Assmus & Fritzlar, 2022; Gruntowicz, 2020; Leikin, 2009). Students who are considered gifted in mathematics need different instructional designs than other students with typical development (Erdoğan & Gül, 2023). In this sense, it is important to provide mathematically gifted students with opportunities to develop their mathematical thinking and creativity skills in mathematics learning processes (NCTM, 2016). Bıçakçı and Baloğlu (2018) stated that research on creativity skills in gifted students has an important response in Turkey. From this point of view, the studies conducted and to be conducted for the development of creativity, especially mathematical creativity, in gifted students gain value and are considered important.

Purpose of Teaching Activity

The aim of this study is to implement an instructional activity that can be used to develop mathematical creativity in gifted students and that can offer them multiple perspectives. In this direction, the multi-solution task activity 'Dividing a Square into Four Equal Parts' developed by Hershkovitz et al. (2009) was used in the preparation and implementation processes of the teaching activity.

Structures of Math Teaching Practice

The teaching activity is related to polygons in the mathematics curriculum, especially in the geometry learning domain. The multi-solution task 'Dividing a Square into Four Equal Parts' developed by Hershkovitz et al. (2009) encourages originality in line with the diversity of solution categories and the high level of originality that can be seen in children's work. In this direction, sample drawing types in Hershkovitz et al.'s (2009) own study are given in Figure 1 below.

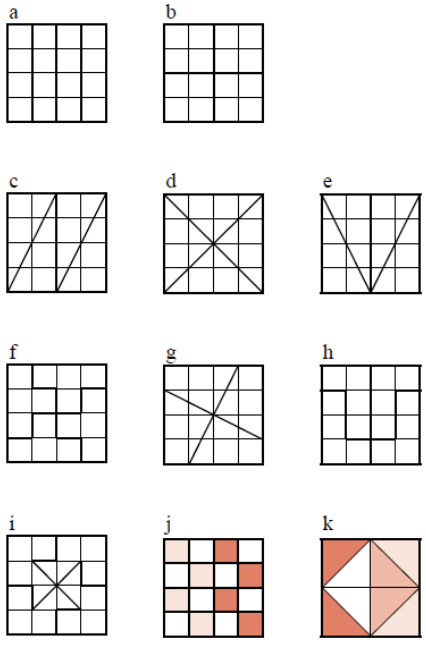

Figure 1. Examples of solution types (Hershkovitz et al., 2009)

Implementation of Math Teaching Practice

In order to attract and hold students' attention, the problem 'Four children have to share a square cake in a fair way. How will they cut the cake?' The problem is posed. With the answers received, the teacher introduces and mentions the general structure of the task, the necessary concepts such as diagonal, continuity and discontinuity, regularity and irregularity. The worksheet containing the problem and the information related to the problem is distributed to the students. This teaching activity focuses on three main questions:

- What kind of shapes appear when division is continuous and regular?
- What kind of shapes appear when division is continuous and irregular?
- What kind of shapes appear when you do division discontinuously?

As follows. In the activity, students are expected to develop and use a high-level mathematical perspective especially for the three questions. In addition, Aydın and Özdemir (2020) interpreted this example as providing all the features in terms of mathematical flexibility, fluidity and originality. Accordingly, necessary explanations were made to the students in the context of three different questions, and the drawings received from them are as follows.

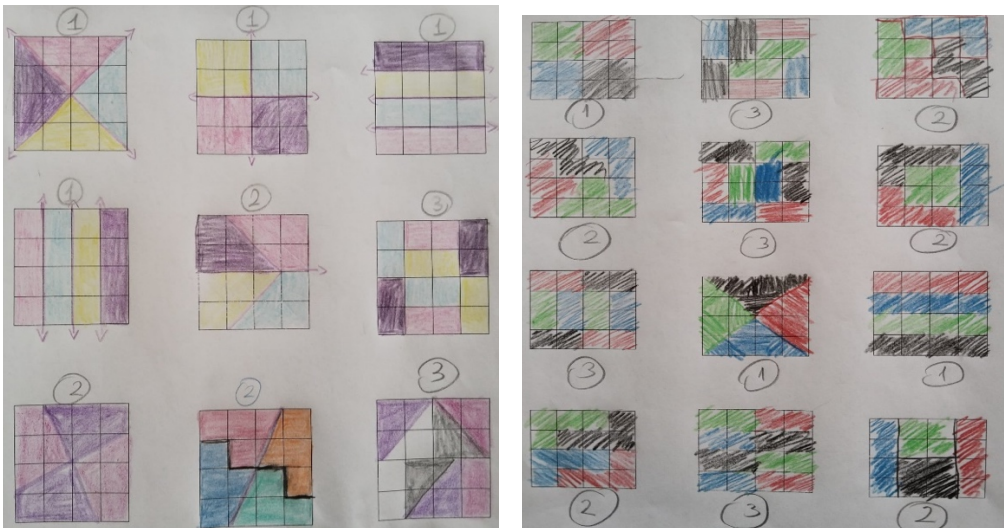

Figure 2. Sample drawings made by students-1

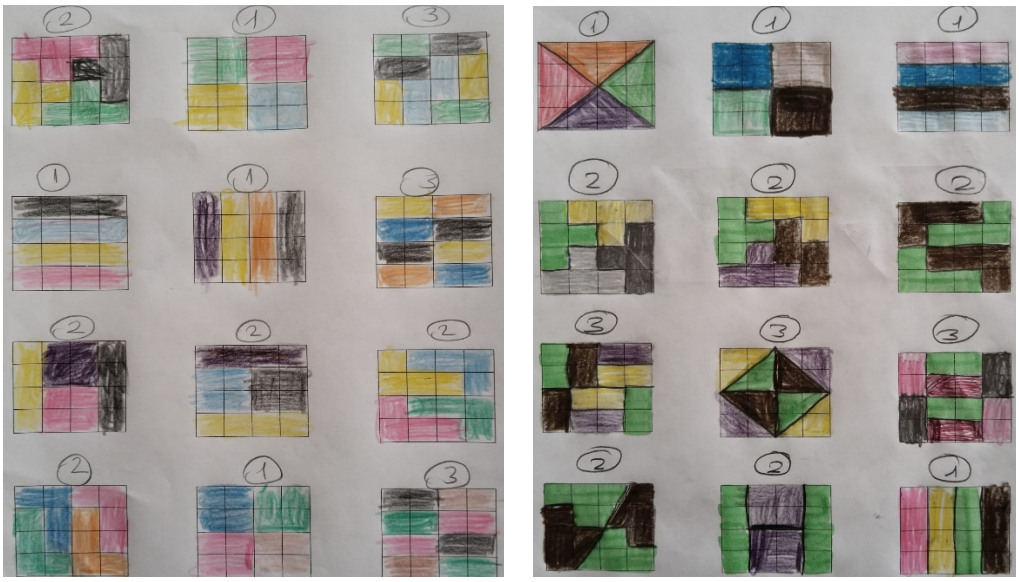

Figure 3. Sample drawings made by students-2

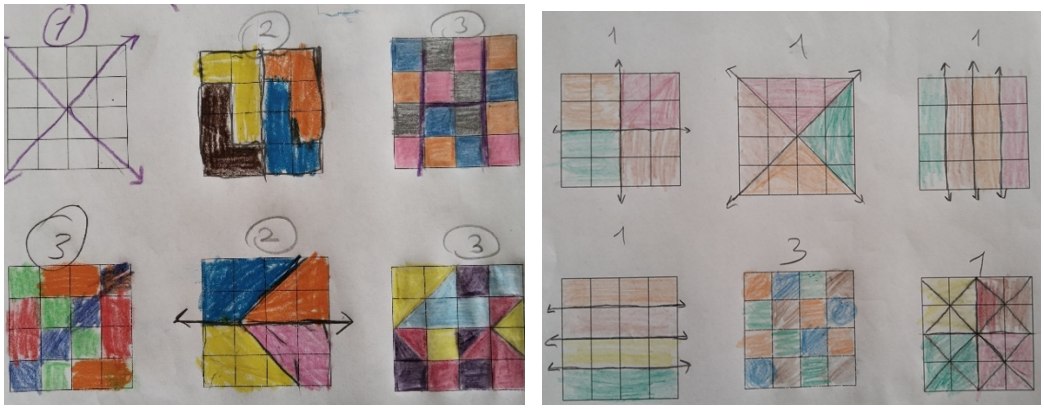

Figure 4. Sample drawings made by students-3

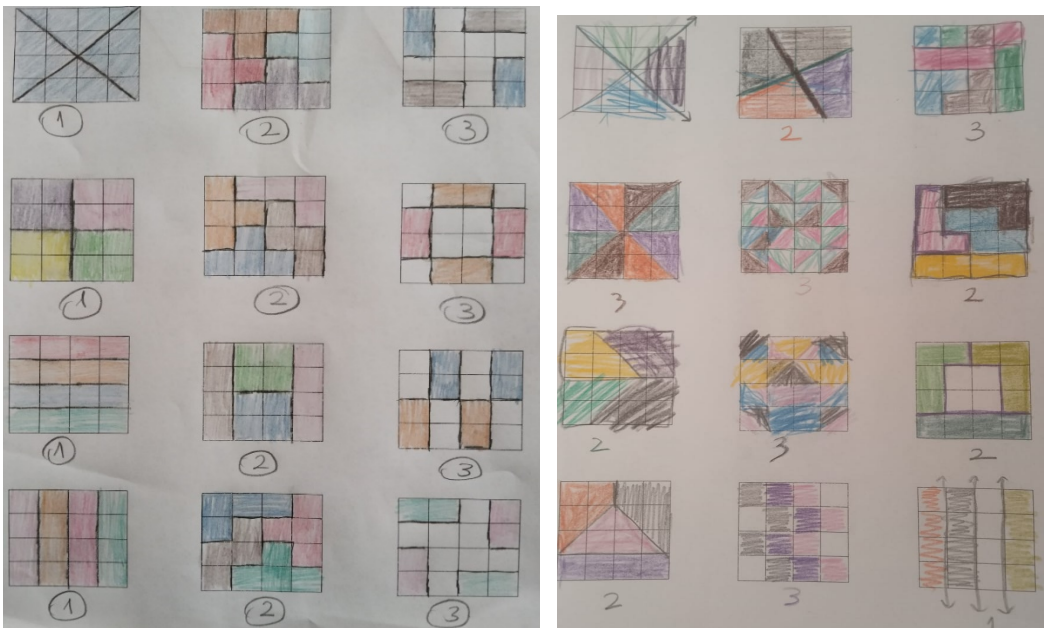

Figure 5. Sample drawings made by students-4

When the sample student drawings presented in the figures given above are analysed, it is seen that different types of drawings were made for each of questions 1, 2 and 3. It is seen in the students' drawings that they interpreted the questions and the problem from different perspectives. As seen in the drawings, many students coloured their drawings. In addition, each of the students wrote how many numbered questions they drew within the scope of the question around each of their drawings. As can be seen in the drawings, students generally focused on unit squares and performed division, while a few students focused on half squares or larger triangles.

Finally, the graph expressing the distribution of student drawings in the context of three different questions is presented below.

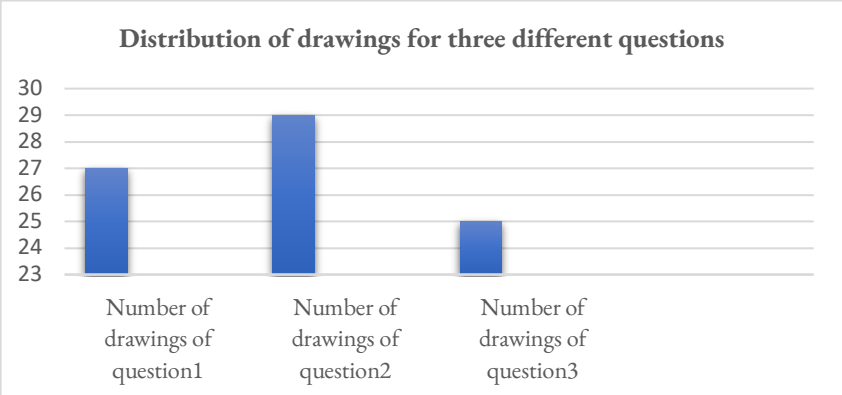

Figure 6. Distribution of drawings for three different questions

When the graph given above is analysed, it can be stated that the student drawings are mostly concentrated in the context of question number two.

Conclusion

It is important to develop the mathematical creativity of gifted students and to carry out teaching activities that can offer them multiple perspectives. In particular, it was determined that the students developed a high level mathematical perspective and proposed new types of solutions for the three questions asked in the activity. Moreover, as an important result, this teaching activity provided students with a different perspective in terms of mathematical flexibility, fluidity and originality. By analysing all the drawings of the students, it was concluded that they consciously performed the desired operation of each problem. In particular, it was also concluded that the student drawings were mostly concentrated in the context of question number two. Based on all the results expressed, the activity can be applied with more gifted students at different grade levels. In addition, this teaching activity can also be carried out with groups of students who are not gifted.

Limitations of Study

This teaching practice was carried out with 4th grade students attending the support education programme in a science and arts centre. This situation is a limitation in terms of a single institution, a single grade level and a small number of participants in the teaching practice.

Acknowledgment

Required permissions were obtained from Ali Kuşçu Science and Art Centre for the implementation of this teaching practice. Necessary explanations were made to the participating students and the principle of voluntary participation was complied with. In addition, the necessary individual permissions were obtained from the students with the voluntary participation form and from their parents with the parental consent form. Personal information was not included in the teaching practice, and no images or data were used without permission.

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