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The Effect of Instruction Supported by Internet Memes on Students' Mathematics Anxiety and Mathematics Motivation

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Abstract

This research aims to investigate the effect of instruction supported by mathematical internet memes on 8th-grade students' mathematics anxiety and motivation. The research consisted of a pre-test post-test quasi-experimental design conducted for two weeks. The research sample consists of 8th-grade students who study in a state school in Turkey. Data were gathered by using mathematics anxiety and motivation scales before and after the instruction supported by internet memes. As a result of the Mann-Whitney U-test analysis conducted between groups, it is seen that instruction supported by internet memes significantly raised students' mathematics motivation level in favor of the experiment group. In the analysis conducted by using the Wilcoxon Signed Ranks Test, it is revealed that there is a statistically significant difference in raising mathematics motivation levels and lowering mathematics anxiety levels in terms of scores obtained from mathematics anxiety and motivation scales for the experimental group, while there is no significant difference on the control group. As a result of the Spearman rank correlation analysis, it was revealed that there was a negative and moderately significant relationship between the scores obtained from both scales. It is recommended to use mathematical internet memes as supportive elements in mathematics teaching.

Introduction

Technological advancements have changed communication styles and daily life in different ways after the emergence of the internet in the late 1900s. Technological tools have replaced face-to-face communication in human relationships. Social media is at the center of this new communication style (Öztürk & Talas, 2015). Social media has become one of the most frequently used mediums in the world in daily life. The sphere of influence of social media continues to expand day by day. Many social media content such as internet memes attract the attention of many people, especially children. Social media has brought innovations to many sectors from commerce to art. Social media inevitably brings up issues that can be discussed under the heading of education (Konuk & Nebiye, 2019). The use of internet memes in education is one of these issues. Dawkins explains the concept of the meme as "a unit of cultural transfer, or a unit of imitation" and explains it in his work where he

establishes a relationship between the "memes" he created from "mimeme" to be compatible with the word gene (gene) (Yılmaz, 2017). The meme has spread like a gene and has become popular among the younger generation in a short time according to Dawkins. Today it is widely used in various fields such as advertising, marketing, politics, etc. (Reddy et al., 2020).

Memes are digital objects created by web users as an outcome of the process of copying an image and overlaying it with a personal caption (Miltner, 2014). Memes are all over the internet (Başpehlivan, 2023). It is seen that the usage areas of memes have expanded by differentiating from their initial entertainment purpose (Saltık, 2017). Many internet memes have been created related to many fields from law to mathematics (Bini et al., 2020). Teng (2022) stated that internet memes affected the brand images of companies in the marketing industry positively. Keehn (2023) drew attention to the epistemological potential of political internet memes by investigating how internet memes affected elections in the USA. It is emphasized that internet memes are very important because of their unique recognition, reproducibility, and potential to create a productive space that can help students create a discussion environment (Keehn, 2023). Bonetto (2018) published an article discussing copyright issues in internet memes under European Union law. Bonetto argues that internet memes remain in a gray area in terms of copyright as they are a product of the recreation of content previously created by other people.

The widespread use and popularity of memes also affect the educational field (Reddy et al., 2020). Instructors can use internet memes to explain abstract concepts concretely. In addition, memes can be incorporated into students' lives to a large extent, and interesting memes related to the topic can be used during the lesson to increase the memorability of the lesson. On the other hand, it should not be forgotten that internet memes can not eliminate the problem of abstract concepts, but they can concretize abstract procedures (Reddy et al., 2020).

Mathematical meme is an internet phenomenon with significant potential to teach and learn mathematics. Mathematical memes are products that combine a mathematical idea and meme base with humorous and emotional elements to concrete mathematical content rigorously (Bini et al., 2020). Mathematical memes evoke a feeling of curiosity in users (Van,2021). Furthermore, there are internet memes that emphasize the irony of teaching mathematics as well as how students handle calculations in memes rigorously. Therefore, the rising importance of meme culture can stimulate students to informal learning (Van, 2021). Van (2021) conducted a study to explore the role of memes in mathematics teaching by implementing course-related (mathematical memes) and non-related (emotional memes) memes in the classroom. As a result of his study, he stated that emotional memes negatively affect the cognitive aspect of the student, but mathematical memes significantly increase the curiosity of the student and motivate the student. Therefore, it is thought that memes can be a solution to students' low math motivation levels (Van, 2021).

Bini et al. (2020) stated that a mathematical meme makes a mathematical statement easier to code in our minds and combines that mathematical statement with a meme template or base humorously. Because mathematical memes provide a mathematical concept by using a recognizable framework. They encourage students into critical thinking to figure out relations between statements in memes, just like a riddle (Bini et al., 2020).

In Figure 1, in the "Spiderman" meme, the expansion of a perfect square expression is given in a way to evoke the feeling of Spiderman's reflection in the mirror, and it is intended to help understand the equality of two algebraic expressions. In Figure 1, the information that the algebraic expression $(a+b)^2$ is equal to the algebraic expression $a^2+2ab+b^2$ is presented visually by using the Spiderman character, which most students are interested in. Thus, the mathematical expression to be emphasized will draw the attention of the student who is interested in the Spider-Man animation/cartoon. Similarly, in Figure 2, an attempt was made to help students encode the factorization of the algebraic expressions x^2-1 and x^4-1 in their minds through the Tom and Jerry cartoon. The visual in Figure 2 allows the student to encode the factorization of an algebraic expression in his/her mind as the division of a notebook into as many parts as the number of factors.

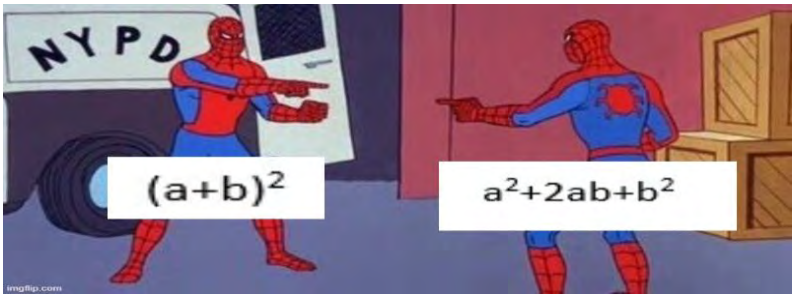

Figure 1. Spiderman Meme

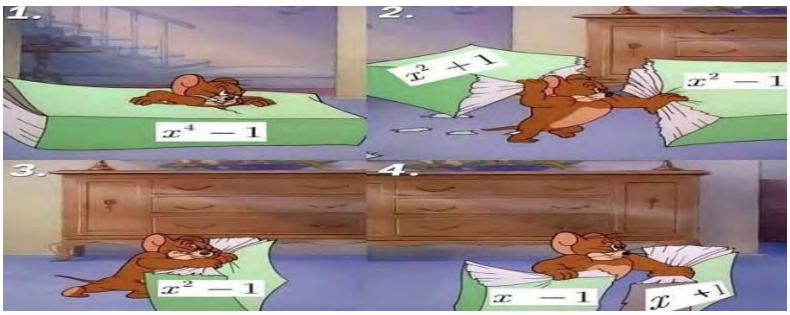

Figure 2. Tom and Jerry Meme

Students may be expected to doodle and perform operations on memes. Figure 3 shows a meme on which students can doodle and perform operations. In the "Sponge Bob's Paper" meme, students were given the algebraic expression 2x. (2x + 2) and were asked to model the given expression correctly on the blank paper. Thus, the modeling process takes place on the meme. SpongeBob acts as a kind of teacher here. In the meme, SpongeBob is given the feign of a teacher who controls the operations performed by the students. Figure 4 shows the correct modeling of the product 2x. (2x + 2).

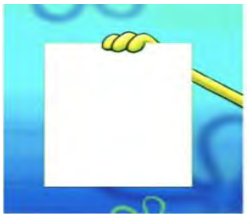

Figure 3. Sponge Bob's Paper

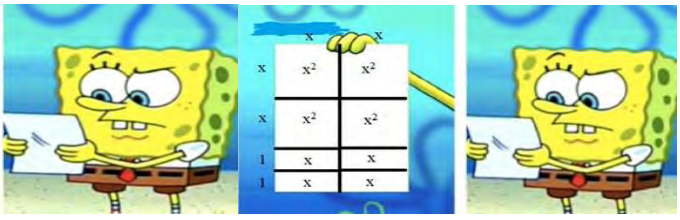

Figure 4. Sponge Bob's Paper

Subbiramaniyan et al. (2022) conducted a study in which they researched whether a mem-based approach has a positive effect on improving medical students' collaboration and enhancing their learning in physiology courses. As a result of the study, it is stated that in the feedback received from the students, expressions such as "fun" and "stress-reducing" were frequently encountered in relation to memes, and 30% of the students mentioned the themes that memes simplify complex information and 38% mentioned that memes make it easier to remember information. According to Subbiramaniyan et al. (2022), memes used in teaching stimulate student interest, increase peer interaction, simplify complex information, and help create a positive learning environment. Kristianti (2021) emphasizes that problems that need a long explanation can be eliminated with a single meme and that memes help to understand concepts more easily, therefore, studies examining the effect of a teaching environment using memes on learning should be conducted.

Antón-Sancho (2022) stated that memes increase students' interaction and motivation and are used in different disciplines as a learning tool. Scardina (2017) emphasized that memes are not only fun but also have a high educational value as they develop students' critical thinking skills. According to Scardina (2017), memes are worth talking about. Because memes are a means of reflecting on what students have learned, can create an environment for discussion and can be effective in making connections. Thus, the learning environment will be enriched by memes and memes will add value to learning. Tu et al. (2022) had their students create memes through online applications in the field of molecular biology for one semester during the pandemic and enabled students to share their work. Tu et al. (2022) stated that in the survey conducted at the end of the semester, 100% of the students stated that their interaction with their peers improved positively, 95% stated that their stress decreased and 85% stated that their interest in the course increased.

Kyrpa et al. (2022) investigated the impact of integrating internet memes into language teaching. The study emphasized the need to develop teachers' pedagogical, creative, and critical thinking skills by incorporating internet memes into English language teaching. In this context, the study emphasized the need to investigate the epistemological potential of internet memes not only in linguistics but also in other fields. Purnama et al. (2017) reported that students gave positive feedback to meme-making activities in English lessons and 30.2% of them used the words "interesting", 30.2% "fun" and 20.9% "confidence building" in their feedback. The study revealed that students' creativity skills and motivation to learn English increased (Purnama et al., 2017). Harshavardhan et al. (2019) stated in their study that internet memes add humor to English lessons and that the effective use of humor in lessons has the potential to motivate students and reduce their anxiety.

de Oliveira (2022) conducted a study that integrated internet memes into the course to increase the motivation of students between the ages of 12-15 to learn English during distance education during the Covid 19 pandemic period. As a result of the study, he stated that he received positive feedback from the students and that internet memes increased students' cognitive and communication skills. On the other hand, some studies conducted during the pandemic period showed that students' math anxiety levels increased (Christiansen, 2021; Mendoza, 2021; Nurhasanah et al., 2022). With the pandemic, educators have sought new approaches in teaching to keep students active in the learning process, to prevent students from getting bored and distancing themselves from school, to keep their motivation high, and to reduce their anxiety. It is thought that memes can be integrated into lessons in

line with this pursuit. Karadeniz Kayalı (2021) stated that memes increase students' interest in the lesson and memes can be used in an innovative learning and teaching process.

Mathematical memes can help students feel more engaged with the subject and their peers, thereby increasing motivation and reducing anxiety. Memes often contain humorous and visual elements that make mathematics seem less intimidating and more relatable. Seeing mathematical concepts in a humorous or relatable way can help students feel more confident in their mathematical capabilities by reducing the negative stigma associated with mathematics. Learning mathematics depends on many factors, such as time and quality of education. However, other factors also play an important role in the learning process (Foley, 2017). In the process of learning mathematics, motivation, anxiety, attitudes, and interests play an important role as well as cognitive characteristics (Ashcraft & Kirk, 2001; Cleary & Chen, 2009; Gunderson et al., 2018; Núñez-Peña, 2013; Pantoja, 2020; Ramirez et al., 2013; Usta & Cagan, 2020; Wang, 2015).

Anxiety is the state of feeling worried or tense with the thought that something bad will happen in our lives (Oxford Learner's Dictionaries, 2023). There are many definitions of mathematics anxiety in the literature. Mathematics anxiety refers to the feeling of fear, shyness, or nervousness that interferes with mathematics performance in academic situations or when solving mathematical problems in daily life (Ashcraft, 2002; Dowker et al., 2016). Mathematics anxiety is negatively related to mathematics performance according to many researchers (Bayırlı et al., 2021; Gunderson et al., 2018; Núñez-Peña, 2013; Ramirez et al., 2013). Mathematics anxiety can lead students to irrelevant and unwanted thoughts, which may cause students to dislike mathematics and withdraw from the course (Ramirez et al., 2018). According to Douglas (2001), high levels of anxiety are associated with low mathematics performance. Accordingly, when students experience mathematics anxiety, they tend to give unexpected reactions such as rushing and giving up because they cannot focus on the problem while solving mathematical problems. Such behaviors and reactions often lead to low mathematics performance and cause students to avoid mathematics lessons. Students with high levels of mathematics anxiety tend to make more mistakes than students with low levels of mathematics anxiety (Hassani-Zangbar & Livarjani, 2017 as cited in Yaftian & Barghamadi, 2022). Negative attitudes towards mathematics due to anxiety are an important factor affecting the emergence of mathematical abilities (Hannula, 2005). According to Tobias (1993), math anxiety causes problems such as lack of self-confidence and inability to remember. Moreover, students with good mathematics performance and high levels of mathematics anxiety tend to lose self-confidence as time goes by and are unable to exert their maximum effort (Yaftian & Barghamadi, 2022). Many researchers emphasize that mathematics anxiety is one of the factors that significantly affect students' performance and motivation (Clute, 1984; Hung et al., 2014). Many cognitive, environmental, psychological, and physical factors increase students' mathematics anxiety levels. These factors can manifest themselves in different ways such as feeling that mathematics is difficult, thinking that they are unsuccessful in mathematics, sweating, nausea, feeling nervous, not being able to meet parental expectations, being affected by the teacher's strict attitude, experiencing loss of concentration, and being ridiculed by peers (Shaikh, 2013). Looking tense and anxious, elevated heart rate, and feeling hopeless are also indicators of anxiety (Mamolo, 2022). Students may have the misconception that mathematical ability is innate and that only students with this ability can be successful. Therefore, teachers should be able to deal with such misconceptions by motivating their students (Smith, 2004). Motivation is one of the

important factors affecting mathematics teaching (Schukajlow et al., 2023) as well as being significantly effective in the learning process (Glynn et al., 2005; Martin, 2001, as cited in Yaman & Dede, 2007). According to Palmer (2007), motivated students are students who are attentive, able to take responsibility, willing to ask questions, and volunteer to answer them. Therefore, motivated students appear to be happy and enthusiastic.

The most general definition of motivation is the degree to which an individual takes action and the continuity of his/her purposeful attempt (Adler et al., 2001). Motivation is defined as the reason why someone does something or behaves in a certain way (Oxford Learner's Dictionaries, 2023). According to Ispir et al. (2011), mathematics motivation refers to students' willingness to learn mathematics and their participation in mathematical activities. Studies investigating the role and impact of mathematics motivation in mathematics learning reveal that motivation is a determinant of mathematics performance and there is a positive relationship between them (Cleary & Chen, 2009; Herges et al., 2017; Moenikia & Zahed-Babelan, 2010; Michaelides et al., 2019; Shores & Shannon, 2007; Suren & Kandemir, 2020; Xiao & Sun, 2021; Yunus & Wan-Ali, 2009; Živković et al., 2023). Therefore, mathematics motivation is one of the most important factors in the process of learning and teaching mathematics (Schukajlow et al., 2023). Therefore, teachers should enrich the educational environment to motivate their students.

Importance and Rationale of the Research

This study aims to investigate the effect of the instruction of algebraic expressions and identities assisted with mathematical internet memes on eighth-grade students' mathematics anxiety and motivation. According to Altun (2005), algebra requires abstract thinking skills. Therefore, it is an important learning domain in mathematics. The fact that mathematics is the science of abstraction shows itself fully in algebraic expressions. According to MacGregor and Stacey (1997), algebra develops students' abstract thinking and logical deduction skills. However, many studies in the field of algebra indicate that students have difficulty in this course and have difficulties understanding algebraic concepts and solving algebraic problems (Aksoy, 2019). To overcome these difficulties and teach algebra effectively, international organizations related to mathematics teaching (National Assessment of Educational Progress [NAEP], 2002; National Council of Teachers of Mathematics [NCTM], 2000) recommend the use of various methods and techniques in algebra instruction. In this study, algebra, which is a learning domain in which students have difficulty, was chosen as a learning domain because it was thought that algebra courses could be fun and interesting with memes. In the literature review, no study was found among national and international publications that examined the mathematics anxiety and motivation of eighth-grade students in a teaching process supported by the use of internet memes in algebra learning. In this context, it is thought that this study will contribute to the literature. On the other hand, universal studies indicate that memes created and used by users in technology and computer-based communication environments are an important part of today's digital civilization. In Turkey, it is seen that very few studies have been conducted on caps and other memetic types as memetic concepts (Yılmaz, 2017). As a result of the search with Dergipark Academic, three articles were found, and as a result of the search with the National Thesis Center of the Presidency of the Council of Higher Education, two master's theses were found. These studies indicate that memes are fun and valuable.
Studies demonstrate that mathematics anxiety and motivation are two of the important factors affecting

mathematics learning (Clute, 1984; Glynn et al., 2005; Hung et al., 2014; Suinn & Edward, 1982; Tobias, 1993; Yaman & Dede, 2007). In the studies on memes, it is seen that positive results have emerged in different fields (e.g., medicine, molecular biology, English language teaching) and the reflections are positive in the feedback received from students (e.g., Antón-Sancho, 2022; de Oliveira, 2022; Karadeniz Kayalı, 2021; Kristianti, 2021; Kyrpa et al., 2022; Purnama, et al., 2017; Scardina, 2017; Subbiramaniyan et al., 2022). In these studies, learners stated that the use of memes was stress-reducing, fun, facilitating learning, engaging, and motivational by adding humor to learning. Researchers emphasize that it is also important to see the results of using memes in different disciplines (Antón-Sancho, 2022; Kristianti, 2021; Scardina, 2017). Damian and Duguid (2004) stated that teaching mathematical concepts by associating them with multimedia and fun activities helps in learning the concepts and connecting them with daily life (as cited in Hung et al., 2014). As a result of the literature review conducted by us, it was decided to conduct this study since no study was found in the field of mathematics teaching with the use of memes in algebra courses with middle school students. Based on the idea that integrating mathematical memes as supportive tools into instruction will help students increase their motivation and reduce their anxiety, this study is thought to contribute to the literature.

The Research Problem and Sub-Problems

What is the effect of mathematics instruction supported by mathematical internet memes on eighth-grade students' mathematics anxiety and motivation?

1. Is there a statistically significant difference between the scores obtained from the mathematics motivation scale by the students in the experimental group where internet memes-supported instruction was implemented, and the scores obtained from the mathematics motivation scale by the students in the control group where the current curriculum with traditional instruction (MoNE, 2018) was implemented?
2. Is there a statistically significant difference between the scores obtained from the mathematics anxiety scale by the students in the experimental group where internet memes-supported instruction was applied, and the scores obtained from the mathematics anxiety scale by the students in the control group where the current curriculum with traditional instruction (MoNE, 2018) was applied?
3. Is there a statistically significant difference between the pre-test and post-test scores of the students in the experimental group where mathematical internet memes-supported instruction was implemented for mathematics anxiety and mathematics motivation scales?
4. Is there a statistically significant difference between the pre-test and post-test scores of the students in the control group in which the application was made according to the current curriculum with traditional instruction (MoNE, 2018) for mathematics anxiety and mathematics motivation scales?
5. What is the relationship between mathematics motivation and mathematics anxiety of eighth-grade students?

Method

In this study, a pretest-posttest quasi-experimental model with a control group was used. According to this model, measurements are made before and after the application (Büyüköztürk et al., 2013). In this study, it was deemed

appropriate to use this method since the effect of using mathematical internet memes as supportive elements on students' mathematics anxiety and mathematics motivation in the eighth grade was examined. The experimental group (EG) and control group (CG) were used in the study. The experimental design of the study is given in Table 1.

Table 1. Experimental Design of the Study

	Pre Test			Post Test	
	MAS	MMS	Experiment	MAS	MMS
EG (N=19)	✓	✓	Instruction Supported by Internet Memes within the Scope of the Current Mathematics Curriculum	✓	✓
CG (N=15)	✓	✓	Instruction within the Scope of the Current Mathematics Curriculum	✓	✓

MAS: Mathematics Anxiety Scale; MMS: Mathematics Motivation Scale

In the study, both between-group (experimental and control) and within-group (pretest-posttest) measurements were made with appropriate data analysis techniques (Büyüköztürk, 2019). The independent variable of the study is the instruction supported by mathematical internet memes, and the dependent variables are students' mathematics anxiety levels and mathematics motivation levels. In the current Mathematics Curriculum (MoNE, 2018), EG and CG were applied in line with the outcomes in the Algebraic Expressions and Identities topic of the Algebra learning domain. These objectives are as follows: (1) Understand simple algebraic expressions and write them in different forms. (2) Multiplies algebraic expressions. (3) Explains identities with models. (4) Factors algebraic expressions.

Participants

The study group of this research consists of eighth-grade students of a public middle school affiliated with the Ministry of National Education in a province of the Western Black Sea Region in Turkey. The convenience sampling method was used in the study. EG and CG were determined by lottery using ready-made groups. Initially, EG consisted of 24 students and CG consisted of 20 students. However, 5 students each in EG and CG did not attend the lessons regularly. Therefore, the data of these students were not included in the analysis. Accordingly, the data from 19 students in EG and 15 students in CG were included in the analysis. Students participated in the study voluntarily.

In terms of research ethics, codes were used instead of the real names of the students participating in the study. There are 6 eighth grade classes in the school. Since the convenience sampling method was used in the study, the classes of the mathematics teacher who said that she could help us in the study and who had at least two eighth-grade classes were included in the study. The fact that the teachers of the classes where the research was conducted were the same is also important in terms of not affecting the results of the research. In addition, the analysis of EG and CG's pre-test scores from the mathematics anxiety and mathematics motivation scales showed that the

two groups were equivalent in this context. In the study, EG received an instruction supported by mathematical internet memes. In the study, an instruction supported by mathematical memes was conducted for EG. For CG, on the other hand, the approach recommended by the mathematics curriculum was conducted with an explanatory approach. While the instruction was provided to EG by the researchers, CG was administered by the current teacher of the course with the normal procedure (explanatory approach). No intervention was made to CG.

Data Collection

"MAS" was used to measure the effect of the applied method on eighth-grade students' mathematics anxiety levels and "MMS" was used to measure its effect on mathematics motivation levels.

Mathematics Anxiety Scale (MAS)

In the study, the Likert-type 10-item "MAS" developed by Bindak (2005) was used to determine the mathematics anxiety levels of eighth-grade students. In the scale developed by Bindak (2005) to measure the mathematics anxiety levels of primary and middle school students, 9 of the items have positive and 1 has a negative item radix. The scale is a 5-point Likert-type scale consisting of "always", "usually", "sometimes", "seldom" and "never" options. Positive items in the scale are graded as 1-2-3-4-5 and negative items as 5-4-3-2-1. The Cronbach Alpha reliability coefficient of this scale was calculated as 0.84. In the 10-item scale, the highest score that can be obtained from each item is 5 and the lowest score is 1. A score close to 5 means that students' anxiety towards mathematics is high. "MAS" is given in Appendix 1.

Mathematics Motivation Scale (MMS)

In the study, the "Motivation Scale for Mathematics Classes" developed by Üzel et al. (2018) for middle school students with a Cronbach's Alpha reliability coefficient of .88 was used to measure eighth-grade students' motivation toward mathematics courses. The scale consists of 26 items, 18 of which are positive and 8 of which are negative. The scale is a 5-point Likert-type scale consisting of "strongly agree", "agree", "undecided", "disagree" and "strongly disagree" options. Positive items in the scale are scored as 5-4-3-2-1 and negative items are scored as 1-2-3-4-5. The highest total score that can be obtained from the scale is 98 and the lowest score is 58. A high score means that the student's motivation towards mathematics is high. "MMS" is given in Appendix 2.

The Process of Designing Mathematical Memes

The process of designing mathematical memes refers to the process of connecting mathematical concepts with humorous events in the meme base in order to create interesting and entertaining content. The process of designing mathematical memes was carried out in a cyclical structure. Each stage in the cycle is interrelated and supports each other. The cyclical structure in the process of designing the mathematical memes used in this study is given in Figure 5.

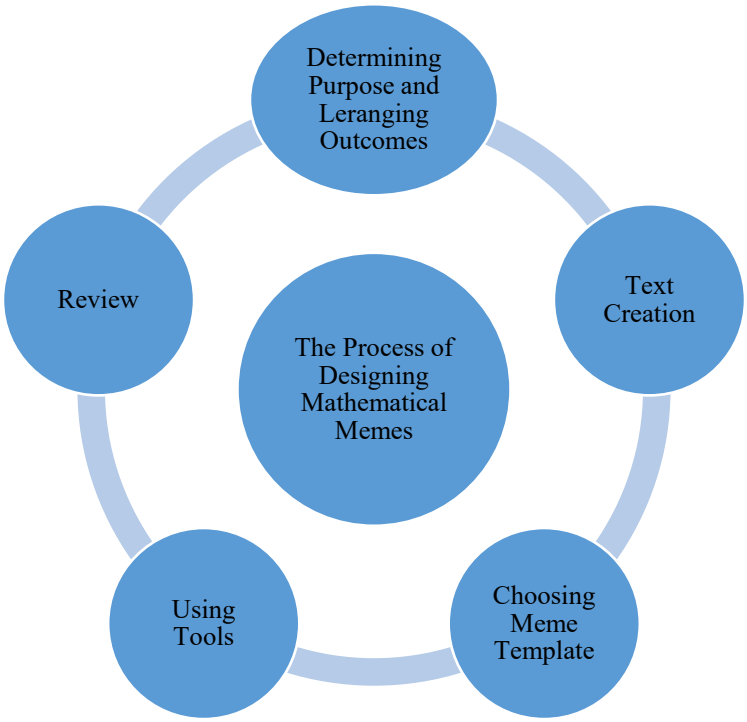

Figure 5. Process Cycle for Designing Mathematical Memes

Table 2 describes what was done at each stage of the design cycle of the mathematical memes.

Table 2. Stages of the Design Cycle of the Mathematical Memes

Stages of the Mathematical Memes Design Process Cycle	**What is done in the phases**
Determining Purpose and Learning Outcomes	• Algebra learning domain/ algebraic expressions, identities, and factorization. • Helping to understand the concept within the framework of the learning outcome. • Drawing attention to the misconceptions identified in the relevant literature within the framework of the learning outcome. • Drawing attention to mathematical formulas for the learning outcome • Initiating, supporting, and sustaining class discussions
Text Creation	• Writing concepts, formulas, and mathematical expressions within the framework of the learning outcome using humorous elements by the selected meme base.
Choosing Meme Template	• Benefit from students' interests • Prioritizing the selection of characters that students are generally interested in and like • Examining meme templates within the framework of the learning

Stages of the Mathematical Memes Design Process Cycle	What is done in the phases
	outcome • Deciding on the appropriateness of meme templates for students' level • Deciding on the meme template that can be used according to the learning outcome
Using Tools	• Utilizing the Imgflip.com website • Adding appropriate texts to the selected meme templates • Analyzing and editing texts in terms of writing style, size, and visual aspects
Review	• Reviewing the memes designed in line with the student opinions by conducting a pre-application with a group of students at the same socio-economic level outside the research group • Checking the appropriateness of the designed memes to the student level • Controlling the harmony of visual and text elements with the meme • Checking whether the mathematical idea intended to be given in memes is clear and whether it is expressed clearly • Deciding which memes are not understood, liked, and interesting by the students and which ones should not be used • Identifying memes whose design is appropriate, understandable, and engaging for students and deciding on their use in the actual implementation

Imgflip, an online meme generation platform, was used to design mathematical memes. Imgflip is an online platform that allows users to create and share their memes. There are many meme templates on the site and users can create fun content by adding their text, images, or GIFs. Key features of the site include meme creation tools, image and GIF editing options, and interaction and sharing between users. Users can also join the Imgflip community to share memes they have designed, vote on shared memes, and interact with other users' content.

Examples of Mathematical Memes Used in the Study

Figure 6 shows the definition of "identity" in the meme "Kanye's Notepad". Figure 7 is the "They're The Same Picture" meme. The meme in Figure 7, is aimed to discuss the idea of under which conditions the mathematical expressions given can be equal or not. It was tried to convey in an entertaining way which concepts the expressions given in both conditions evoke. In the meme in Figure 7, it is investigated whether the expressions $(x+2)^2$ and x^2+4x+4 have the same value for $x=7$. In the rest of the class, after this meme is shown, it is discussed whether the expression $(x+2)^2 = x^2+4x+4$ is true only for $x=7$. Students are asked whether this meme can be prepared for every value that x can take. If it can be prepared, it is also discussed whether these expressions can be represented by a different meme. For example, if the given expressions are identities, the "Spiderman" meme can be used.

With the "Change my mind" meme in Figure 8, students are expected to think about the given identity and create a discussion environment. This meme is intended to make students think about whether the area of a square with one side of length a+b units is a2+2ab+b2. This meme is expected to foster interaction between students. The "Sad Cat" meme in Figure 9 is designed to draw attention to common mistakes made by students. This meme was used to metaphorically represent students forgetting the term 2ab when doing the expansion $(a+b)^2 = a^2+2ab+b^2$ and writing $(a+b)^2=a^2+b^2$, i.e. forgetting the "important thing which is 2ab". With this meme, it is thought that discussing the expansion of a perfect square expression will increase the memorability of identities.

Figure 6. Kanye's Notepad

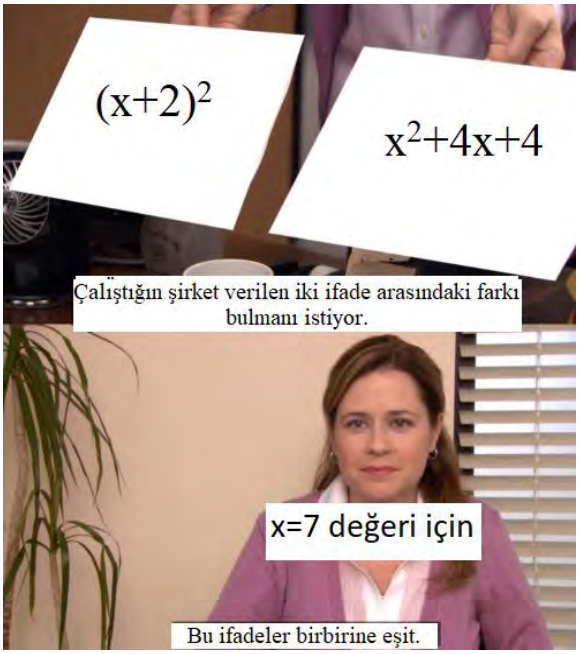

Figure 7. They're The Same Picture

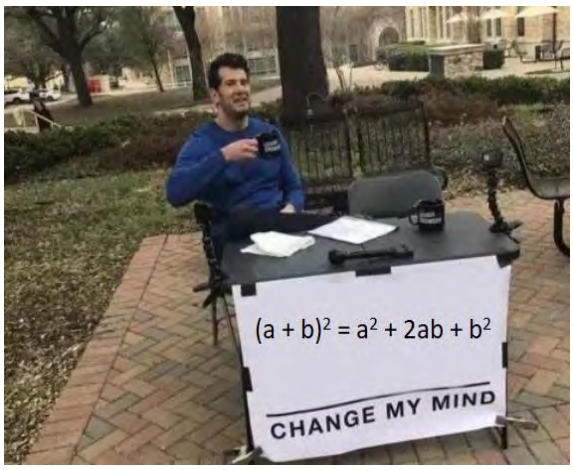

Figure 8. Change My Mind

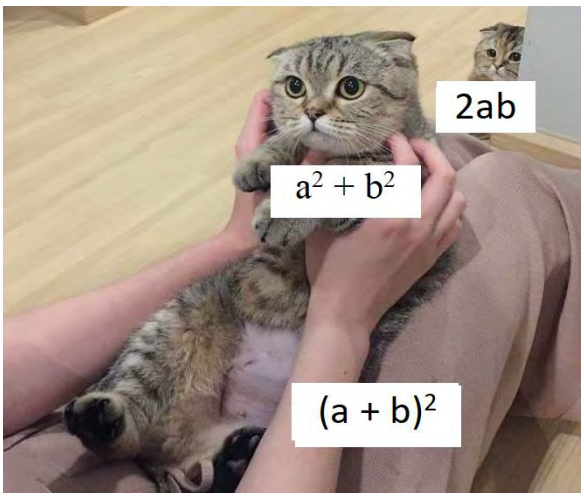

Figure 9. Sad Cat Meme

If there is a common factor in each term of a polynomial expression, the expression is bracketed to find the factors. The memes in Figure 10 and Figure 11 are designed to help students explore the link between the distributive property of multiplication on addition and factorization.

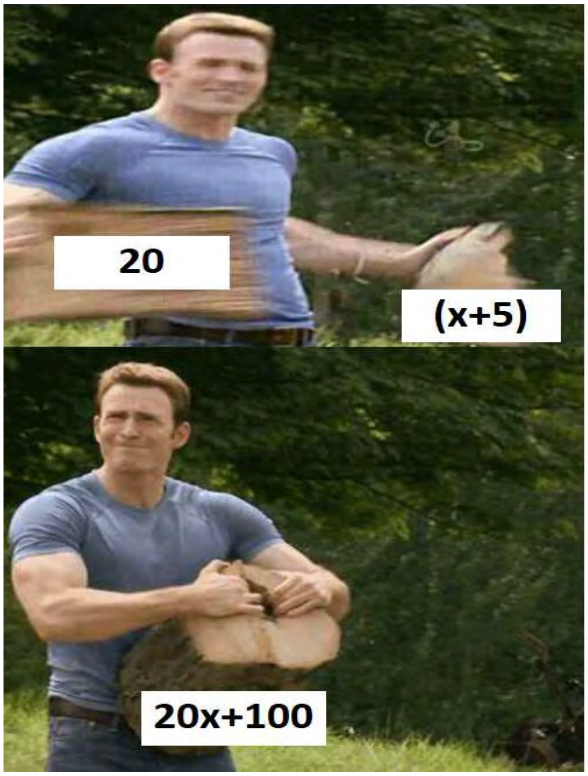

Figure 10. Reversed Captain America

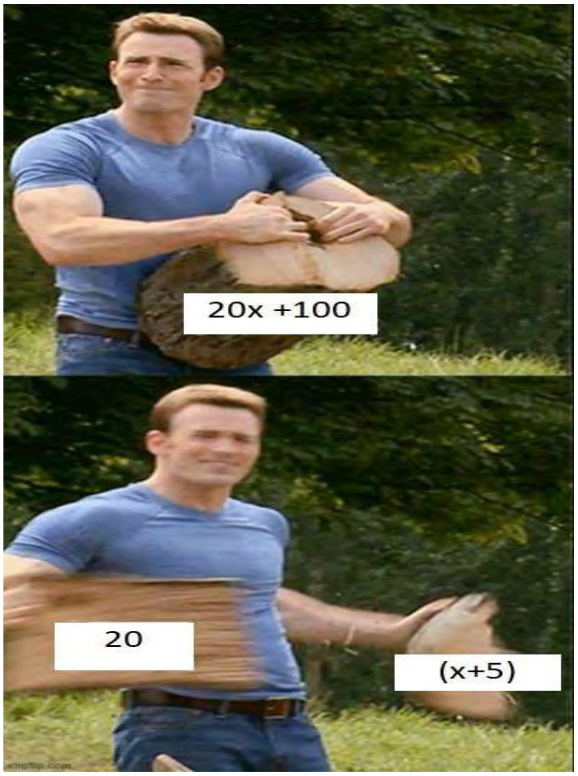

Figure 11. Captain America

Experimental Stage

EG and CG were used in the study. There were 19 students in EG and 15 students in CG. Both groups were instructed within the scope of the eighth-grade algebraic expressions and identities in the Mathematics Curriculum (2018). In the current curriculum, it is recommended to use teaching methods and techniques based on the constructivist approach such as the explanatory lecture method, using mathematical activities and problem-solving (Mathematics Curriculum, MoNE, 2018).

In implementation, Ausubel's (1963) method of "meaningful learning through reception" from the learner's perspective and "expository teaching" from the teacher's perspective, which is one of the approaches envisaged by the current mathematics curriculum, was used. This method is related to the learners' making meaning from the material presented (Ausubel, 2000). In this period, the teacher needs to select and organize the content of the lesson, make it meaningful for the learner, and present and explain it to the student with various materials. For EG, mathematical memes appropriate to the subject were designed in line with the relevant learning outcomes in the current curriculum, and these memes were used as teaching supplementary. For CG, instruction was made within the framework of the current curriculum in line with the same learning outcomes. The difference between the instruction to EG and CG is that mathematical memes supported the instruction in EG.

EG Implementation Period

EG students were informed about internet memes and how the study would be conducted before starting the

implementation. Internet memes-supported instruction was conducted by one of the researchers. Mathematical memes prepared by the researchers were used in the instruction. A two-week implementation lasting 8 hours was applied to EG. This implementation was carried out two days a week, two lesson hours in one day on two different days. At the beginning of the first lesson, the researcher asked EG students whether they had any knowledge about "internet memes" and if so, what they knew. It was understood from the answers that they had no knowledge about this term and the researcher showed the students examples of internet memes related to daily life. The students were asked to comment on these memes and were given information about them. In the lessons, students were given activities to fill in the blanks in the memes and were asked to correctly place algebraic expressions in the blanks. Secondly, students were given algebraic expressions together with verbal expressions and asked to place these expressions in memes in a meaningful way. Students were asked to "provide information about their answers", "explain the reasons for their responses" and "explain what is meant by the meme", and in this way, a discussion environment was created.

Similarly, various mathematical memes were used for identities, factorization, and multiplying algebraic expressions. Students were asked to comment on these memes by asking various questions. In this way, mathematical memes were linked to the topic. For example, in the "Sad Cat" meme, students were expected to reach the main idea of "forgetting something important". It is apparent that students tend to forget to write the middle term 2ab in the expansion of the identity $(a+b)^2=a^2+2ab+b^2$ or have a misconception about it. For this reason, the "Sad Cat" meme was intended to draw attention to the middle term.

After the activities, students were given study sheets containing various meme templates. Students were asked to create and explain their own mathematical memes related to the subject with these templates. While the implementation continued in this way, students were also shown memes containing incorrect mathematical information. The purpose of this is to create a vivid discussion environment with memes, to enable students to decide on the error together, and to help them find the correct idea. In this way, students also exchanged ideas on how to correct an error in the meme. The implementation in EG continued in this manner until the end of the topic. At the end of the instruction, MAS and MMS were applied to EG for the second time as a post-test and the procedure was completed. The difference between the EG and CG implementations was that the instruction in EG was supported by mathematical memes.

CG Implementation Period

An implementation was carried out for CG within the framework of the recommended activities in the Mathematics Curriculum (MoNE, 2018). For the learning outcome "Understands simple algebraic expressions and writes them in different forms", "Matching the same algebraic expressions with each other" and "Matching verbally given expressions with their algebraic expressions" activities; for the learning outcome "Multiplies algebraic expressions", "Matching algebraic expressions" activity; and for the learning outcome "Explains identities with models", "Showing models with the help of A4 paper" activities were performed. In addition, problem-solving activities were conducted for the learning outcome "Factorize algebraic expressions" and other learning outcomes. At the end of the implementation, CG was applied to the MAS and MMS as a post-test for the

second time and the procedure was completed.

Data Analysis

Analysis of the Data Obtained from MAS and MMS

The data obtained in the research were analyzed by using methods based on a quantitative approach. The independent variable of the study was the instruction supported by mathematical memes and the dependent variables were the scores of the students on the MAS and MMS. SPSS 22.00 statistical program was used to analyze the data. If the number of participants is few, nonparametric statistical methods should be used instead of parametric methods to analyze the data (Büyüköztürk, 2019). Due to the insufficient number of students in the groups, the data were analyzed with the Mann-Whitney U-test and Wilcoxon Signed Ranks Test, which are nonparametric statistics tests (Büyüköztürk, 2011, 2019). In addition, according to Cohen's (1992) small-medium-large effect size classification, the effect size value r of the difference between the groups was calculated with the formula $r = \frac{Z}{\sqrt{n}}$ (Corder & Foreman, 2009, as cited in Cevahir, 2020; Karadimitriou et al., 2018). The effect sizes of the r coefficient were classified as small effect sizes for values less than r=0.30, medium effect sizes for values between r=0.30 and 0.50, and large effect sizes for values of r=0.50 and above.

A correlation analysis was carried out to examine whether there was a statistically significant relationship between the scores obtained from MAS and MMS. Since the data were not normally distributed, correlation analysis was performed through Spearman rank correlation. A correlation coefficient between 0.00 and 0.25 indicates a poor relationship between the two variables, a correlation coefficient between 0.26 and 0.49 indicates a poor relationship between the two variables, and a correlation coefficient between 0.50 and 0.69 indicates a moderate relationship (Kalaycı, 2010).

Findings

In this part of the study, the findings of the sub-problems are presented and interpreted.

Findings and Comments on the First Sub-problem

Mann-Whitney-U Pre-test Analysis Results of EG and CG regarding the Scores they obtained from the MMS

The Mann Whitney-U test was employed to examine whether there was a statistically significant difference between the pre-test scores of EG students and CG students' pre-test scores on the MAS and the finding on whether there was a significant difference is given in Table 3.

Table 3. Mann Whitney U Test MMS Pre Test Analysis of EG and CG

Group	N	Mean	Sum	U	p
EG	19	19.05	362.00	113.000	.306
CG	15	15.53	233.00		

Table 3 presents the results of the pre-test analysis of EG and CG's mathematics motivation. From Table 3, it is observed that there is no significant difference between EG and CG's mathematics motivation pre-test scores (U=113.000, p>.05).

Mann-Whitney-U post-test analysis results of EG and CG regarding the scores they obtained from the MMS

The Mann Whitney-U test was employed to examine whether there was a statistically significant difference between the post-test scores of EG students and CG students' post-test scores on the MMS and the finding on whether there was a significant difference is given in Table 4.

Table 4. Mann Whitney U Test MMS Post Test Analysis of EG and CG

Group	N	Mean	Sum	U	p
EG	19	22.42	426.00	49.00	.001
CG	15	11.27	169.00		

Table 4 presents the results of the analysis according to the post-test scores of EG and CG students. Accordingly, at the end of the quasi-experimental study, it was revealed that there was a significant difference between the post-test scores of EG students from the MMS post-test of the instruction supported by mathematical memes and the post-test scores of CG students from the MMS post-test of the instruction based only on the current curriculum (U=49.00, p<.05). The effect size of this difference, which was determined as Z=-3,245 and n=34, was r=0.55, indicating that the difference had a large effect and 30% of the total variance was explained by the independent variable which is instruction supported by mathematical memes (r=0, 55, r2=0.30). When the rank means are taken into consideration, it is understood that EG students who received instruction supported by internet memes had higher math motivation than CG students. This finding indicates that the instruction supported by mathematical internet memes was effective in increasing EG students' mathematics motivation.

Findings and Comments on the Second Sub-Problem

Mann-Whitney-U Pre-test Analysis Results of EG and CG regarding the Scores they obtained from the MAS

The Mann Whitney-U test was employed to examine whether there was a statistically significant difference between the pre-test scores of EG students on the MAS and the pre-test scores of CG students on the MAS, and the finding on whether there was a significant difference is given in Table 5.

Table 5. Mann Whitney U Test MAS Pre-Test Analysis of EG and CG

Group	N	Mean	Sum	U	p
EG	19	20.18	383.50	91.500	.076
CG	15	14.10	211.50		

Table 5 presents the results of the pre-test analysis of EG and CG's mathematics anxiety levels. From Table 4, it is seen that there is no significant difference between EG and CG's math anxiety pre-test scores (U=91.500, p>.05).

Mann-Whitney-U Post-test Analysis Results of EG and CG regarding the Scores they obtained from the MAS

The Mann Whitney-U test was employed to examine whether there was a statistically significant difference between the post-test scores of EG students on the MAS and the post-test scores of CG students on the MAS, and the finding on whether there was a significant difference is given in Table 6.

Table 6. Mann Whitney U Test MAS Post-Test Analysis of EG and CG

Group	N	Mean	Sum	U	p
EG	19	18.74	356.00	119.00	.430
CG	15	15.93	239.00		

Table 6 presents the results of the analysis according to the post-test scores of EG and CG students on the MAS. Accordingly, at the end of the quasi-experimental study, it is revealed that there is no significant difference between the post-test scores of EG students and CG students on the MAS post-test ($U=119.00$, $p>.05$). This finding suggests that the mathematical internet memes-supported intervention was not effective in eliminating EG students' math anxiety.

Findings and Comments on the Third Sub-Problem

Results of Wilcoxon Signed Rank Test analysis of EG's scores on the MMS

The results of the Wilcoxon signed rank test regarding whether there is a statistically significant difference between the pre-test and post-test scores of EG, in which the instruction supported by mathematical internet memes was carried out, are given in Table 7.

Table 7**.** Results of Wilcoxon Signed Rank Test analysis of EG's pre-test and post-test scores on the MMS

Post Test- Pre Test	N	Mean	Sum	z^*	p
Negative rank	1	2.00	2.00	-3.744	.000
Positive Rank	18	10.44	188.00		
Equal	0	-	-		

* Based on negative ranks

The results of the analysis in Table 7 indicate that there is a significant difference between EG's scores on the MMS before and after the implementation ($z=-3.744$, $p<.05$). According to Table 7, it can be concluded that the instruction supported by mathematical memes had a significant effect on increasing the mathematics motivation of EG students.

Results of Wilcoxon Signed Rank Test analysis of EG's scores on the MAS

The results of the Wilcoxon signed ranks test regarding whether there is a statistically significant difference between the pre-test and post-test scores of EG, in which instruction supported by mathematical internet memes

was carried out, are given in Table 8.

Table 8. Results of Wilcoxon Signed Rank Test Analysis of EG's Pre-test and Post-test Scores on the MAS

Post Test- Pre Test	N	Mean	Sum	z*	p
Negative rank	12	9.17	110.00	-2.190	.029
Positive Rank	4	6.50	26.00		
Equal	3	-	-		

* Based on positive ranks

The results of the analysis in Table 8 demonstrate that there is a significant difference between EG's scores on the MAS before and after the implementation (z=-2,190, p<.05). According to Table 8, it can be concluded that the instruction supported by mathematical memes had a significant effect on reducing EG students' math anxiety levels.

Findings and Comments on the Fourth Sub-Problem

Results of Wilcoxon Signed Rank Test analysis of CG's scores on the MMS

The results of the Wilcoxon signed ranks test regarding whether there was a statistically significant difference between the pre-test and post-test scores of CG, in which the instruction was implemented only according to the current curriculum, are given in Table 9.

Table 9. Results of Wilcoxon Signed Rank Test Analysis of CG's Pre-test and Post-test Scores on the MMS

Post Test- Pre Test	N	Mean	Sum	z	p
Negative rank	5	9.30	46.50	-.769*	.442
Positive Rank	10	7.35	73.50		
Equal	0				

* Based on negative ranks

The results of the analysis in Table 9 show that there was no significant difference between CG students' scores on the MMS before and after the instruction (z=-.442, p>.05). According to Table 8, it can be concluded that the instruction according to the current curriculum did not affect increasing CG students' mathematics motivation.

Results of Wilcoxon Signed Rank Test Analysis of CG's Scores on the MAS

The results of the Wilcoxon signed ranks test regarding whether there is a statistically significant difference between the pre-test and post-test scores of CG, in which the implementation was made only according to the current curriculum, are given in Table 10. The results of the analysis show that there is no significant difference between CG students' scores on the MAS before and after the instruction (z=-,740, p>.05). According to Table 10, it can be concluded that only the implementation according to the current curriculum did not affect eliminating CG students' mathematics anxiety.

Table 10. Results of Wilcoxon Signed Rank Test Analysis of CG's Pre-test and Post-test Scores on the MAS

Post Test- Pre Test	N	Mean	Sum	z*	p
Negative rank	5	9.40	47.00	-.740	.459
Positive Rank	10	7.30	73.00		
Equal	0	-	-		

* Based on negative ranks

Findings and Comments on the Fifth Sub-Problem

Results of the Correlation Analysis between the Scores obtained from the MAS and the MMS

Table 11 presents the results of the correlation analysis between the scores obtained by eighth-grade students from the MAS and the MMS.

Table 11. Results of the Correlation Analysis between the Scores obtained from the MAS and the MMS

Variables	MMS	MAS
MMS	1	.600
MAS	.600	1

As a result of the Spearman rank correlation analysis carried out to examine whether there is a statistically significant relationship between the eighth-grade students' scores on the MMS and their scores on the MAS, [r(34) =.600;p= < .05] was calculated. Based on this finding, it is concluded that there is a negative, moderate and significant relationship between the eighth-grade students' scores on the MAS and their scores on the MMS.

Discussion and Conclusion

In this research in which experimental and control groups were used, the effect of the instruction supported by mathematical memes on eighth-grade students' mathematics motivation and mathematics anxiety was examined. As a result of the implementation, it was revealed that the math motivation of the experimental group students increased compared to the control group. It was found that there was a statistically significant difference between the scores of the experimental group students and the control group students on the mathematics motivation scale in favor of the experimental group (U=49.00, p<.05). The effect size of this difference in the experimental group was found to be r=0.55 and 30% of the variance was explained by the independent variable, instruction supported by mathematical memes. From this finding, it was concluded that the instruction supported by mathematical memes was effective in increasing students' mathematics motivation levels.

Based on within-group analyses, it was observed that the implementation in the experimental group made a significant difference in increasing mathematics motivation, whereas there was no significant difference in the control group, in which mathematical memes were not used and instruction was carried out only according to the existing curriculum. Hence, it can be concluded that the use of mathematical memes as a supportive element for teaching is effective in increasing students' mathematics motivation levels. It can be stated that mathematical

internet memes attract students' attention and make the lesson more fun and therefore have an effect on increasing students' mathematics motivation. One of the studies supporting the result of our research that the instruction supported by the use of mathematical memes increased students' mathematics motivation conducted by Van (2021). Van (2021) stated that the use of mathematical memes in mathematics teaching significantly increases students' curiosity and motivates them. Based on this result, he stated that mathematical memes can be a solution to students' low mathematics motivation. In this context, the results of the study conducted by Van (2021) are similar to the results of our research. The fact that memes make it easier to code in the mind and have an interesting feature may have been effective in the emergence of this result. According to Bini et al. (2020), a mathematical meme makes it easier to encode a verifiable mathematical expression in the mind. This is because memes combine mathematical expression in a humorous way with the help of the meme base and use a recognizable framework. The meme base and the framework it uses encourage students to think critically like riddles or puzzles to help them make connections between mathematical concepts. The "Spider-Man" and "Tom and Jerry" characters used in our research are two of the examples where a recognizable framework is presented by combining it with humor. The "Spider-Man" meme was designed to facilitate the students' coding in their minds of the expansion of a perfect square expression in such a way as to evoke the feeling of the reflection of the spider man in the mirror and thus to think about the equality of two algebraic expressions. Similarly, in the mathematical meme designed by using characters from the cartoon "Tom and Jerry", the mental coding of the idea of factoring an algebraic expression was combined with humor. It can be argued that the memes used in the study facilitated coding in the mind and that the memes were interesting and effective in increasing students' mathematics motivation.

One of the purposes of using memes in the implementation was to initiate a discussion about the subject or concept and to reveal potential ideas and critical thoughts. It can be stated that allowing students to express themselves comfortably in the discussion environment increased their interest in the lesson and thus had a positive effect on their motivation. Keehn's (2023) argument that memes have the potential to create a productive space that can help create a discussion environment supports this conclusion. Karadeniz Kayalı's (2021) view that memes increase students' interest in the lesson and that teaching practices supported by memes can be a solution to students' low motivation and the results of Purnama et al.'s (2017) study are in line with the results of our research. The findings of Antón-Sancho (2022), who stated that memes increase students' interaction and motivation, support the findings of our study. In our research, it can be concluded that implementing an instruction supported by memes and students trying to find the relationships in the memes as if they were solving a puzzle encouraged them to learn mathematics better and thus increased their motivation. As a conclusion of our research, it is thought that it is appropriate to use internet memes not as a teaching tool alone, but as a tool that supports teaching and increases student interaction, together with appropriate teaching methods/techniques in lessons. This conclusion is similar to the studies of Bini and Robutti (2019) and Reddy et al. (2020).

Subbiramaniyan et al. (2021), in their study using memes in medical education, state that memes arouse interest in students, increase peer interaction, simplify complex information and create a positive learning environment. Similarly, Kristianti (2021) states that memes make concepts easier to understand and that expressing a difficult problem with a single meme can eliminate difficulties, so a learning environment that includes memes reflects positively on learning. The views of Subbiramaniyan et al. (2021) and Kristianti (2021) support the conclusion

that the instruction supported by mathematical memes was effective in the emergence of the result that it increased students' mathematics motivation. The results of the studies in the literature (Antón-Sancho, 2022; Scardina, 2017; Tu et al., 2022) that the use of memes increases students' motivation, creates a discussion environment, and increases students' interest in the lesson are in parallel with the results of our research in this context. It is observed that internet memes are also used in English language teaching (de Oliveira, 2022; Harshavardhan, 2019; Kyrpa et al., 2022; Purnama et al., 2017) and biology (Tu et al., 2022) and increase students' motivation. In this context, it is reasonable to say that the result that the use of memes as supporters in our study is effective in increasing students' motivation is in line with the results of similar studies in other fields.

In our research, it was revealed that there was no significant difference in favor of the experimental group in terms of eliminating mathematics anxiety in the analysis between the groups in the instruction supported by mathematical memes ($U=119.00$, $p>.05$). From this finding, it can be concluded that the experimental group, in which instruction supported by mathematical internet memes was implemented, was not effective in eliminating the mathematics anxiety of the students. However, within-group analyses showed that there was a significant difference between the pre-test and post-test scores of the experimental group students on the mathematics anxiety scale in favor of the post-test. This indicates that the instruction supported by mathematical memes was effective in eliminating the mathematics anxiety of the experimental group students. From this point of view, it was revealed that the use of mathematical internet memes as supportive tools was effective in eliminating the mathematics anxiety of the experimental group students. This result is in line with the study of Harshavardhan et al. (2019) in the field of English education.

On the other hand, in the control group, in which mathematical memes were not used and instruction was carried out only according to the current curriculum, it was observed that there was no significant difference between the scores obtained for mathematics anxiety before and after the within-group analysis. Based on this finding, it can be concluded that the implementation of the current curriculum was not effective in eliminating students' mathematics anxiety. Therefore, the fact that there was a significant difference in favor of the post-test in reducing the mathematics anxiety of the experimental group students in which instruction supported by mathematical memes was carried out as supportive to the current curriculum can be accepted as an indicator that mathematical memes can be used as supportive in courses. In the studies conducted by Christiansen (2021), Mendoza (2021) and Nurhasanah et al. (2022) during the Covid 19 pandemic period, it was observed that students' math anxiety levels increased. On the other hand, based on the results of her study, Karadeniz Kayalı (2021) stated that teaching supported by memes can be a solution to eliminate students' high levels of anxiety. In our study, there was no significant difference between the experimental and control groups in terms of mathematics anxiety in the intergroup analyses. However, in within-group analyses, it was found that mathematics anxiety decreased significantly in favor of the experimental group compared to the pre-implementation period. According to the results of intergroup analysis, the results of our study are not similar to the studies conducted by Christiansen (2021), Mendoza (2021), Nurhasanah et al. (2022) and Karadeniz Kayalı (2021). However, in the context of the positive effect of the instruction supported by mathematical memes within the experimental group, Karadeniz Kayalı's (2022) views that instruction with memes can be a solution for the elimination of high anxiety support the result of our study.

The last sub-problem of the research is to examine whether there is a statistically significant relationship between the scores obtained from mathematics motivation and mathematics anxiety scales. Spearman's rank correlation analysis was employed to examine whether this relationship existed. As a result of the analysis [r (34)=.600;p= < .05], it was revealed that there was a negative and moderately significant relationship between the scores obtained from both scales. This result is in line with the fact that mathematics anxiety is one of the factors that significantly affect students' mathematics motivation (Clute, 1984; Hung et al., 2014). When students experience high levels of mathematics anxiety, they tend to distant themselves from the lesson (Ramirez et al., 2018), have problems focusing on the lesson, and tend to react with behaviors such as rushing and giving up (Douglas, 2001). Therefore, such negative tendencies decrease the student's mathematics motivation and prevent the student from putting maximum effort (Yaftian & Barghamadi, 2022). While such reactions lead students to avoid mathematics lessons, students with high levels of mathematics anxiety tend to make more mistakes than students with low levels of mathematics anxiety (Hassani-Zangbar & Livarjani, 2017 as cited in Yaftian & Barghamadi, 2022). On the other hand, highly motivated students are eager, interested, responsible, and willing to ask and answer questions (Palmer, 2007). The views expressed in these studies are in line with the results of our study.

Recommendations

The use of mathematical internet memes in mathematics teaching does not eliminate the problem of learning abstract concepts (Reddy et al., 2020), but it can be recommended to be used as a supportive element in teaching. In this study, it was revealed that the use of mathematical internet memes as supportive structures in teaching increased students' mathematical motivation. The results of this study, which was conducted with a small sample, cannot be generalized, but may support the idea of conducting large-scale studies. Therefore, it is hoped that the results of this study will contribute to the related literature. This research was conducted in a 2-week period with 8 class hours. It is observed that this period is not sufficient to eliminate students' math anxiety. Mathematics anxiety is an important factor that causes students to dislike and disengage from the course (Ramirez et al., 2018). Therefore, it may be recommended to conduct long-term studies examining the effects of using mathematical memes on students' mathematics motivation and mathematics anxiety and to compare the results with the results of this study.

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Ethics Committee Approval

This research has ethics committee permission obtained from Bartın University Social and Human Sciences Ethics Committee dated 30.12.2022 and numbered E-23688910-050.01.04-2300000137.

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Appendix 1. Mathematics Anxiety Scale (in Turkish)

	İfadeler	Her zaman	Çoğu zaman	Ara sıra	Hemen hemen hiç	Hiçbir zaman
1	Matematik denince aklıma karmaşık, anlaşılmaz şeyler gelir.					
2	Matematik derslerinde tahtaya kalkmak bana zor geliyor.					
3	Matematik derslerinde bana daima soru sorulacağından endişelenirim.					
4	Şimdi matematik anlıyorum fakat giderek zor olacağından endişe duyuyorum.					
5	Matematik sınavlarından korktuğum kadar diğer hiçbir şeyden korkmam.					
6	Matematik yüzünden sınıfımı geçemeyeceğimden korkuyorum.					
7	Matematik dersine girdiğimde kendimi korkudan büzülmüş hissederim.					
8	Matematik sınavlarına nasıl çalışacağımı bilemiyorum.					
9	Benim için matematik çok eğlencelidir.					
10	Matematik dersinde soru sormaktan korkuyorum.					

Mathematics Anxiety Scale (in English)

	Statements	Always	Most of the time	Sometimes	Hardly ever	Never
1	When I think of math, I think of complicated, incomprehensible things					
2	I find it difficult to go up to the board during math classes.					
3	I always worry that I will be asked questions during math classes.					
4	I understand math now but I am worried that it will become increasingly difficult.					
5	I fear nothing else as much as I fear math exams.					
6	I'm afraid I won't pass my class because of math.					
7	When I attend a math class, I feel shriveled up with fear.					
8	I don’t know how to study for math exams.					
9	For me, math is very fun.					
10	I’m afraid to ask questions in math class.					

Appendix 2. Mathematics Motivation Scale (in Turkish)

İfadeler	Hiç Katılmıyorum	Katılmıyorum	Kararsızım	Katılıyorum	Tamamen Katılıyorum
1.Matematik derslerinde bana öğretilen dışında bir şey öğrenmek istemem.					
2.Matematik dersinde zor soruları cevaplamaktan zevk alırım.					
3.Sınıfta öğrendiğimden daha fazlasını öğrenmek için çalışırım.					
4.Matematik dersine çalışmaktan zevk alırım.					
5.Sınav olmadığı zamanlarda bile matematik dersini tekrar ederim.					
6.Matematik dersinden önce notlarımı tekrar ederim.					
7.Matematikten düşük not almak beni mutsuz yapar.					
8.Matematik dersini anlamayı severim.					
9.Matematik dersinden en yüksek notu almak isterim.					
10.Okulda başarılı olduğum zaman kendimi iyi hissederim.					
11.Matematik dersinde başarılı olmayı severim.					
12.Matematik derslerine ilgi duymam.					
13.Matematik dersinde öğrendiklerimizin, yaşantımızı kolaylaştıracağına inanıyorum.					
14.Matematik dersinde zamanımı boşa harcadığımı düşünüyorum.					
15.Matematik dersi gerçek yaşamdaki bağlantılar ile ilgilidir.					
16.Ders kitapları dışında matematik kitapları okumam.					
17.Matematik dersi benim için bir yüktür.					
18.Matematik dersinde konuyla ilgili tartışmalara girmeyi sevmem.					
19.Matematik ile ilgili televizyonda çıkan yayınları izlemeye çalışırım.					
20.Matematik dersleri beni ürkütür.					
21.Matematik dersinde merak ettiğim bilgileri araştırır, öğrenirim.					
22.Matematik dersine çalışmak beni dinlendirir.					
23.Matematik dersiyle ilgili yapılan uygulamaları vakit kaybı olarak görüyorum.					
24.Matematik dersi sevilmese bile öğrenilmesi gereken bir derstir.					
25.Matematikteki yeni fikirleri öğrenmek isterim.					
26.Matematik dersinde çözdüğümüz soruları ilk bitiren kişi olmak isterim.					

Mathematics Motivation Scale (in English)

Statements	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1. I don't want to learn anything beyond what is taught to me in math classes.					
2. I enjoy answering difficult questions in math class.					
3. I study to learn more than what I am taught in class.					
4. I enjoy studying for math class.					
5. I review math lessons even when there is no exam.					
6. I review my notes before math class.					
7. Getting a low grade in math makes me unhappy.					
8. I like understanding math lessons.					
9. I want to get the highest grade in math class.					
10. I feel good when I succeed in school.					
11. I like being successful in math class.					
12. I'm not interested in math classes.					
13. I believe what we learn in math will make life easier.					
14. I think I'm wasting my time in math class.					
15. Math is related to real-life connections.					
16. I don't read math books other than textbooks.					
17. Math class is a burden for me.					
18. I don't like engaging in discussions about the topic in math class.					
19. I try to watch TV programs related to math.					
20. Math classes frighten me.					
21. I research and learn the things I'm curious about in math class.					
22. Studying for math class relaxes me.					
23. I consider the activities related to math class a waste of time.					
24. Even if it's not enjoyable, math is a subject that must be learned.					
25. I want to learn new ideas in math.					
26. I want to be the first to finish the questions we solve in math class.					