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CURRENT AND ADVANCED RESEARCHES IN SCIENCE AND MATH EDUCATION I

EDİTÖR: DOÇ. DR. TAYFUN TUTAK

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Gülen ÖNAL KARAKOYUN[1], Sevim Göknur ERGÜN[2]

Introduction

Science can be defined as an effort to study nature on a regular basis and to predict possible future events (Çil & Uğraş, 2015). One of the areas where scientific activities are frequently carried out is education. The number of scientific activities carried out to increase the quality of education is increasing day by day. Some of the issues that scientists work on within the scope of increasing the quality of education are: Examining the reasoning of students (İlhan & Asiltürk, 2019; Karakoyun & Asiltürk, 2021), the effects of computer assisted teaching (Tutak et al., 2018), examination of the books or the questions in the books (Çelik et al., 2022; Nayıroğlu et al., 2021; Çakmak & Çil, 2014), examining the deficiencies or mistakes of teachers (Tutak et al., 2019), examining the relationship between students' curiosity about computer technologies and their learning (İç & Tutak, 2018), examining the attitudes, perceptions and opinions of teachers or teacher candidates (Erbek et al., 2023).

The above-mentioned studies are also carried out in the field of science education. Science education aims to raise individuals who understand the events taking place around them, who can produce creative solutions to the problems they encounter in daily life, who have scientific process skills and who have a positive attitude towards science.

Science education also aims to train individuals with effective, analytical and scientific reasoning skills. However, many scientific studies on science education show that students rely more on short-cut strategies rather than effective, analytical and scientific reasoning (Karakoyun & Asiltürk, 2022). In

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order for science education to achieve these goals, students' science learning needs to be measured and evaluated effectively. Traditional measurement and evaluation methods usually consist of multiple-choice tests or short-answer questions that test students' memory-based knowledge. These methods do not adequately reflect students' depth of science knowledge, application skills or attitudes. Therefore, alternative measurement and evaluation methods are needed in science education (Büyüktokatlı & Bayraktar, 2014).

Alternative measurement and evaluation methods are methods that aim to determine students' science knowledge, skills, attitudes and values differently from traditional methods. Alternative methods enable students to find solutions to real life problems, think creatively, collaborate and express themselves. Alternative methods include performance tasks, portfolios, observations, projects, student products, oral exams, concept maps and rubrics. By using these methods, both teachers and students participate more in the learning process and can receive feedback (Öncü, 2009).

The use of alternative measurement and evaluation methods in science education has its benefits as well as difficulties. For example, alternative methods are time-consuming, difficult to achieve objectivity, resource-intensive and require practical skill. In order to overcome these difficulties, it is necessary to provide adequate training to teachers, provide resources and support them (Orhan, 2007).

Measurement and Evaluation

Measurement and evaluation have a critical importance in terms of the validity, reliability and consistency of decision-making processes in education and daily life (Türkmen & Köseoğlu, 2018). Measurement is the process of assigning numerical values to certain attributes of objects, events or people according to a set rule. Evaluation, on the other hand, is the process performed to make a judgment by interpreting the measured values according to a certain rule (Özeren, 2013). Evaluation is a process used to identify students' areas of development, support and motivate their learning. It also provides feedback on teachers' proficiency and performance levels (Teacher.info, 2011). Evaluation is a broader concept than measurement. Measurement provides a numerical representation of learning outcomes. Evaluation is the process of analyzing the learning outcomes according to the determined criteria and making a decision as a result of this analysis (Özgüven, 2003).

The qualities that are the subject of the measurement or the behaviors intended to be gained by the students are directly related to the objectives and achievements in the curriculum (Türkmen & Köseoğlu, 2018). The process of showing an attribute using numbers or symbols based on the results of observation is called measurement (Kan, 2017; Açıkgöz & Karslı, 2015).

A change must exist for the measurement process. Changeable attributes or situations may be the subject of measurement. Different types of measurement can be used depending on the type of observation, the quality to be measured or the situation. If a quality can be observed and measured directly, it is called direct measurement (Türkmen & Köseoğlu, 2018). For example, counting the number of students in a class or measuring the height of a student with a meter is directly included in the measurement.

If it is necessary to refer to another variable or attribute to measure, then indirect measurement is mentioned. In indirect measurement, qualities such as motivation, attitude, interest, and academic success are measured (Türkmen & Köseoğlu, 2018). For example, a mother's feeling the baby's temperature with her hand can directly measure; determining the baby's temperature with a thermometer is included in the indirect measurement. The attributes that do not have their own definition but gain meaning in relation to other variables and are defined through arithmetic operations are derived measures. Attributes such as speed, velocity, density, volume, and area are derived variables (Kan, 2017; Kilmen, 2017; Semerci, 2015; Yaşar, 2008; Yaşar, 2014).

Evaluation consists of three components. These are measurement results, criterion and decision. The measurement results reflect the accuracy of the measurement. In other words, it shows how valid and reliable the measurement is. Measurement results and criteria are very important for the evaluation process. The criterion makes the measurement results meaningful. It is critical that the criterion be suitable for the measurement and evaluation processes, as well as the validity and reliability of the measurement results. The decision is an evaluation output. It is the judgment reached as a result of comparing the measurement result and the criterion (Fisher & Frey, 2007; Kan, 2017; Kilmen, 2017; Semerci, 2015; Yaşar, 2008; Yaşar, 2014).

The Place and Importance of Measurement and Evaluation in the Education System

Measurement and evaluation activities are of vital importance for the quality and efficiency of training activities. The importance of measurement and evaluation in education can be listed as follows (Ergül, 2019):

- Measurement and evaluation makes it possible to observe students' performances for the achievements of any course.
- It contributes to identifying the problems encountered in the education and training process and finding solutions.
- It guides teachers in adapting the content and methods of the course.
- Increases students' motivation by giving necessary praise and feedback.

- It allows to evaluate student participation and interaction towards the lesson.

Measurement and evaluation are an integral component of the education and training process. Provides teachers with information and feedback on the extent to which the objectives have been achieved. In our country, changes have been made from time to time in the curriculum and, accordingly, in the scope of measurement and evaluation. One of these changes took place in 2005. Since 2005, the constructivist approach has been taken as a basis in our country. In this context, the most radical change has taken place in measurement and evaluation. The product-oriented evaluation has been replaced by the process-oriented evaluation (Korkmaz, 2004).

Measurement and evaluation are of great importance in terms of education and training, as well as for students and teachers. From the student's point of view, it is important for the student to choose, develop and apply the appropriate assessment and evaluation tool, to get to know the student, to identify the learning deficiencies, to eliminate these deficiencies and to take measures to prevent their recurrence, in order for the student to perform well by receiving a qualified education. As a result of the measurements and evaluations, the teacher can evaluate and improve himself, gain awareness about the effectiveness of his own expression and technique, compare himself with his colleagues, and become a better educator by realizing his deficiencies or faults. As a result of the measurements and evaluations covering the whole process of education, the effectiveness of the curriculum is revealed and discussed, and it is aimed to increase the quality of education by making necessary arrangements (Ergül, 2019).

Alternative Measurement and Evaluation in Science Education

Alternative measurement and evaluation techniques differ significantly from traditional measurement and evaluation techniques (Aksu, 2008). In measurement and evaluation studies, teachers mostly use traditional measurement and evaluation techniques. Although alternative measurement and evaluation techniques are well known by some teachers, it is seen that many teachers have insufficient knowledge about these techniques (Okur, 2008). As emphasized in the 2018 science curriculum, measurement and evaluation practices; It is an integral component of education and is maintained throughout the education process. Since it is not correct and sufficient to measure the student's development with a single technique, multi-dimensional measurement and evaluation is essential (Söylemez, 2022). These measurement and evaluation practices are carried out with the active participation of teachers and students (MEB, 2018). Constructivist approach is adopted in science

courses. In this direction, alternative measurement and evaluation techniques play an important role within the scope of science courses (Söylemez, 2022).

Alternative assessment and evaluation practices reveal the following three dimensions of students' social literacy;

- First, as a result of alternative evaluation, the concepts and opinions in the minds of the students are determined.
- Second, the development of students' analysis, evaluation and synthesis skills is observed.
- Third, students who complete alternative assessment activities improve their cognitive skills by making connections between their existing knowledge and new knowledge and drawing comprehensive conclusions (Nelson & Drake, 1997).

The traditional measurement and evaluation approach has been replaced by alternative measurement and evaluation approaches. This evaluation method can be applied in different ways in science education (MEB, 2005).

In order for science teachers to know the ways of measurement and evaluation, they need to know the areas to be evaluated and the strategies to be used in measurement and evaluation (Türkmen & Köseoğlu, 2018). In order to evaluate the science teaching process, they need to know the evaluation strategies that are currently used and included in the science curriculum of that period (Ateş & İnaltun, 2018). Today, the Ministry of National Education 2018 Science Curriculum is implemented in all schools. Many current evaluation techniques are also included in this program. Before choosing the evaluation technique to be used, the purpose of the evaluation should be considered. The purpose of these evaluations may be to evaluate a process or a product (Türkmen & Köseoğlu, 2018). In today's science curriculum, it is stated that besides measuring the knowledge of students directly, it is also important to measure the skills they have acquired (MEB, 2018). The achievements given below in the 2018 Science Curriculum, performance evaluation, product selection files, concept maps, structured grid, diagnostic branched tree, written reports, group and peer, self-evaluation, It is an example for the use of techniques such as posters (Türkmen & Köseoğlu, 2018).

Some Scientific Studies on Alternative Measurement and Evaluation in Science Education

Büyüktokatlı and Bayraktar (2014) tried to determine whether there is a difference in the frequency of use of alternative measurement and evaluation methods by 75 classroom teachers and 40 science teachers according to gender, seniority, branch and type of school they graduated from. Data were collected with a questionnaire and statistical analyzes such as frequency, percentage,

t-test and analysis of variance were performed. As a result, it was observed that the frequency of teachers' use of alternative measurement and evaluation methods differed according to some variables. For example, female teachers used alternative measurement and evaluation methods more frequently than male teachers. In addition, science teachers used less alternative measurement and evaluation methods than classroom teachers.

Şenel, Çoruhlu et al. (2009) conducted their studies in the screening model, which aimed to reveal the problems faced by science teachers in using alternative measurement and evaluation techniques. The sample of the study consisted of 40 science teachers. Data were collected with a questionnaire and frequency and percentage values were tabulated. As a result, it has been seen that science teachers do not have sufficient knowledge and skills about alternative measurement and evaluation techniques and they encounter various problems when they start to practice. Among these problems are the excess of the class size, lack of time, indifference of the students, the reaction of the parents and the pressure of the administrators. Researchers suggested that in-service training programs should be organized for alternative measurement and evaluation techniques. This research shows the difficulties and solutions encountered in the application of alternative measurement and evaluation techniques.

Yaman (2011) conducted a quantitative research in which he aimed to compare the perceptions of primary school 4th and 5th grade science teachers about measurement and evaluation practices according to various variables. In the research, the survey method was used and data were collected with the participation of 175 teachers. Statistical techniques such as frequency, percentage, mean, standard deviation, t-test and analysis of variance were used in the analysis of the data. As a result, it has been determined that teachers use traditional measurement and evaluation methods and tools more in science lessons. While the perceptions of the teachers according to the quality and purpose of the methods and techniques they used did not differ significantly according to their seniority, gender and participation in in-service training, they differed significantly according to their self-efficacy. It has been determined that teachers who consider themselves competent in measurement and evaluation think that they make more effective practices in first grade science lessons.

In the research conducted by Çepni, Şenel and Çoruhlu (2010) as a qualitative research, the reflection of the knowledge gained from an in-service training course prepared for alternative measurement and evaluation techniques to the learning environment was investigated. The sample of the study consisted of two science teachers (who attended an in-service training course) and 65 students of these teachers. The data were collected by semi-structured observation form,

unstructured interview questions and questionnaire and analyzed by descriptive analysis method. As a result, it has been determined that the question-answer technique, which is one of the traditional measurement and evaluation techniques, is used a lot by the teachers and instead of alternative measurement and evaluation techniques, teachers prefer to use techniques that do not require much effort. In addition, it was concluded that the economic level of the students, the education level of the families and student interests were effective in developing alternative measurement and evaluation techniques with rich content. This research shows that in-service training courses are not sufficient in the application of alternative measurement and evaluation techniques and other factors should be taken into account.

In the study conducted by Kurnaz and Pektaş (2013) as a qualitative case study, the use case of the concept map method was examined. The sample of the study consisted of 29 science teachers. The data were collected with two different concept maps and analyzed by content analysis method. As a result, it was determined that the concept map method was seen as an effective method by the teachers and they used it in their lessons. However, it has been revealed that there are lack of knowledge and practice during the evaluation phase. It has been determined that teachers are insufficient in scoring, interpreting and giving feedback on concept maps. This research shows that teachers should be guided on how to use the concept map method in the measurement and evaluation phase.

In this research, conducted by Yeşilyurt (2012) as a qualitative research, it is aimed to determine the techniques that science teachers use to measure and evaluate the academic success of students in their classes and the difficulties they encounter while using these techniques. The sample of the study consisted of 54 science teachers. The data were collected with a semi-structured interview form and analyzed by descriptive analysis method. As a result, science teachers mostly asked multiple choice, completion-blank, written exam, matching and true-false type questions from traditional measurement and evaluation techniques; Among the complementary methods, it was determined that they used projects and product selection files, performance-based processes. However, these techniques have also been found to create some problems. For example, problems such as the inability of the students to express what they know in the written exam type, the fact that the students write whatever comes to mind in the completion questions, and the students find the right answer in the multiple-choice, matching and true-false questions were experienced. In the project method and performance-based processes, the teachers stated that they faced the problem of getting more help from the families, getting their homework ready from the internet, and not being able to produce an original

product while preparing the students' homework. This research reveals the use of measurement and evaluation techniques by science teachers and the difficulties they face.

Güneş et al. (2010). The sample of the study consisted of 95 primary school teachers (45 science teachers and 50 classroom teachers). Data were collected by questionnaire form and clinical interview questions and analyzed by frequency, percentage, mean, standard deviation, t-test, analysis of variance and descriptive analysis methods. As a result, it was concluded that teachers use alternative measurement and evaluation techniques less than traditional techniques. A remarkable part of the teachers stated that they did not receive in-service training on this subject, and the teachers who received this training stated that this training was not sufficient. In general, although traditional techniques are preferred by teachers, it has been determined that both methods and techniques are used together. While science teachers generally prefer alternative measurement and evaluation techniques, classroom teachers in private schools still prefer traditional assessment techniques more. This research contributes to revealing the attitudes, competencies and needs of teachers towards measurement and evaluation techniques.

Şaşmaz, Ören et al. (2011) carried out their studies in the form of mixed research, in which they investigated the self-efficacy levels and opinions of science teaching students about alternative measurement -evaluation approaches. The sample of the study consisted of 53 science teaching students. Data were collected through a self-efficacy scale for alternative assessment-evaluation approaches, an opinion form consisting of open-ended questions about alternative assessment-evaluation approaches, and a semi-structured interview. The obtained data were analyzed by frequency, percentage, mean, standard deviation, t-test, analysis of variance and descriptive analysis methods. As a result, it was determined that science teaching students had a high level of self-efficacy towards alternative measurement -evaluation approaches. According to the results obtained from the opinion form and interviews, the pre-service teachers stated that they wanted to use these approaches for different purposes in their future teaching life, but they believed that they might experience some problems in the application of these approaches. Among these problems, factors such as excess class size, lack of time, attitudes of parents and administrators, lack of resources and insufficient education can be counted. This research contributes to revealing the attitudes, expectations and needs of science teaching students towards alternative measurement -evaluation approaches.

Açıkgöz and Karslı (2015) conducted their research in the form of quantitative research, in which they aimed to prepare an achievement test

for the 7th grade “work and energy” subject using alternative measurement approaches and to analyze the validity-reliability of the test. The sample of the study consisted of 70 primary school students. The data were collected with a multiple-choice test consisting of 30 questions and analyzed using statistical techniques such as Cronbach’s Alpha coefficient, item difficulty index and item discrimination index. As a result, it was determined that the Cronbach’s Alpha coefficient of the developed test was 0.689. The mean difficulty index (0.67) and distinctiveness index (0.44) were calculated by performing item analysis. The researchers concluded that it is appropriate to use the developed test as an achievement test. This research provides an example of achievement test development using alternative measurement approaches.

Turan and Sakız (2014) conducted their research in the form of quantitative research, in which they aimed to examine the effect of portfolio use in science teaching on student achievement and permanence of learning. The sample of the study consisted of 40 students consisting of two fifth grade students. In the research, the pretest-posttest control group model, which is one of the real experimental models, was used as a method. In addition, a semi-structured student opinion form was also used to get the students’ opinions on portfolio use. Data were collected with achievement test and opinion form and analyzed with t-test, analysis of variance and descriptive analysis methods. As a result, it was determined that the experimental group students had positive effects on the course success and the permanence of the learned compared to the control group students. It was also observed that students expressed positive opinions about the use of portfolios. This research shows that the use of portfolio is an effective method in science teaching.

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ANXIETY AND STATE ANXIETY IN SCIENCE EDUCATION

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Introduction

Science education is an important field of science that enables students to understand natural events, develop their scientific process skills and be interested in science (Polat & Yılayaz, 2023). Science education encourages students to learn for life by increasing their curiosity, creativity and critical thinking abilities (Önal Karakoyun & Asiltürk, 2023). Science education, which contributes to students' future career choices and solutions to social problems, also allows students to discover the richness around them, to understand how the things they eat, drink, breathe and use work, and to think creatively to improve them (Önal & Sarıbaş, 2019). However, many scientific studies on science education show that students' creative thinking skills are weak and students prefer primitive and short-cut ways of thinking instead of scientific and creative thinking (Karakoyun & Asiltürk, 2020a; Karakoyun & Asiltürk, 2020b; Karakoyun & Asiltürk, 2021; Karakoyun & Asiltürk, 2022). In order to eliminate such deficiencies in students and to increase the quality of education, many scientific researches are carried out both in the field of science and in other fields. Research on many subjects such as the use of artificial intelligence (Bagır et al., 2022) or computer Technologies (İç & Tutak, 2018; Tutak et al., 2018) in education, the examination of perceptions / attitudes and thoughts of teachers/students (Erbek et al., 2023), the determination of student/teacher achievements and inadequacies (Tutak et al., 2019), the examination of textbooks and the questions in the boks (Çelik et al., 2022; Nayıroğlu et al., 2021) aim to improve education.

There are many factors that affect the efficiency and success of the learning-teaching process. One of them is anxiety. Anxiety is the state of worry, fear

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or distress in the face of a danger, threat or difficulty that an individual has or will face (Dominglos et al., 2015). Anxiety can affect an individual's physical, mental, and emotional responses. If the anxiety experienced by individuals in the education process is at a certain level, it can increase the attention of students, increase their motivation and lead them to success. However, in cases where the level of anxiety is very high or very low, the learning process of students may be negatively affected (Megreya et al., 2021).

Exam anxiety is one of the commonly observed anxiety types in the education-teaching process, and apart from this, anxiety related to basic language skills such as science anxiety, mathematics anxiety, writing anxiety, speaking anxiety constitute the anxiety problems that students encounter in the education-teaching process. Such anxieties negatively affect students' interests, attitudes and motivations, weaken their self-efficacy and self-esteem, and limit their ability to conduct scientific research (İşlek, 2016).

The factors that cause the emergence of anxiety in the education-teaching process can be grouped into three main groups as individual, social and institutional. While students' personality traits, self-efficacy perceptions, learning styles, motivation levels, success expectations, exam preparation situations and stress management skills constitute the individual elements; The relations of the students with their families, friends, teachers and other social environments, and the expectations, pressure and support situations arising from these relations constitute the social elements. Institutional elements refer to factors such as the structure of the education system, the content of the curriculum, measurement and evaluation methods, and the physical and psychological conditions of the educational environment. Each of these elements or together may cause students to experience anxiety in the education process (Guzeller & Doğru, 2012).

In terms of increasing learning-teaching activities, it is very important to consider the effect and importance of anxiety on the education-teaching process. By keeping the level of anxiety at an optimum level, it can be contributed to the students' being more successful, happy and productive in the education-teaching process.

Types of Anxiety

Anxiety is an emotion as old as human history. The historical process of anxiety has been handled in different ways in different periods in the fields of psychology and philosophy. While anxiety in ancient Greece was seen as a corruption of the human spirit or punishment of the gods, in the Middle Ages anxiety was the fear of sinning or the influence of the devil; In the Renaissance, a situation where man had to deal with his free will and reason; In the Age of Enlightenment, a problem in which one has to suppress or control their irrational

emotions; In the modern era, anxiety has been described as a psychopathology influenced by psychological and biological factors (Çağlıyan, 2020).

Anxiety is generally classified in two different ways as normal and abnormal (pathological) in studies in the literature (Kaya, 2004). Anxiety helps the individual protect himself and adapt. However, when anxiety begins to negatively affect an individual's quality of life and functionality, it is defined as abnormal anxiety. The difference between normal anxiety and abnormal anxiety can be determined by the severity, duration, and impact of the anxiety. Normal anxiety is an emotion that increases the individual's performance, helps him adapt, and is appropriate for the situation (Carey et al., 2017). Normal anxiety decreases or disappears with the end of the situation. Abnormal anxiety, on the other hand, is an emotion that reduces the individual's performance, prevents him from adapting, and is disproportionate to the situation. Abnormal anxiety persists despite the end of the situation or spreads to other situations (Fan et al., 2019).

Spielberger (1966), on the other hand, addressed anxiety in two dimensions, state anxiety and trait anxiety, depending on the person's perception of stressful situations. Anxiety is an emotional state that an individual frequently encounters in his life, and it can help the individual protect himself and adapt. However, when the feeling of anxiety begins to negatively affect the quality of life and functionality of the individual, anxiety disorder occurs. Anxiety disorder is a diagnostic group with different types. Trait anxiety and state anxiety are among these types of anxiety disorders (Cüceloğlu, 2015; Köknel, 2013).

Trait and State Anxiety

Anxiety is a natural part of human life. People may encounter various problems in their daily lives and may be worried about these problems. Anxiety can occur in different ways in each person and cause changes in cognitive, emotional, physical and psychological areas (Kaya and Varol, 2004; Shimura et al., 2023). The idea that anxiety is a two-dimensional concept and divided into two subtypes as situational and trait anxiety was first put forward by Cattell (1966) (Güngör, 2008; Tanrıverdi, 2015). According to Spielberger's (1976) theory, these two subtypes of anxiety show different characteristics.

Trait Anxiety

Trait anxiety is a condition that the individual perceives as a threat when faced with stressful situations, and his emotional reactions intensify and become chronic. This situation varies between individuals and is related to personality traits. Spielberger defined trait anxiety as a person's tendency or potential to be anxious. This tendency is related to how the individual evaluates situations and expectations. Individuals who generally evaluate situations as

stressful and have negative expectations are individuals with high trait anxiety (Kılınç, 2012). Trait anxiety can cause even objectively harmless situations to be interpreted as dangerous and threatening by the person and to give intense emotional reactions such as discomfort, unhappiness, anxiety, and pessimism (Tütüncüoğlu, 2012). The person perceives the situation he is in as stressful and threatening and believes that he cannot cope with it. This belief lowers the individual's perception of self-efficacy and weakens coping strategies. Trait anxiety negatively affects the mental health of the individual and may lead to psychological problems (Güngör, 2008).

The symptoms of trait anxiety can manifest themselves psychologically and physically. Psychological symptoms include tension, restlessness, being in a state of panic, and worrying as if something bad is going to happen. Physical symptoms include shortness of breath, dry mouth, palpitations, sweating, tremors, and weakness. In addition, people who are constantly anxious may avoid some activities in daily life (eg, not being able to enter the crowd, not using public transportation, etc.) (von der Embse, 2013).

Some of the ways to cope with trait anxiety are (Bistline-Bonilla, 2020):

- Recognizing and accepting anxiety: Knowing what anxiety is and focusing the mind on the "here and now" can reduce the negative impact of anxiety.
- Changing unrealistic thoughts: Anxious feelings can turn into catastrophic expectations. It may be helpful to identify these thoughts as unrealistic thoughts and replace them with more positive or neutral thoughts.
- Tendency to solve problems: A feeling of helplessness can be experienced in anxious situations. In this case, defining the problem, finding and applying alternative solutions can make it easier to cope with the problem.
- Calming the body: In cases of anxiety, stress hormones are secreted in the body. It may be helpful to do breathing exercises, relaxation techniques, or physical activity to lower the level of these hormones.
- Taking time to worry: Instead of suppressing anxious thoughts, expressing them for a certain period of time can help control anxiety. It is possible to write, talk or think about anxiety-provoking situations during this time. However, anxious thoughts should not be allowed outside of this period.

State Anxiety

The reasons for the emergence of state anxiety are related to how the individual perceives, evaluates and interprets the situation he encounters. If the individual perceives the situation as dangerous, harmful or insurmountable, he may experience state anxiety (Spielberger, 1972). The level of state anxiety may increase during times of intense stress or decrease when stress

is low or disappearing. An increase in the level of state anxiety can also lead to physiological changes. Among these changes, reactions such as redness, yellowing of the body, acceleration of heartbeat, sweating and trembling in the body can be counted (Kikkawa et al., 2023).

State anxiety can affect an individual's performance both positively and negatively. While optimum level of state anxiety motivates the individual, excessive level of state anxiety can hinder the individual (Shimura et al., 2023). There are some basic characteristics of situations in which state anxiety arises. These features include the individual's perception of the situation as dangerous and threatening, feeling uncomfortable with this situation, and excitation in the nervous system (Spielberger, 1983; Ensari et al., 2015). State anxiety has a relationship with external and internal factors. State anxiety is an emotional state that can be experienced at that moment in the form of danger experiences that can be perceived as real or close to reality. State anxiety is a person-specific fear that an individual can feel depending on the situation (Tharpe, 2023).

State anxiety is an important factor that can affect the learning-teaching process (Şahin et al., 2015). The task performance and academic achievement of individuals with high state anxiety levels may decrease (Hashim & Baghepour, 2016). On the other hand, task performance and academic achievement of individuals with appropriate state anxiety levels may increase (Goes et al., 2018). It is possible to replace state anxiety with appropriate educational measures in educational settings. For this reason, it should be dealt with in a more important way than trait anxiety, which is one of the types of anxiety. For this reason, it is extremely important to understand the learner's state anxiety level in the science learning-teaching process (Kang & Kim, 2020).

Science Anxiety and State Science Anxiety

The concept of science anxiety was defined by Mallow (2006) in 1977. This concept expresses the feelings of panic and fear that students feel during exams in science classes. It has been observed that students with science anxiety are calmer and more productive in subjects other than science (Mallow 2006). It has been stated that science anxiety is a common problem, but it is not adequately understood and addressed (Britner, 2010). Mallow (2006) emphasized that science anxiety is different from general exam and performance anxiety, and that students experience a harmful panic situation in science lessons. This situation negatively affects the learning processes of students. Science anxiety emerges especially in the secondary school period and reduces students' science achievement (Borman & Overman, 2004; Britner & Pajares, 2006).

Science anxiety is a concept that expresses students' negative feelings, attitudes and beliefs towards science lessons. This anxiety is a factor that can interfere with students' science learning and career choices. (Britner, 2010).

Science anxiety, unlike general exam and performance anxiety, is a situation that causes students to experience panic in science classes (Mallow, 2006). This situation negatively affects the learning processes and achievements of students in the field of science. Science anxiety becomes more evident in the secondary school period and students' science achievements decrease in this period (Avcı & Kırbaşlar, 2017). Science success has a critical importance in terms of students' future goals and career choices (Kaya & Yıldırım, 2014). In addition, it has been observed that self-confident students in science courses are more successful in other courses as well (Borman & Overman, 2004; Britner & Pajares, 2006).

Science anxiety (Mallow, 2006), which is one of the most serious problems middle school students face in the process of learning science, negatively affects students' interest in science, their career goals and perspectives. Science anxiety reduces students' learning potential and self-esteem, hinders their ability to conduct scientific research, and creates disturbing emotions and behaviors (Griggs et al., 2013). How comfortable students feel in a course determines their interest and motivation for that course and their future career choices. It is an inevitable result that students with high science anxiety move away from the science lesson and their performance in this lesson decreases (Megreya & al-Emadi, 2022).

Science anxiety also functions as a career filter, causing students to be prejudiced against the field of science and avoid entering science-related departments (Udo et al., 2004). Identifying the state anxiety of the student in a particular situation can provide appropriate feedback. In order to analyze the effects of state anxiety that arises in the science learning process on learning, students should be aware of their anxiety levels while solving science problems, checking their answers, and learning concepts (Megreya et al., 2021). In addition, monitoring the changes in anxiety that occur or may occur in the science learning process can contribute to the determination of the causes of anxiety and enable the development of a learning guidance strategy. State anxiety can be reduced or increased with educational interventions, so it is important to identify students' state anxiety in the science learning process and to intervene accordingly (Henschel, 2021).

State anxiety in science education is the temporary state of anxiety that students feel about a certain situation they encounter in science lessons. State anxiety is an important variable that can affect students' science learning process and academic performance (Bryant et al., 2013). State anxiety can negatively affect students' interest, motivation and attitudes towards science lessons. In addition, state anxiety can complicate students' cognitive processes, problem-solving skills and conceptual understanding in science lessons (Cooper et al.,

2018; Kesici et al., 2011). In order to reduce state anxiety, students should be provided with a positive learning environment in science lessons, students' success expectations towards science lessons should be increased, students' exam stress in science lessons should be reduced and students should be kept away from the competitive environment in science lessons (Lee & Lee, 2020; Uzuntiryaki-Kondakçı & Çapa Aydın, 2013). Identifying and monitoring state anxiety can provide students with appropriate feedback and educational interventions (Saviola et al., 2020). State anxiety can be affected by various factors that can occur in science classes. These factors include fear of students, using an inappropriate learning style, having negative and irrational thoughts about exams, not getting enough rest, exam schedule, excessive course load, gender, previous exam experience, and inadequate preparation (Kostova, 2015; Putwain). et al., 2015).

Some Scientific Researches on Science Anxiety and State Science Anxiety

In his study, Çelik (2021) aimed to develop a scale to measure secondary school students' science anxiety levels and to use this scale to examine the relationship between students' anxiety levels and variables such as gender and grade level. The method of the study is a survey type and as a data collection tool, the 13-item 5-point Likert-type Science Anxiety Scale of Secondary School Students (OFECS) was used. The development of the scale was carried out with 354 participants, and its implementation was carried out with 659 secondary school students in three different provinces in Turkey. The data were analyzed with the SPSS package program. The results of the research revealed that the anxiety levels of the students did not differ significantly according to gender, but showed a significant difference according to the grade level. It was observed that the level of anxiety increased as the grade level increased. These results show that anxiety is an important factor in science education and may negatively affect students' science learning and their orientation to science fields.

In his research, Gögebakan (2020) aims to determine and examine secondary school 8th grade students' anxiety towards science lesson according to variables such as gender, teacher's gender, school type, family helper and science grades. The method of the study is quantitative research method and survey model, and the Science Lesson Anxiety Scale was used as a data collection tool. The scale is one-dimensional and aims to measure students' science lesson anxiety levels. The study was conducted with 335 secondary school 8th grade students studying in public, private and village schools in Ankara and Ağrı. Data were analyzed with Independent t-test and One-Way ANOVA test. The results of the research revealed that the anxiety levels of the students showed a significant

difference according to their science grades, the education level of the person who helped with the study in the family and the type of school, but did not show a significant difference according to the gender and the gender of the teacher. It has been observed that students with low levels of anxiety are more anxious than those with high levels of anxiety, students with a low level of education in the family who helps with their studies are more anxious, and students studying in public and rural schools are more anxious than those studying in private schools. These results show that anxiety towards science course is an important factor and can affect students' academic achievement and interest in science.

In the study of Uçar and Say (2019), it was aimed to determine the reasons for the anxiety of secondary school students towards the science lesson. The method of the study is the relational survey model and a form consisting of a single open-ended question was used as a data collection tool. A total of 296 secondary school students studying in the 6th, 7th and 8th grades participated in the study. According to the findings of the study, the students stated that the reasons for their anxiety about the science lesson were related to the lesson, their teachers, themselves, their social environment, some events they had experienced in the past, and professional concerns. While 2.4% of the students stated that everything about the science lesson made them anxious, 3% of them stated that they did not have any anxiety about the science lesson. The results of this study show that students' anxiety towards science lesson is affected by various factors and these concerns may negatively affect learning.

In his study, Erdoğan (2016) aimed to examine the relationship between the academic procrastination behavior of university preparatory class students and the level of state anxiety and whether these variables differ according to variables such as gender, age and number of siblings. The method of the study is the relational survey model and Academic Procrastination Scale, State Anxiety Scale and Personal Information Form were used as data collection tools. The study was carried out with 276 students studying in the preparatory class of the university. The data were analyzed with the SPSS 22.0 program. Whether the data were normally distributed or not was determined by Kolmogorov-Smirnov and Shapiro Wilk tests, and the equality of variances was determined by Levene's Test. Pearson Moments Relationship Analysis was used for the relationship between students' academic procrastination behavior and state anxiety level, and Independent Samples t-Test was used for the difference according to gender, age and number of siblings. The results of the study revealed that there is a positive significant relationship between students' academic procrastination behavior and their state anxiety level, that male students show more academic procrastination behavior than girls, but that the variables of gender, age and number of siblings do not have a significant effect on the level of state anxiety. These results show that academic procrastination

behavior of university preparatory class students increases state anxiety and this behavior differs depending on gender.

Akça (2016) aims to examine the relationship between secondary school students' mental risk-taking perceptions towards science and their science anxiety. The method of the study is the relational survey model and the Perception Scale of Mental Risk Taking and its Predictors and Science Anxiety Scale were used as data collection tools. The scales are in 5-point Likert type and include variables such as interest in science, creative self-efficacy, perception of teacher support, and science anxiety. The study was carried out with 600 secondary school students studying in İzmir. The data were analyzed with the SPSS 18.0 program. Descriptive statistics, Mann Whitney U, Kruskal Wallis H test and correlation analysis were used in the analysis of the data. The results of the research revealed that the students' risk-taking levels towards science were high and their science anxiety levels were low, and that students with high levels of anxiety had low mental risk-taking tendencies in science lessons. These results show that the perception of mental risk taking in science lesson is inversely proportional to science anxiety and may affect students' attitudes towards science lesson.

In his study, Kağıtçı (2014) developed a scale to measure secondary school students' anxiety towards science lesson and examined the relationship between students' science lesson anxiety and attitudes by using this scale. In his study, he also aimed to examine whether students' science lesson anxieties and attitudes differ according to variables such as gender, school type and achievement level. The method of the study was the pretest-posttest experimental design with control group and the 5-point Likert-type Science and Technology Lesson Anxiety Scale, the Science Class Attitude Scale and the Demographic Characteristics Questionnaire were used as data collection tools. The study was carried out with 1146 students consisting of 6th, 7th and 8th grade students from three different secondary schools in Kocaeli. For the success level, the course achievements in the Placement Exam in 2010 were taken as the basis. Data were analyzed by Cronbach Alpha Internal Consistency, Test-Retest, Item-Total Correlation, t-Test, One-Way Analysis of Variance (ANOVA) and Correlation analysis. The results of the research show that the Science and Technology Lesson Anxiety Scale, which measures secondary school students' anxiety towards science lesson in a valid and reliable way, has been developed, there is a moderate negative correlation between students' anxiety and attitudes towards science lesson, and their anxiety scores are significantly different according to gender and grade level. showed no difference, but showed a significant difference according to the level of success. He also determined that attitude scores showed a significant difference according to gender and grade level, but not according to school type. These results show that anxiety towards

science lesson is an important variable and may affect students' academic achievement and attitudes towards science lesson.

In his research, Alkan (2013) aimed to examine the effects of teaching the "Systems in Our Body" unit of the science and technology course with open and closed-ended experiment techniques on the science anxiety, attitudes towards the laboratory and academic achievement of the sixth grade students. The method of the study is an experimental design with a pretest-posttest control group, and the Systems in Our Body Achievement Test, Science and Technology Laboratory Self-Efficacy Scale and Science Anxiety Scales were used as data collection tools. The study was applied to three sixth graders in a primary school in Antalya for eight weeks. Open-ended experiment technique was applied to experimental 1 group, closed-ended experiment technique was applied to experiment 2 group, and lessons were taught according to the existing science program in the control group. Data were analyzed with one-way analysis of variance (ANOVA). The results of the research revealed that there was no significant difference between the groups on attitude towards science and science anxiety, but the experimental group, in which open-ended experiment technique was applied, showed significantly higher success than the control group on academic achievement. These results show that open-ended experiment technique in science and technology lesson is an effective method in increasing the academic achievement of students.

In Zeybek's (2012) study, it was aimed to compare the state anxiety levels of students studying at the second level of primary education in Turkish, Mathematics, Science and Technology, and Social Studies courses and their attitudes towards these courses according to gender and academic achievement variables, and to determine the relationship between them. The method of the study is quantitative research method and survey model, and attitude scales towards lessons and state anxiety scales were used as data collection tools. The study was carried out with 249 students consisting of second grade students of a state primary school in Serdivan district of Sakarya province. For academic success, the course achievements in the Placement Exam in 2010 are taken as a basis. Data were analyzed with Simple Correlation Coefficient, One-Way Analysis of Variance and Independent Samples t-Test. The results of the research revealed that the students' state anxiety levels towards the lessons were related to each other at various rates, did not show a significant difference according to gender, but showed a significant difference according to academic achievement. In addition, it was determined that only the Turkish lesson attitude of the students showed a significant difference according to gender and academic achievement. These results show that the anxiety towards the science lesson in the second level of primary education is an important variable and may affect the academic achievement and attitudes of the students towards the lessons.

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WAYS TO REDUCE MATH ANXIETY IN LGS EXAM: SUGGESTIONS FOR STUDENTS

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Abstract

The countries' development level is parallel with the high level of education. For this reason, it is necessary to establish cause-effect relationships, make logical inferences, etc. Mathematics learning is critical in terms of gaining skills for individuals. It enables individuals who are aware of the universal value of mathematics to be responsible by following a systematic way and, accordingly to be more self-confident. Mathematics is an essential tool for an individual to be aware of his/her characteristics and to use these properties. Mathematics is of great importance in raising individuals who can use more active thinking methods thanks to mathematics, transfer it to their daily lives, and solve every problem they encounter, such as the High School Entrance System (LGS) Exam, with more practical thinking methods, and transfer what they have learned thanks to mathematics to their daily lives. Test anxiety has become a common problem in Turkey in recent years, especially before major exams such as LGS. The LGS exam is an important step that shapes students' future, and one of the most important factors affecting students' performance is math anxiety. This study aims to reveal some of the methods recommended to students to reduce math anxiety in the LGS exam and why these methods are essential with the research obtained from the literature review. As a result of this study, It has been seen that individuals who approach the problems they encounter in daily life with a critical perspective, the anxiety they develop due to their anxieties towards mathematics affects their success.

Keywords: *Mathematics Lesson, LGS, Anxiety*

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Introduction

Our society, which has a large young population, faces the conflicts and problems of young people from different socio-economic and cultural backgrounds, whose numbers increase yearly. Identifying these problems is vital for understanding our society and youth. Especially the middle school and high school years are the most challenging and unstable times of the youth period. Research conducted during this period provides a better understanding of the problems and depression of young people (Kulaksızoğlu, 1998).

Mathematics is directly related to living conditions and technological developments around the world. Countries with a high level of education are also progressing in economic and technological developments. Technology and computer concepts are the most critical elements in daily life, business life, and education for modern societies and education systems (Tutak, İlhan, & İç, 2018). Therefore, if mathematics education is not suitable for its purpose, there can be no development in a country (Işık et al., 2008). Mathematical literacy enables students to understand the place and importance of mathematics in the world, to associate it with their daily lives, to develop their mathematical thinking skills, and to make critical analyses in every field (Özgen & Bindak, 2008).

The mathematics curriculum (MEB, 2018a) aims to develop students' higher-order thinking skills. However, the curriculum must emphasize adequate strategies, activities and materials to support acquiring these skills. It is necessary to provide more opportunities and guidance to develop students' higher-order thinking skills (Erdoğan, 2019). Mathematics develops the skills of establishing relationships between events, solving problems, analyzing, synthesizing, looking at events from different perspectives and predicting. These skills help people keep up with the times and quickly solve problems. Mathematics education also contributes to the development of individuals' thinking abilities. Therefore, mathematics education is one of primary education's most important building blocks (Umay, 2003).

Failure and negative attitudes toward mathematics lessons in Turkey stem from the student's perception of mathematics as a difficult lesson. These negative thoughts begin in primary school and continue to increase in secondary and high school years. This causes students to feel insecure about mathematics and to misjudge their mathematics skills (Baykul, 2009). The primary purpose is to enable students to effectively use their potential, such as reasoning and short-cut solutions, by improving their problem-solving abilities.

In education, it is believed that it is essential to raise students with mathematical skills and therefore have high logic and reasoning skills. Among the general objectives of the mathematics curriculum of the Turkish education

system, it is aimed that students develop problem-solving skills from different perspectives and have mathematical thinking and application skills (Ministry of National Education [MEB], 2018a). Mathematics is essential in all national or international selection and ranking exams students will experience throughout their academic life. One of these exams is the High School Entrance System (LGS) central exam, held for eighth-grade secondary school students to select students who will study in qualified high schools as of 2018 (MEB, 2018b). According to the evaluation report made after the LGS central exam, it was seen that the students failed more than the new generation mathematics questions. These questions measure students' logic and reasoning levels rather than their knowledge level (MEB, 2019). Today, many of the students experience feelings of anxiety and anxiety before the LGS exam. The reason for these feelings is that the LGS exam is crucial in shaping students' futures. One of the most important factors affecting students' success in this exam is math anxiety. Mathematics anxiety may cause students to develop a negative attitude towards mathematics and believe they will fail the exam. Therefore, it may be helpful to offer some suggestions to students to reduce their math anxiety in the LGS exam. In this study, some suggestions that students can apply to reduce math anxiety are given by using the literature.

Problem Situation

Evaluations that directly affect the individual's future life and getting to know them are only possible by placing the individuals in programs suitable for their current characteristics. With our country's changing and developing education system, individuals are expected to maximize their potential (Gedikoğlu, 2005). For this reason, there is a need for education and training programs and assessment systems for the acquisition of mathematics skills. With correctly applied methods and techniques, individuals can reduce their anxiety and develop positive attitudes toward mathematics with a more efficient mathematics education (Taşdemir, 2009). With an effective education system, individuals can develop mathematical logic, make predictions, and establish relationships between mathematical concepts to succeed. Individuals who apply the solution formulas they have developed with appropriate methods to their problems also approach them daily with a solution-oriented critical perspective. Formulas that make people love mathematics should be developed instead of rules that lead individuals to memorize without thinking. Within the framework of the objectives in line with the current education vision in our country, the purpose of all exams in the education system and the content of the question types should be rearranged, and an approach that does not require the acquisition of mental skills such as critical thinking and interpretation and memorization should be brought to the fore. It is aimed for the individual to be active with the new

education system that can keep up with the developing technology following the requirements of the age, which prevents the learning-based information from being memorized and then forgotten, rather than the traditional method of teaching, which is brought into the Turkish education system (Umay, 2003). Many students experience failure in mathematics lessons and face mathematics anxiety (Berberoğlu, 2007). This situation causes students to develop negative attitudes towards mathematics and difficulties developing their mathematics skills (Ekşi, 1998). In addition, students' failure in mathematics can prevent them from having difficulties in many exams throughout their academic life and from applying to jobs related to mathematics later in their lives (Ergene, 1994). This problem situation requires thinking about what solutions can be found to improve students' math skills and reduce math anxiety.

Aim

This study presents different methods and suggestions that secondary school students can use to reduce their anxiety in mathematics exams by using the literature to prepare for the LGS exam. Mathematics anxiety can be caused by students' uncertainty about mathematics, fear of failure, or negative experiences with mathematics, and this anxiety can negatively affect students' exam performance. Therefore, this study aims to increase students' exam success by offering suggestions to help students reduce their math anxiety.

Method

In this study, the document analysis method, one of the qualitative research methods, was used. Document analysis examines the existing written source of the researched subject (Hitchcock & Hughes, 1995). Document analysis is also defined as examining visual materials containing information about the event or phenomena planned to be investigated (Yildirim & Simsek, 2008; Çelik et al., 2022). The primary purpose of document analysis is to examine the obtained documents in a theory-oriented, systematic and data-based manner (Saglamoz & Soysal 2021).

Definition of Mathematics Concept

Mathematics is a tool that helps people discover their potential and direct them correctly, and contributes to developing logical thinking and analysis skills (Bulut, 1988). Mathematics teaching, on the other hand, covers all activities carried out in the learning process (Aydın, 1990).

Mathematics is often associated with performing four operations and counting in everyday life, such as calculating where to go on time, calculating at home, shopping, at work, on the road, or watching TV. However, mathematics is about more than just these operations. Mathematics can be used even without numbers. Mathematics is used unconsciously in daily life and even

while thinking. For the solution of a problem, data is put forward, solutions are produced based on these data, the solutions produced are analyzed and the result is tried to be reached most shortly (Umay, 1996). Mathematics is a concept that significantly affects science and technology in contemporary life (Yıldırım, 1988).

According to the definition of TDK, mathematics is a science that covers the branches of science such as arithmetic, geometry and algebra, which form the basis of numbers and measures, and investigates the properties of entities (TDK, 2021). Mathematics enables us to develop our problem-solving skills rationally and gain essential knowledge and skills we use in every aspect of our daily lives (Yenilmez & Dereli, 2009). Mathematics should be offered more than just to teach basic skills and simple calculations. On the contrary, individuals should be offered reasoning, skills to interpret statistics correctly, and many contributions to make sense of their daily lives.

Importance of Mathematics Education

One of the primary purposes of mathematics education is to improve the problem-solving skills of individuals (Baki, 2008). Since mathematics is an essential tool for individuals and societies, mathematics education also has an important place. Mathematics education develops thoughts and ideas (Aydın, 2003). Unfortunately, many students in Turkey think that mathematics is complex and develop low self-esteem, anxiety and negative attitudes. This negative attitude starts in primary school and increases as the school years progress. As a result of this situation, students develop negative attitudes and self-confidence toward mathematics. Students think they are not smart enough to learn mathematics and that mathematics is unsuitable for their interests (Baykul, 2009).

Dealing with mathematical problems improves individuals' thinking, discussion and reasoning abilities (Altun, 2006). To solve mathematical problems, it is necessary to read and analyze the question carefully, to look at it from different angles and interpret it. Then, solutions are produced, the solutions are tested sequentially, and solutions are sought. Thanks to mathematics education, individuals seek solutions by transforming real-life problems into mathematical problems through mathematical models. They can look at problems from different perspectives, produce original solutions and adapt the solutions found to real life. In this way, the real-life skills of individuals develop. In addition, the skills of using mathematical knowledge, producing different solutions, critical thinking, reasoning, establishing relationships, interpreting and persuading during problem-solving also develop. Mathematics is a subject that, unfortunately, has a negative image in society (Aydın, 2003). Mathematics education increases the ability of individuals to think, analyze and reason by

improving their problem-solving skills. It provides the ability to solve real-life problems through mathematical models and develops skills such as inductive and deductive thinking and critical thinking. In addition, it should provide a mathematics education that can explain and analyze the experiences gained within the framework of social interactions by understanding the developing technology.

Mathematics Curriculum

Learning means changing. Therefore, learning is a change in knowledge, attitude and behavior due to an individual's life (Saban, 2004). Mathematics is one of the most important lessons that students should learn. However, this course is perceived by many students as a challenging course to learn (Peker & Mirasyedioğlu, 2003). Although the mathematics course is essential, students generally agree that it is boring and unpleasant (Aksu, 1985). Students who think mathematics is complex may have a negative attitude towards mathematics because they think they cannot succeed in mathematics in a prejudiced way. This situation can continue from the beginning to the end of the student's education. Students tend to develop a negative attitude toward mathematics throughout their education, which may create distrust toward themselves (Yenilmez & Dereli, 2009). Mathematics teaching aims to teach individuals the mathematical knowledge and skills needed in daily life and to develop their problem-solving skills (Altun, 2010). Effective teaching programs should be created to raise individuals who develop a positive attitude towards mathematics, produce knowledge by using active thinking skills, associate it with daily life, develop strategies suitable for the difficulties encountered in daily life, and produce and use knowledge by researching mathematics.

Definition of the Concept of Anxiety

Anxiety is a natural response of people to deal with stress. While this feeling encourages people, it can sometimes hinder them. According to learning theories, anxiety can be learned as a conditioned response. Whether the anxiety is normal or pathological is determined by its severity, duration and external danger (Başarır, 1990). Anxiety is an essential factor affecting the learning process. This anxiety may be caused by students' personality structures, course content or negative experiences. However, it is impossible for students to succeed in the lesson without eliminating anxiety. Learning anxieties, such as fear and anxiety about math, impair and inhibit a student's ability to think, organize, and relate. A study by Rotella & Learner (1993) showed that math fear and anxiety make it difficult for children to think, organize information, and relate. Spielberger (1995) divides anxiety due to the person's perception of the environment as stressful into two state anxiety and trait anxiety. Booms:

State Anxiety

State anxiety is the type of anxiety that occurs due to the situation, which is specific to the situation and is temporary. When state anxiety occurs, the individual's consciousness is clear, and signs of anxiety occur in the individual (Köknel, 1982). Therefore, the cause of the anxiety experienced by the individual is easily understood by others (Şahin, 1985).

Constant Anxiety

The individual tends to experience anxiety. While "trait anxiety" stems from the individual's personality traits, "state anxiety" originates from the expectation of a negative outcome that the individual feels in the face of any specific situation. The negative result felt by the students towards the exams can be given as an example of anticipatory anxiety (Kapıkıran, 2002).

Anxiety in Mathematics Education

Mathematics anxiety causes a person to feel fearful of all math-related stimuli. This fear leads to uneasiness about thinking about mathematics and hinders learning and achievement. As a result, a desire to solve mathematical problems may cause emotional reactions (Bünyamin, 2011). Mathematics anxiety causes emotions such as rush, tension, panic, embarrassment, hopelessness, fear, lack of pleasure and decreased self-confidence. In addition, it can cause many physiological reactions such as math anxiety, difficulty breathing, sweating in the hands, stomach problems and distraction (Bünyamin, 2011; Üldaş, 2005). All these adverse effects limit the person's academic success and career options (Üldaş, 2005).

Mathematics anxiety is a complex emotional state caused by different factors (Aydın et al., 2009). Environmental factors include negative experiences in the classroom, family pressure, inadequate teachers, false prejudices about mathematics, and classroom environments where students are passive. Mental factors are stated as incompatibility between students' learning styles and teaching methods, lack of motivation, giving up easily, wrong perception of mathematics, low self-worth, and lack of self-confidence. Among the personal factors are false prejudices such as being afraid to ask questions in the classroom, embarrassment, stiffness, self-confidence, and seeing mathematics as a field only men can achieve (Aydın et al., 2009). Mathematics anxiety is a problem that arises from the combination of these factors and can negatively affect the student's mathematics learning, achievement and academic success.

Suggestions for Students to Cope with LGS Math Anxiety

The new examination system by the Ministry of National Education in 2018 uses qualified problems to measure students' reading comprehension, interpretation, inference, problem-solving, analysis, critical thinking, scientific

process skills and similar skills (MEB, 2018). These problems differ from what students have seen in previous and written exams. For this reason, developments in the LGS exam create pressure as students struggle to solve such problems. Some experts and critics have expressed that the exam is complex and poorly understood (URL 1).

A study by Güler, Arslan and Çelik (2019) reveals that these exams, which are different from the usual, result from a sudden and radical change. Pepper, Tuna, Uysal, and Kabuklu (2018) emphasized that this situation carries uncertainties for both students and teachers. Students are expected to have difficulties because LGS contains problems that students are not accustomed to and requires specific cognitive skills (Kaya & Kablan, 2018). It is seen that students are less successful in non-routine problems (Çelik & Güler, 2013; Dündar & Yaman, 2015). It can be said that while this situation causes some students to decrease their motivation and increase their math anxiety, it also creates an opportunity for some students to make more effort.

In order to reduce math anxiety in the LGS exam, we can make the following suggestions by taking support from the literature (Kablan and Bozkus, 2021; Yüksel, 2004; Berkedmir, Işık, & Çikili, 2004; Bekdemir, 2007; Aydın & Keskin, 2017; URL 2):

1. **Learn Mathematics Subjects Enough**: Students preparing for the exam adequately learn mathematics subjects, increasing their self-confidence when they take the exam. Therefore, students must ensure they fully understand the topics they have learned and repeat the ones they still need to include.
2. **Apply Question-Solving Techniques and Strategies:** The techniques and strategies to be used while solving math questions in the LGS exam help students give faster and more accurate answers. It may be beneficial for students to learn different techniques and strategies that they can use in the exam, such as the method of similarity and difference, the method of expressing the given information in mathematical expressions.
3. **Use Relaxation and Breathing Techniques:** Exam stress can increase students' math anxiety. Relaxation and breathing techniques can help students reduce exam stress. These techniques may include deep breathing, muscle relaxation exercises, and meditation.
4. **Be Prepared Before the Exam:** Preparing before the LGS exam can reduce exam anxiety. Students need to get a good night's sleep, prepare their exam materials, and plan their route before going to the exam venue.
5. **Positive Thinking and Confidence:** Positive thinking and self-confidence reduce math anxiety. It is essential for students to believe that they will be successful in the exam and to have confidence in themselves so that

exam stress can be reduced and students can study more comfortably for the exam. Anxiety carries an essential relationship between motivation and success. A little anxiety increases students' motivation and learning and drives them to work. It is thought that anxiety about well-known and frequently repeated topics can increase performance. However, too much anxiety can reduce motivation and success (Baltaş, 1995).

6. **Do Physical Exercise and Eat Healthy:** Doing physical exercise and eating a healthy diet can help students feel more relaxed and not stressed during the exam. This can help students feel better and keep their minds sharper before and after the exam. Regular exercise can reduce stress and mental fatigue, allowing students to work more efficiently. A healthy diet can help the body function healthily and increase mental performance.
7. **Get Regular and Effective Study Habits:** Most math questions in the LGS exam can be learned by studying regularly and effectively. Students should devote sufficient time to understanding the math topics required for the exam. This requires developing a regular and effective study habits. Students can better understand math topics by planning ahead, dedicating time to their lessons regularly, and repeating what they have learned.
8. **Read the Questions Carefully and with Understanding:** It is essential to carefully read and understand the math questions in the LGS exam. More than fully understanding the questions can lead to incorrect answers. Students should read each question carefully and understand what is being asked. If the question still needs to be fully understood, students should try to understand the questions by rereading the questions and taking notes if necessary.
9. **Sample questions and solutions:** It is an effective method to reduce math anxiety in practice. In this section, sample questions and solutions for how students can solve math problems can be presented. These examples enable students to approach math questions and reduce math anxiety confidently. Sample questions can be created similar to the questions in the mathematics section of the LGS exam. These questions can be of different difficulty levels and different math topics. For example, questions on geometry, algebra, arithmetic, and data analysis can be prepared. These questions help students prepare for the questions they will face in the actual exam. Solutions describe the necessary steps and mathematical operations to solve the questions. Solutions give students a clear idea of how to solve the questions. In addition, the solutions show students the methods necessary to avoid making mistakes in math questions. Applied math anxiety reduction methods with sample

questions and solutions effectively reduce students' math anxiety. This method increases students' ability to solve math problems and helps them prepare for the questions they may encounter in the exam.

10. **Solve Practice Exams:** Students should solve practice exams to understand the types of questions and difficulties they will encounter in the exam. This can reduce test math anxiety and help students feel more prepared on test day. Practice exams allow students to identify which subjects are weaker and study those subjects further.
11. **Pay Attention to Your Sleep Pattern:** Adequate and regular sleep can help students reduce test anxiety and increase their mental performance. Irregular sleep can increase students' stress levels and cause mental fatigue. Therefore, students must get enough sleep before and before the exam day.
12. **Exam Day Stress Management:** The LGS exam can be a stressful experience and it is vital for students to cope with exam stress. Students should practice stress management techniques before and on the exam day. These techniques may include breathing exercises, meditation, and walking. These techniques can help students have a more relaxed state of mind in the exam by reducing their test anxiety.
13. **Post-Exam Evaluation and Self-Improvement:** After the LGS exam, students need to evaluate the exam and improve themselves. This allows students to identify which subjects they are good at and which they need to work on. By analyzing the exam results, students can determine which topics to focus more on and take the necessary steps to correct their deficiencies. In this way, students can better prepare themselves for the exam.

These subheadings include strategies to help students reduce their math anxiety in the LGS exam. These strategies can help students perform better on exams and overcome test anxiety. However, every student is different, so they need to experiment to determine which strategies are most effective.

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NEW GENERATION QUESTIONS IN MATHEMATICS EDUCATION

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Abstract

Rapid developments in the 21st century are driving societies to social, cultural and economic changes and transformations. Especially advances in information and communication technologies change the human profiles that countries need. This change has made it essential to raise qualified individuals who can offer creative solutions to social problems, have analytical thinking skills and can think critically (Polat, 2017). Therefore, the most effective way to adapt individuals to the needs of the age is through education. With the constant changes in the world, the importance of education is increasing, and societies have realized that educated individuals have a fundamental impact on the development of society by making education compulsory with this awareness (Nayıroğlu, Tutak, & Tutak, 2021). The places where education is most efficient and effective are formal education institutions, namely schools. Schools must renew to keep up with the change process and organize their education programs according to these developments. Educational institutions in countries that have adopted the modern education approach apply for specific exams to evaluate whether their educational goals are realized. These exams allow for reviewing and revising education policies. In addition, the results obtained from these exams allow the education systems of other countries to be compared with their own. Such international examinations are conducted through tests such as PISA and TIMSS. Turkey regularly participates in such exams, and the Ministry of National Education organized exams in 2018 with new-generation questions in high school and university entrance exams. In this way, it is aimed to achieve the desired success in international exams. This research it is aimed to provide information about the new generation's questions in mathematics education by doing a literature review.

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Introduction

In the age of information and technology, societies are experiencing a great process of change and transformation in terms of social, economic and cultural aspects. In this process, information spreads rapidly and reaches all parts of the world. Advances in science and technology have led to the accumulation and accumulation of knowledge. The need for qualified individuals who can distinguish the correct information, and think critically, think analytically and creatively in this mass has become indispensable for countries (Polat and Kontaş, 2018).

Education is a process that takes place in all areas of life and continues in schools and throughout life. Many disciplines are included in formal education institutions in schools, and one of these disciplines is mathematics. Mathematics course requires individuals who can think critically, have analytical skills and offer creative solutions. Countries apply to tests such as PISA and TIMSS to determine the quality of education offered and its position at the international level. These exams determine students' literacy level in reading comprehension skills, mathematics and science (MEB, 2019).

In order to increase success in international exams, Turkey has started to include skill-based questions in exams such as the high school entrance exam (LGS) and university entrance exam (YKS) (Ormancı, 2019). Such questions measure students' high-level thinking skills (Duran & Bahadır, 2022). In this way, it aims to increase students' success in international exams (Erden, 2020). However, Turkey's rankings in mathematics in international exams are not at the desired level. Mathematics test averages are low in LGS and YKS exams. The rate of students answering the questions correctly is low and the rate of questions left blank in the exams is high (MEB, 2018). This is due to the lack of a qualified mathematics education program and the fact that students are not used to such questions (Ekinci & Bal, 2019).

In this study, studies in the national literature on skill-based questions in the field of mathematics education were examined. This research will likely contribute to teachers and researchers who want to work in this field. In this way, it aims to reveal the problems and solution suggestions related to using skill-based questions in mathematics education.

Problem Status

Mathematics education aims to gain knowledge and problem-solving skills that can be used in daily life by making abstract information concrete (Güler, Arslan, & Çelik, 2022). Maths; has a vital role in fields such as economy,

engineering, science and technology (İncebacak, 2022). However, mathematics lesson has become the nightmare of students in many countries. In this field, where there are new generations and skill-based questions, mathematics has become more difficult because it is a subject that is not understood anyway. For this reason, countries aim to prepare individuals for these questions by including them in their mathematics curriculum (Atiktürk, 2022).

In the international exams, the countries' success in mathematical literacy has critical importance. However, the average mathematical literacy scores in these rankings could be higher. In order to overcome this problem, skill-based and new-generation questions have started to be used in the exams held in our country, especially in the field of mathematics. In order to reach a successful level in new generation mathematics questions, it should be determined how students think about these questions, how they perceive the questions and what attitude they develop towards them (Azili & Tutkun, 2021).

In this context, the place and importance of skill-based questions in mathematics lessons were explained by focusing on PISA and mathematical literacy to analyze the current situation in mathematics better.

Purpose of the study

This study aims to provide information by scanning the literature on new-generation mathematics questions. This study is essential for understanding the importance and impact of new-generation questions in mathematics education.

Method of Study

In this study, the document analysis method, one of the qualitative research methods, was used. Document analysis examines the existing written source of the researched subject (Hitchcock & Hughes, 1995). Document analysis is also defined as examining visual materials containing information about the event or phenomena planned to be investigated (Yildirim & Simsek, 2008; Çelik et al., 2022). The primary purpose of document analysis is to examine the obtained documents in a theory-oriented, systematic and data-based manner (Saglamoz & Soysal 2021).

PISA and Mathematical Literacy

PISA is the Program for International Student Assessment and has been run by the OECD since 2000. This program aims to identify education levels and deficiencies among developed countries. PISA exams are held every three years and target 15-year-old students from OECD member countries. These exams assess the extent to which students can use the knowledge and skills acquired daily. PISA exams include tests in reading skills, science, and mathematical literacy. In this way, it helps to identify strengths and areas for improvement in countries' education systems (OECD, 2019).

Forty-three countries took part in the first test of PISA and the number of participating countries increased in the following years (MEB, 2019). Since Turkey became a member of the OECD in 2003, it has started participating in PISA exams. The PISA exam assesses reading skills, science and mathematical literacy.

The ability to understand the problems encountered in daily life and to offer creative solutions, which requires mathematical intelligence, requires mathematical literacy. Analyzing and interpreting numerical data is also an essential skill in this field. Therefore, individuals need to have high levels of mathematical literacy. However, mathematics education needs to be given in schools at a sufficient level (Akdemir & Akdemir, 2022).

In order to increase the level of mathematical literacy, mathematical models should be used, these models should be evaluated in the problem-solving process, and mathematical literacy should be used effectively in daily life. Mathematical literacy links the mathematical knowledge taught at school and the knowledge encountered daily (Yılmaz & Doğan, 2022). In this way, mathematics becomes an essential tool for making intelligible and mathematically-based judgments or reasoning in real-life situations.

Mathematical literacy helps individuals realize mathematics's role in the world and contributes to making well-founded judgments and decisions by making them constructivist and thoughtful individuals (OECD, 2013).

Technology and computer concepts are essential in daily life, business life and education for modern societies and education systems (Tutak, İlhan, & İç, 2018). In daily life, especially in many fields such as economy and weather, and in technologies created by science and technology, mathematical language is at the forefront, and people encounter this mathematical language. In this context, mathematical literacy includes understanding and using mathematical knowledge. Mathematical literacy attaches importance to understanding mathematics in real-life situations and establishing a solid foundation when assessing or creating a justification (Çolak, 2022).

Mathematical literacy refers to an individual's capacity to formulate, use and interpret mathematics in various contexts. This capacity includes thinking mathematically and using mathematical concepts, procedures, facts and tools to explain and predict phenomena. This enables individuals to realize mathematics's role in the world and helps them make well-founded judgments and decisions as constructive and thoughtful citizens (OECD, 2013).

Skill Based Questions

An education vision document for 2023 has been created in our country, which focuses on learning by doing, meaningful learning and high-level

thinking skills. The Education Vision Document, published by the Ministry of National Education in 2018, emphasizes the 21st-century skills targeted for 2023 and the training of individuals with high-level thinking skills. It is stated that these skills are indispensable for 21st-century societies. The 2023 Education Vision Document aims to gain problem-solving, critical thinking, productivity, teamwork and multi-literacy skills through "Design and Skills Workshops" (MEB, 2018).

In developing these skills, new generation questions that combine daily life skills and school knowledge in the education given in schools; in other words, skill-based questions play an important role. For this reason, changes have been made in our country's assessment and evaluation approach for transition exams such as LGS and YKS. In 2018, new-generation questions, including skill-based ones, were included in LGS exams for the first time.

Skills are the ability of people to propose creative solutions to the problems they encounter and solve them (Cansoy, 2018). The concept of skill in education has a different meaning. Skills in education are the abilities that individuals acquire, develop and use by combining them with their daily life experiences during the education process. Skill can also be defined as the ability to acquire new knowledge through acquired knowledge.

The new generation questions adopted in our country, namely skill-based, consist of context-based questions. In these questions, the problems and obstacles individuals may encounter daily are asked to be solved. The first step in solving a problem is to understand that problem fully. Problems are presented to students in a real-life context. Because problems and questions that are not context-based and not associated with daily life cannot be considered the basis of life (Elmas & Eryılmaz, 2015).

Evaluation of Mathematical Literacy

In the 21st century society, mathematical thinking skills and the existence of mathematical understanding gain importance. Individuals who grow up in schools face the problems of the age and need to define and understand these problems and overcome them with creative solutions. Measurement and evaluation to be made in the last stages of compulsory education give individuals experience in solving the problems they will encounter in their future lives. At this point, the mathematical literacy in the PISA exam allows individuals to transfer mathematics to their daily life experiences.

Encountering students with mathematical problems related to daily life allows them to develop their skills. At the same time, this structure aims to reveal students' reasoning skills and ability to use mathematical concepts and tools while explaining mathematical events. Mathematical literacy enables

individuals to realize how much mathematics is involved in daily life and helps them make the right decisions when faced with problems. The concepts of formulating, applying and interpreting are indicators of the active involvement of individuals in mathematical processes. Therefore, the mathematical model and mathematical literacy should be intertwined.

When the questions in the PISA exam are examined, it is seen that descriptive expressions suitable for mathematical literacy qualifications are seen. Three factors are prioritized in the assessment:

- Mathematical processes
- Competence in mathematical processes
- Mathematical content context

Based on this evaluation, the concept of mathematical literacy has the quality of answering three questions:

- Which processes do students follow for contextual problems? What skills are developed as mathematical literacy progresses?
- What mathematical subjects do 15-year-olds know?
- How should the observation and evaluation of mathematical literacy be carried out? (OECD, 2019).

Mathematical processes include formulating, using mathematical tools, and interpreting and evaluating results specified in mathematical literacy. Questions in PISA mathematics applications also follow these three processes.

The formulation process aims to improve the ability to solve problems by using mathematics when faced with problems. In this process, the ability of students to understand the problem and interpret it with mathematical expressions is essential. There are steps such as defining mathematical problems associated with daily life, identifying variables, preparing for mathematical analysis, identifying constraints and assumptions, and expressing the problem mathematically. It is also essential to understand the connection between contextual and formal language and to translate the problem into mathematical language. It is aimed at solving mathematical problems by making use of technology.

In the use process, skills such as applying mathematical concepts, facts and processes to the formulated problem, applying mathematical strategies, using tools and technologies, using algorithms and rules in problem-solving, and applying graphical and statistical data are aimed. It is also vital to make generalizations based on the results obtained.

In the interpretation process, it aims to evaluate the results obtained in real-life conditions, to interpret them according to the context of the problem and

to evaluate their logic. It is vital to examine the logical harmony between the result and the context and to interpret the result by turning it into the context of the problem.

Implementing these processes aims to improve students' mathematical thinking skills, ability to use mathematical concepts, and ability to solve problems. The questions in the PISA exam are also designed to evaluate these skills (PISA, 2015).

Basic Mathematical Skills in Mathematical Processes

In the PISA exam, students' mathematical literacy skills are measured. As a result of the analyzes made by Niss (2003), it was determined that eight different abilities were examined in the PISA exam. However, in later PISA implementations (like 2018), these capabilities have been reduced to 7. These abilities include a mathematical understanding of real-life situations and problem-solving abilities. It is known that as the difficulty level of mathematical problems increases, students' problem-solving skills also increase.

Mathematics questions in the PISA exam measure students' use of communication skills, their ability to formulate mathematical problems, their ability to reason and prove, their ability to use symbolic and technical language and operations, their ability to use mathematical tools, and their ability to interpret and evaluate results.

Communication ability involves students explaining their thoughts and using communication as a tool while solving problems using mathematical formulas and symbols. The ability to mathematize refers to transforming real-life problems into mathematical expressions and relating mathematics to daily life.

The ability to reason and prove involves logical thinking processes such as concluding the statements in the problem, checking the given proof, and making logical connections. The ability to use symbolic, formal and technical language and operations includes understanding, using and interpreting symbolic expressions. The ability to use mathematical tools includes recognizing and using tools that can be useful in the mathematical solution process.

The ability to interpret and evaluate the results, on the other hand, refers to the ability to interpret and evaluate the mathematical results obtained in real-life conditions.

These abilities play an important role in determining the core competencies of mathematical literacy. Students' mathematical skills and abilities are measured by evaluation in the PISA exam, and it contributes to the development of mathematics education (OECD, 2019).

Results

The study results show that new-generation questions have significant potential in mathematics education. New generation questions allow students to develop their skills in encountering real-life problems and solving these problems. Next-generation questions encourage mathematical thinking skills and enable students to relate mathematical concepts to their daily lives. This increases mathematical literacy and improves students' ability to use their mathematical thought processes daily. The use of new-generation questions is essential in mathematics education. Teachers should include realistic and challenging questions relevant to daily life in their lessons to support students' mathematical skills and problem-solving abilities. In addition, education policies and curriculum designs should encourage the inclusion of next-generation questions and support this approach to raise students' mathematical literacy.

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AUGMENTED REALITY IN GEOMETRY EDUCATION

Ayşegül GÖKHAN[1], Turgay AKGÜN[2]

Abstract

This study investigates the effect of using augmented reality (AR) technology in geometry education. The research was done with a literature review method through various academic databases and search engines. This research aims to determine how AR can contribute to geometry education and help students better understand geometric concepts. AR technology can help students visualize abstract geometric concepts more concretely by enabling virtual objects to be displayed in real life. The literature review results reveal the potential advantages of AR in geometry education. Students can develop a deeper understanding when they have the opportunity to explore and interact with geometric objects in a real-world setting. AR apps can make learning fun and engaging for students, increasing their motivation. In addition, it has been observed that AR is effective in improving students' visual intelligence and spatial skills. However, some things could be improved in using AR in geometry education. The design and development of AR applications are time-consuming and costly. In addition, teachers need to receive appropriate training and support to use AR technology effectively. It is also possible for students to adapt to AR technology and encounter some technical problems. In conclusion, this literature review reveals the potential advantages and challenges of AR in geometry education. It has been concluded that AR technology can be an effective learning tool in geometry teaching and help students better understand geometric concepts. However, the practical problems and difficulties associated with using AR should also be considered.

Keywords: *Geometry Education, Technology, Augmented Reality*

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Introduction

The primary purpose of education is to educate individuals as individuals who can be successful in daily life and have reasoning, problem-solving, and critical thinking skills. More opportunities and guidance should be provided to develop students' higher-order thinking skills (Erdoğan, 2019). Therefore, mathematics, especially geometry, is a critical daily subject that needs to be understood (MEB, 2006). Geometry is a sub-discipline that helps us to systematically describe the world and understand nature (Yolcu, 2008). Geometry contributes to developing visualization, reasoning ability, and understanding of the natural world (NCTM, 2000).

The importance of geometry in everyday life is indisputable. For example, geometry is needed even in simple problems such as wallpapering, framing, and tiling (Altun, 2001). Geometry is also used in many fields, such as science, art, architecture, painting, and music. Geometry is also of great importance in terms of school mathematics. According to the National Council of Mathematics Teachers (NCTM), the geometry course teaches students about geometric shapes and structures, their basic properties, and their relationships. In addition, this course develops students' decision-making and reasoning abilities. Students with a good command of geometry concepts and strong spatial awareness are ready to learn advanced mathematics, numbers, and measurement subjects more easily (Cantürk-Günhan, 2006).

Geometry enables individuals to describe, analyze and evaluate their environment more realistically. In addition, geometry is a primary tool for gaining knowledge and skills in many branches of science. Geometry is an essential component of problem-solving strategies and supports the development of skills such as design and diagramming. Also, geometry plays a vital role in many professions, for example, architects, designers, cartographers, etc. It is an essential aid for Geometry, supports mental development, and contributes to developing skills such as constructing and verifying propositions. Teaching geometry, starting with games and puzzles at an early age, constitutes the most exciting and enjoyable part of mathematics, thus helping students develop a positive attitude toward mathematics (Okur, 2006). As a result, geometry is essential as a skill used in daily life and mathematics education. Students mastery of geometry helps them better understand mathematical concepts while improving their visual and analytical thinking skills. The role of geometry in daily life contributes to individuals' understanding of their environment, solving problems, and improving their thought processes.

Although geometry is an important field, the results of national and international exams have shown that our country still needs to achieve sufficient success in geometry. Turkey's low level of success in various international

exams emphasizes the necessity of using more games, activities, and active learning methods in mathematics and geometry education (Toluk-Uçar, 2005). These techniques can pave the way for developing positive attitudes towards mathematics and geometry by making lessons more exciting and fun. Students with a positive attitude towards geometry devote more time to mathematics, do their homework, and deal with mathematics-related topics outside school. On the other hand, students who develop a negative attitude towards geometry may turn away from mathematics and are not interested in mathematics-related subjects. This may cause the student to fail the mathematics course. Especially considering the sequencing and ordering of the subjects in the mathematics lesson, the negative attitude developed by the student towards mathematics or a subject may affect the whole mathematics teaching. Students develop a negative attitude when they fail and fail as a negative attitude develops. Attitude and success mutually affect each other. Many studies have revealed that activity- and game-based instruction helps students develop a positive attitude and make the lesson more enjoyable (Yıldız, 1997; Trisha, 1999; Soylu, 2001; Köroğlu & Yeşildere, 2002). Therefore, teaching geometry is of great importance. However, geometry education is still at the forefront of the courses faced with many problems in our country. Teachers and researchers have significant responsibilities in solving these problems.

Problem Stuation

In recent years, many innovations have been made in education worldwide, and developing countries attach great importance to education. In this context, it is necessary to make improvements in courses such as geometry in which there are difficulties in our country. Geometry stands out as a lesson in which students struggle with learning because it is an abstract subject. Therefore, the concretization of geometry can help students to understand this lesson more easily. In recent years, concrete teaching materials have been used in geometry education. Also, the use of technology is gaining importance and augmented reality (AR) has become popular in this field recently. This study emphasizes the benefits of augmented reality in geometry education and how its use can improve students' learning experience.

Method

This study used the literature review method, and the data analysis was carried out with document analysis. Document analysis is a method that includes obtaining data by examining source documents. Document analysis also includes the process of reading, taking notes and evaluating printed and electronic materials (books, articles, internet resources) (Karasar, 2005). In other words, document analysis refers to examining written materials containing

information about the investigated phenomenon or phenomena (Bowen, 2009). This process includes finding, reading and analyzing documents for research purposes (Yıldırım & Şimşek, 2013).

Augmented Reality

Technology and computer concepts are essential in daily life, business life and education for modern societies and education systems (Tutak, İlhan, & İç, 2018). The rapid development of technology is a factor that directly affects our lives. In addition to existing technologies, new technologies are constantly being developed and used. These new technologies are made more valuable and functional with scientific methods. Scientific research contributes to the development of new technologies as well as providing the regulation of existing technologies. In this way, science and technology form a cycle that supports each other (Kapucu & Yıldırım, 2019). Technology develops due to human efforts to question, shape and change their environment. Today's lifestyle represents the age of information and technology by offering environments that involve interaction between thinking, learning and digitalization. The increase in mobile systems and the ease of accessing information from anywhere at any time has increased the diversity of Augmented Reality (AR) applications. In particular, virtual and augmented reality concepts offer the opportunity to redesign and systematize natural spaces and objects (Gümüş & Boydaş, 2021).

Augmented reality (AR) is an application that emerges with the addition of virtual materials in the real world. It is expressed by the term Augmented Reality, abbreviated as "AR". AR applications offer a wide range of information by projecting data through an optical lens onto a specific object. For such an application, it is necessary to use hardware software programs (Gümüş & Boydaş, 2021).

Şekil 1. Sutherland ve Sproull, Democles'in Kılıcı, VR Teknolojisi

The first example of reality technology emerged in 1962 with Morton Heilig's work called Sensorama. Augmented reality was first used in 1992 when it assisted technicians in arranging electrical wiring through a program designed by Tom Caudell and David Mizell. This education-oriented practice formed the basis of the Augmented Reality concept (Caudell & Mizell, 1992).

Incorporating reality into life began with the development of a virtual reality headset called "The Sword of Democles" by computer scientists Ivan Sutherland and Bob Sproull. Subsequently, many innovative studies have been carried out combining virtual and augmented reality. The emergence and rapid spread of the Internet, the interaction of people over the Internet and the creation of interactive worlds have accelerated a sectoral transformation of studies in virtual and augmented reality (Gandolfi, 2018). Sutherland and Sproull's Sword of Democles, VR technology example is given in Figure 1 (Ceken & Karataş, 2022). Computers can develop themselves and have specific abilities thanks to artificial intelligence technology. Virtual reality (VR) and augmented reality (AR) technologies have been used in many sectors such as education, military, design, sports, entertainment and health. However, our country still needs to improve these technologies (Boz, 2019).

Today, using digital tools and materials in education has become inevitable. Technological tools are needed, especially in teaching applied sciences such as mathematics, geometry and science. With the widespread use of the Internet, hyper-media such as video, audio, animation, and pictures and Web 2.0 tools have been used more widely in learning and teaching environments (Andersen, 2007; Greenhow, Robelia & Hughes, 2009). Today, new applications are developed through mobile and wearable technologies and used in learning environments. One of these innovative digital technologies is augmented reality (AR) technology (Akkuş & Özhan, 2017). In augmented reality, users can interact with virtual objects superimposed on a real-world image. In this way, augmented reality complements the real world (Azuma, 1997). Augmented reality is a new technology area where the digital environment and the natural world are combined (Berryman, 2012). Augmented reality technology can offer an educational environment where difficult, costly or impossible materials can be experienced more quickly in the classroom (Atasoy, Tosik-Gün & Kocaman-Karaoğlu, 2017). Augmented reality refers to technologies in which virtual components are integrated with physical elements in real-time (Cheng & Tsai, 2014). It is seen that augmented reality is shaped in different dimensions with the empowerment of computers, the spread of the Internet, the spread of mobile devices and the diversification of wearable technologies (Altınpulluk &Kesim, 2015). It can be said that academic studies on augmented reality in education have become widespread and vital especially in the last 20 years (Abdüsselam & Karal, 2015; Bower, Howe, McCredie, Robinson & Grover, 2014; Somyürek,

2014). Studies on the use of augmented reality at the K-12 and higher education level show that augmented reality technology increases students' interest in lessons and academic success and makes lessons more enjoyable (Chen, 2006; Ibili, 2013; Ivanova & Ivanov, 2011; Solak & Yılmaz, 2014).

Result and Suggestions

Geometry course is one of the courses that students have difficulty in the learning process. Since geometry includes an abstract subject, students may need help learning when their abstract thinking skills are not developed. Many innovations have been tried in recent years to overcome these challenges. These include the use of concrete learning objects and technology-based approaches. Concrete learning objects can be beneficial as they embody geometry learning. However, one of the difficulties encountered in this approach is the need for more materials. Accessing enough materials can be both difficult and costly. For this reason, economically more suitable methods have been developed and technology plays a vital role.

With the constant changes in the world, the importance of education is increasing and societies have realized that educated individuals have a fundamental impact on the development of society by making education compulsory with this awareness (Nayıroğlu, Tutak and Tutak, 2021). Augmented reality can offer all kinds of possibilities in virtual environments. For example, if an automaker works on a new model, it must produce a prototype and undergo various durability tests. These tests can often be costly and dangerous. This is where virtual environments come into play. Performing these tests in virtual environments will be cost-effective and safe. Augmented reality has begun to be used more and more in the field of education, as it is in all areas of life. It provides excellent benefits, especially in concretizing geometry, which is an abstract subject, and in providing a meaningful and permanent learning experience.

The use of virtual environments in geometry teaching has not only solved the problem of lack of materials but has also become quite affordable in terms of cost. In these environments, desired learning environments can be created and students' learning process can be made more accessible. Despite the limited studies in our country, more developments are seen abroad in this regard. In the last 20 years, it has been observed that academic studies on augmented reality (AR) in various fields of specialization in education have become widespread and their importance has increased (Bower, Howe, McCredie, Robinson, & Grover, 2014; Erbaş & Demirer, 2014). Studies conducted at K-12 and higher education levels show that AR technology increases students' interest in lessons and their academic success (Bower et al., 2014; Chen, 2006; İbili, 2013; Küçük et al., 2014). In addition, it is known that AR makes lessons and learning more

fun (Gün, 2014; Solak & Yılmaz, 2014). The literature review also reveals that studies in this field greatly benefit students. It is stated that AR has potential advantages in geometry education.

Students can develop a deeper understanding by exploring and interacting with geometric objects in a real-world setting. AR applications can increase students' motivation by making learning fun and engaging. It has also been observed that AR can help students improve their visual intelligence and spatial

skills. It has been concluded that AR technology can be an effective learning tool in geometry teaching and help students better understand geometric concepts. However, some practical issues and difficulties with the use of AR should also be considered. The design and development of AR applications is a time and costly process. In addition, teachers need to receive appropriate training and support to use AR technology effectively. Some students may need help to get used to AR technology or encounter technical difficulties. Future educational applications in mathematics and geometry are expected to focus on optical-based intelligent glasses. In this way, interaction and usability can be increased. In addition, interactive and gamified AR applications can be developed that focus on common misconceptions in mathematics and geometry. AR applications and content can be developed so that AR technology can be used more widely in education. In addition, determining strategies for AR use and including it in curricula can significantly benefit.

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MATHEMATICS EDUCATION AND HISTORY OF MATHEMATICS

Burhanettin TURĞUT[1]

Abstract

Mathematics has always taken its place in history as a complex subject for students. This difficulty may be due to the teachers' approach or the abstract nature of mathematics. Since mathematics is an abstract course that makes it difficult for students to understand, this situation continues constantly. Countries have developed various methods and techniques to understand mathematics better in recent years. Since it is related to the level of education and development of countries, countries have recently given more importance to developments in the field of education. The use of the history of mathematics in mathematics education is also a topic that has been discussed recently. The use of the history of mathematics in mathematics education has been supported for a long time. In our country, the history of mathematics has started to be used in the primary school mathematics program, which was implemented in 2005. In this study, first of all, the use of the history of mathematics in mathematics education is discussed in the light of the literature. Then, it was discussed whether the history of mathematics should be used as a tool or a goal in mathematics education.

Keywords: *Mathematics, Mathematics education, History of mathematics*

Introduction

With the constant changes in the world, the importance of education is increasing and societies have realized that educated individuals have a fundamental impact on the development of society by making education compulsory with this awareness (Nayıroğlu, Tutak, & Tutak, 2021). For many students, mathematics is perceived as lessons that poison their lives, exams that scare them, and a nightmare they will get rid of after school (Sertöz, 2002). Students see mathematics as disconnected from other disciplines and daily

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life, preventing them from understanding mathematics (Yıldız, 2013). As a result of this alienation, mathematics becomes unloved and even feared subject for many students (Gürsoy, 2010; Ufuktepe, 2003). History of Mathematics (MT) is one of the innovations that will make students love mathematics and make mathematics less scary (Gulikers & Blom, 2001). The use of the history of mathematics in mathematics classrooms is not a new topic of discussion. However, using the history of mathematics in mathematics learning and teaching processes has received more scientific attention in recent years (Baki & Tümer, 2013). Should the history of mathematics (MT) be used in mathematics lessons? Studies show that students can have positive thoughts about the use of MT in mathematics lessons, as well as develop the idea that there is no point in using MT in lessons. One of the reasons why students develop negative thoughts about using MT in mathematics lessons is that they are confronted with intense and complex historical content unrelated to the mathematics curriculum achievements (Bütüner, 2014).

In order to overcome the anxiety and fear of mathematics, a mathematics course enriched with the history of mathematics can be applied as an effective mathematics teaching method. It is thought that using the history of mathematics in mathematics teaching will contribute positively to students' learning with a historical perspective, improving their skills to solve more complex problems and increasing their logical thinking skills (İdikut, 2007; Özcan, 2014). Looking at the history of mathematics, it is seen that ancient mathematicians preferred methods such as cutting, modeling and reaching generalizations in their problem solving processes (Swetz, 1994, p.139). Therefore, the use of the history of mathematics in mathematics teaching is supported by many researchers (Bidwell, 1993; Liu, 2003).

Among the programs made since 2005, the program in which the history of mathematics is given the most place is the 2005 program. When the primary school mathematics curriculum is examined, it is seen that projects under the title of "history of mathematics" are among the general objectives of mathematics education with the statement "The historical development of mathematics and understanding the role and value of this development in human thought and the importance of its use in other fields" (MEB, 2005). It is stated that the history of mathematics is also included under the heading of measurement and evaluation.

NCTM (2000) explains the reasons for using the history of mathematics in lessons with the benefits it will provide to students, such as increasing motivation, developing positive attitudes, showing the difficulties in the development process of mathematics, and improving mathematical thinking with historical problems. In the mathematics curriculum, it is recommended to use the history of mathematics in lessons to give students an idea about the

development of mathematics, improve their attitudes towards mathematics and mathematics learning, and make mathematics more meaningful for students. In this context, examples of mathematics history can be presented to ensure that students are interested in mathematics (MEB, 2018).

Purpose of the research

In this study, the use of the history of mathematics in mathematics education was first discussed with the literature review. Then it was also discussed whether the history of mathematics should be used as a tool or a tool in mathematics education.

Research Method

In this study, the document analysis method, one of the qualitative research methods, was used. Document analysis examines the existing written source of the researched subject (Hitchcock & Hughes, 1995). Document analysis is also defined as examining visual materials containing information about the event or phenomena planned to be investigated (Yildirim & Simsek, 2008; Çelik et al., 2022). The primary purpose of document analysis is to examine the obtained documents in a theory-oriented, systematic and data-based manner (Saglamoz & Soysal 2021).

Using the History of Mathematics in Mathematics Education

In general, it can be said that the use of the history of mathematics in mathematics teaching makes a significant contribution to the development of students' mathematical thinking and problem-solving skills, to make sense of the mathematics lesson, to compare mathematics subjects between the past and present, and to associate mathematics with other disciplines (Sullivan, 1985; Ho, 2008). Fried (2001) gathered the reasons that require using the history of mathematics under three themes. According to Fried, the history of mathematics will make students realize that mathematics has a multicultural nature, make mathematics understandable, exciting and approachable, and provide insight into mathematical concepts, problems and solutions. Through these themes, students will have the opportunity to understand that mathematics is a social activity and its place in social life. Gulikers and Blom (2001) discussed the necessity of using the history of mathematics under three categories. These categories were classified as conceptual discussions, multicultural discussions, and motivational discussions. The discussion about motivation stated that the history of mathematics would increase students' motivation by enabling them to explore different solutions and reduce their fear of mathematics. It is also supported by other studies that the history of mathematics can make mathematics lesson fun and increase students' attitudes and motivations about mathematics (Fauvel, 1991; Swetz, 1997). The history of mathematics in

mathematics teaching emphasizes that mathematics is a human activity and does not consist of solid and unchanging information, revealing that mathematics has a dynamic structure affected by social and cultural factors, and this is a part of multicultural discussions.

Tzanakis and Arcavi (2000) explained the importance of using the history of mathematics in lessons with five items. According to them, using the history of mathematics will help students learn the relevant subject, improving their perspective on the nature of mathematics and mathematical activities. In addition, it will enrich teachers' educational backgrounds and teaching repertoires, positively affect their affective tendencies toward mathematics, and enable them to evaluate mathematics as a cultural and human product.

The National Council of Teachers of Mathematics (NCTM) in the USA emphasized that the history of mathematics should be integrated into mathematics teaching. They explained the reasons for using the history of mathematics in mathematics teaching under five headings:

1. To increase motivation and develop a more positive attitude towards mathematics.
2. To understand the difficulties of learning mathematics today by observing the situations that hindered the development of mathematics in the past.
3. Developing a perspective by incorporating the human factor into mathematical knowledge by using historical sources.
4. To guide learning history.
5. Historical problems to develop students' mathematical thinking.

Liu (2003), on the other hand, presented five reasons why the history of mathematics should be included in the lessons. These reasons are:

1. Historical knowledge increases students' motivation and helps them to have a positive attitude toward mathematics.
2. Seeing the difficulties encountered in the development process of mathematics helps students to solve the problems they are currently facing.
3. Solving problems from history contributes to developing students' mathematical thinking.
4. History reveals that mathematical knowledge has a human nature.
5. History of mathematics guides teachers.

Integration of the History of Mathematics into the Learning –Teaching Process

If the history of mathematics is used as a goal, the historical development and cultural dimension of mathematics are transferred to the students. This approach includes using the history of mathematics as a goal in teaching mathematics (Baki, 2014). Students develop their thinking and evaluation skills about the historical development of mathematics with the influence of the history of mathematics (Jankvist & Kjeldsen, 2011). For example, the teacher's handling of the subject that Kharizmi develops algebraic expressions in the classroom and evaluating the development processes of algebraic expressions in this direction can be an example of using the history of mathematics as a goal.

If the history of mathematics is used as a tool, the history of mathematics is used to help teach a particular subject in mathematics lessons (Alparslan & Haser, 2012). With activities based on the history of mathematics, students' motivation is increased, different proofs are demonstrated with historical approaches, and the positive and negative aspects of modern approaches based on the history of mathematics are compared. For example, teaching the subject of algebra based on algebraic sources used by Harizmi can be an example of using the history of mathematics as a tool. Along with these explanations, using the history of mathematics as a goal or a tool in teaching mathematics helps students to understand mathematics in its historical context and develop their mathematical thinking skills. Baki (2014) summarized and tabulated the use of the history mentioned above of mathematics as a goal and a tool, as in Table 1.

Table 1. Using the History of Mathematics as a Tool and Purpose

• Using the history of mathematics as a tool	• Using the history of mathematics as a goal
• If it is used to teach a subject in mathematics	• If it is used to show the evolving nature of mathematics and that it is the product of human labor.
• If used to compare with modern solutions	• Used to show the historical development of mathematical techniques and notations
• It is used to show students and teachers the different solution and proof approaches used by different cultures.	• If it is used to show that mathematics developed in different ways in different cultures and took its present form.

Jankvist (2009) highlights two essential aspects of using the history of mathematics in mathematics education. The first is using the history of mathematics as a tool to assist in effectively learning and teaching mathematics. The second is using the history of mathematics as an end in itself. In this way, it aims to show students that mathematics has existed and developed in time

and space in different cultures throughout history and that these cultures played an essential role in shaping mathematics or these cultures. When the history of mathematics is used as a goal, it forces students to think of mathematics not as a well-defined knowledge consisting of indisputable and immutable facts but as a developing and changing knowledge (Barbin & Menghini, 2000).

Swetz (1994) states that the history of mathematics can be used in five different ways in the learning-teaching process:

(a) To learn about the life and work of mathematicians.

(b) Learning the origins and meanings of mathematical terms, symbols and words.

(c) Identifying classical or historical problems and investigating their origins or significance.

(d) Practice activities based on historical problems or discoveries.

(e) Using historical films or videos in the classroom.

Bidwell (1993) suggests three different ways of using the history of mathematics in the classroom:

1. Showing photos and lives of famous mathematicians.
2. Use of historical materials during the lesson.
3. Making the historical development of mathematics subjects a part of the course.

The first can be accomplished using encyclopedias, dictionaries, biographies, or words and symbols that describe mathematicians. The second way involves giving information such as the emergence process of each concept on that subject and by whom it was discovered while discussing it. The third way involves referring to the historical development process when describing a topic or solving a problem. For these methods to be used effectively, teachers must be well-equipped in the history of mathematics and willing to stretch the traditional curriculum.

Tzanakis and Arcavi (2000) propose thirteen different methods for using the history of mathematics in classrooms. These are historical sections, research projects based on historical texts, sources, worksheets, historical packages, using mathematicians' mistakes and changing perspectives, historical problems, mechanical tools, experimental math activities, games, movies and other visual materials, out-of-school experiences, and internet classroom methods. On the other hand, Fried (2001) states that we can use the history of mathematics in two different ways as addition and harmony in lessons. In addition, historical sections and short life stories of mathematicians can be told, or historical problems can be mentioned in the classroom. In this method, the curriculum is

only expanded without changing the curriculum. In the adaptation method, the teaching of the subject is carried out by a historical scheme, and the curriculum is adapted to historical conditions or a historical model (Baki & Tümer, 2013). The teacher uses the historical development of that subject as a guide in teaching any mathematics subject (Fried, 2001).

The history of mathematics can explain some subjects better to students, increase their motivation, and help them develop a positive attitude toward mathematics (Swetz, 1994). For example, Fried (2001) emphasized that presenting the methods and thoughts of ancient mathematicians on this subject can enrich class discussion while using the perfect square completion method to find the roots of quadratic equations. Similarly, it is stated that simplifying Hârezmî's ideas about geometric algebra can allow mathematics teachers better to explain quadratic equations (Vinogradova, 2007). In this way, teachers can facilitate students' understanding by associating mathematical concepts with visual objects. Sfard (1995), on the other hand, states that examining its historical development is an essential method for analyzing any mathematical concept. Therefore, the history of mathematics and an effective tool for exploring complex mathematical facts or concepts also contribute to mathematics teachers' mathematical and pedagogical preparation (Fauvel, 1991; Liu, 2003).

Result and Suggestions

Many researchers have emphasized that integrating the history of mathematics into lessons contributes to the development of teachers' field knowledge and teaching professional knowledge and skills and to the cognitive and affective development of students (Yıldız, 2013). For this reason, it is essential to include the history of mathematics in the curriculum to make the learning-teaching process more qualified (Bütüner, 2014).

However, the literature review shows that it is essential for the teacher to be emotionally and cognitively ready and willing for a mathematics lesson enriched with the history of mathematics. In addition, it is an essential prerequisite that the content to be used during the application is appropriate at a level that can be associated with the history of mathematics (Başıbüyük, 2012; Yenilmez, 2011).

However, it is a fact that the integration of the history of mathematics into the curriculum must be done carefully, and this success can only be achieved with the expertise of highly competent educators (Leng, 2006). Therefore, it is essential to use historical arguments appropriately to show the development of mathematical concepts (Brousseau, 1997). In addition, integrating the history of mathematics with mathematics teaching does not immediately make students fully understand the subject, but makes learning mathematics a lived experience, making learning more accessible and meaningful (Siu, 2000).

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WEB 2.0 TOOLS AND USAGE IN MATHEMATICS EDUCATION

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Abstract

Technology has become an indispensable part of our lives with the changing and developing world and has shown its effect in every field. Education and training have also been affected by this rapid technological progress. Web 2.0 tools, on the other hand, stand out with their fun and practical use and allow everyone to access them without limitation of time and place with their exciting content. Web 2.0 is the second-generation web and has become an attractive tool for mathematics education. With its student-oriented teaching approach, web 2.0 tools can easily be accessed in mathematics education. This study aims to examine the literature on web 2.0 tools in mathematics education and present data on the use of these tools. Doing a literature review aims to provide a data source to researchers for new studies in this field. As a result of the examinations, the advantages and disadvantages of web 2.0 tools and the importance of their use in mathematics education have been revealed.

Keywords: *Web 2.0 Tools, Mathematics Education, Technology*

Introduction

With the integration of technology into the education process and the increasing importance given to education, many educational problems have been solved by using technology (Erişen & Çeliköz, 2007). The use of technology in educational environments makes it possible to reduce individual differences, enrich teaching environments, and provide permanent learning by embodying abstract concepts. Technology and computer concepts are essential in daily life, business life and education for modern societies and education systems (Tutak, İlhan, & İç, 2018). Yıldırım, Karaarslan, and Boz (2013) stated that using technology in mathematics education would significantly impact success.

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With the constant changes in the world, the importance of education is increasing and societies have realized that educated individuals have a fundamental impact on the development of society by making education compulsory with this awareness (Nayıroğlu, Tutak, & Tutak, 2021). In recent years, combining technology with education has increased the importance of technology by providing new opportunities (Bal, 2015). The use of technology-supported applications and content in mathematics education contributes to the development of students' advanced thinking skills and mathematical thinking skills (Hansson, 2020; Wenglinsky, 1998). This approach supports learning by actively putting the student at the center. The use of technology in education is also of great importance for mathematics education (Öksüz & Ak, 2010). The National Association of Mathematics Teachers (NCTM) emphasized that technology is a crucial element in learning and teaching mathematics and stated that it affects the mathematics taught and enriches the learning experience of students (NCTM, 2000).

Web 2.0 tools are a term used to describe the interactive and collaborative nature of the internet and have emerged as a valuable tool in various educational fields, including mathematics education. These tools provide convenience in education, support constructivist teaching approaches and contribute significantly to mathematics teaching (Horzum, 2010).

Aim

This study aims to examine and highlight the literature about web 2.0 tools in mathematics education.

Method

This study was prepared to examine the literature about web 2.0 tools in mathematics education. A literature review was conducted to determine these methods. In this study, the data in the literature were defined and evaluated in detail.

Web 2.0 Technology

Web 2.0 is a term used to refer to the second generation of the World Wide Web (www). This concept was introduced by Tim O'Reilly in 2004 and refers to a set of technological tools and platforms that enable users to create, share and interact with content on the Internet (Atici & Yıldırım, 2010).

The Web 2.0 era allows users to actively create and share content instead of passively consuming content (Kaleci, 2018). In this period, internet users experience a more interactive, dynamic and sharing-based experience. Now users are information buyers, producers, and sharers (Elmas & Geban, 2012; Gökcan, 2023).

Web 2.0 tools, unlike Web 1.0, which is the first period of the internet, offer users the opportunity to produce, share, comment and interact with content (Çemrek, Baykuş & Özaydın, 2014). These tools enable different perspectives and knowledge to emerge. Users can create tools such as social media platforms, blogs, forums, and wikis, prepare various content (cartoons, videos, animations, sound recordings, presentations, diagrams, graphics), store files, conduct surveys and quizzes, and share the content they create (Çukurbaşı & Kıyıcı, 2018).

Web 2.0 tools are used in almost all disciplines with the developing technology today. In education, web 2.0 tools are used in various fields, such as homework and grade sharing, preparation of teaching materials, measurement and evaluation (Güler, 2020). Table 1 below shows the usage areas of Web 2.0 tools for 21st-century education, adapted from Elmas and Geban (2012).

Table 1. Classification of Web 2.0 Tools According to Their Usage Areas

Classification of Web 2.0 Tools According to Their Usage Areas		
Content Management Systems-CMS/ WCMS)	Belli bir amaç için hazırlanmış içeriklerin istenilen şekilde düzenlenmesini ve kontrolünü sağlar.	PBWorks (www.pbworks.com) Wikispaces (www.wikispaces.com) Edmodo (www.edmodo.com) Edublogs (www.edublogs.org) Weebly (www.weebly.com
Online Meeting	They are tools that allow meeting and negotiation online.	▪ Voki (www.voki.com) ▪ Todaysmeet (www.todaysmeet.com) ▪ Chatzy (www.chatzy.com)
Online Storage & File Sharing	They are tools that provide a file sharing environment between individuals and groups online.	▪ Dropbox (www.dropbox.com) ▪ Screencast (www.screencast.com) ▪ Minus (www.minus.com) ▪ SugarSync (www.sugarsync.com)
Interactive Presentations	They are tools that allow the preparation of presentation templates in different and different styles.	▪ Prezi (www.prezi.com) SlideRocket (www.sliderocket.com)
Online Survey	It is used in the preparation of questionnaires that the individuals in the target group can fill online on any subject.	Poll Everywhere (www.polleverywhere.com) ▪ Survey Monkey (www.surveymonkey.com)
Animation & Video	They are practical and helpful tools in the preparation of animations.	GoAnimate (www.goanimate.com) Creaza (www.creazaeducation.com) ▪ Animoto (www.animoto.com) Kerpoof (www.kerpoof.com)
Word Clouds or Tag Clouds	They are tools for creating word clouds that increase the emphasis of the key points of the subject for the topics to be told.	Wordle (www.wordle.net) ▪ TagCrowd (www.tagcrowd.com) ▪ WordItOut (www.worditout.com)

Use of Web 2.0 Tools in Mathematics Education

With the rapid development of technology, significant changes are experienced in the field of education. The widespread use of the Internet has made educational services more accessible, interactive and student-oriented. This transformation has also affected mathematics education and has become more efficient and effective with technological applications (Öksüz & Ak, 2010).

Technology and technological applications in mathematics education are vital in enabling students to understand abstract mathematical concepts by embodying them (İnce-Muslu & Erduran, 2020). At this point, web 2.0 tools and expressing the second-generation internet technologies enable students to create, share and interact with content over the Internet. Web 2.0 tools allow students to actively explore and learn mathematical concepts, store content and interact by sharing (Ajjan & Hartshorne, 2008; Altun, 2008).

In addition, web 2.0 tools help students develop their mathematical thinking skills. Students can discuss mathematical problems in online forums, express ideas through blog posts, and develop collaborative projects. In this way, students can develop general skills such as critical thinking, problem solving and communication while deepening their mathematical thinking skills. Web 2.0 tools can also produce course content and provide appropriate learning environments (Rich, 2008). These tools provide students with interactive learning experiences such as interactive math simulations, problem-solving activities, and virtual labs, making abstract math concepts concrete and facilitating students' learning process.

Teachers' effective use of Web 2.0 tools in mathematics lessons can increase students' motivation by eliminating the students' prejudices against the mathematics lesson over time (Öztürk, 2011). Web 2.0 tools increase interaction in the math lesson, encouraging active participation of students and making the learning experience more engaging. This, in turn, helps students form a more positive relationship with mathematics. As a result, web 2.0 tools play an essential role in mathematics education. Studies show that Web 2.0 tools positively affect mathematics learning processes (Elmas & Geban, 2012). These tools encourage cooperation by providing interaction among students and support students to be active participants in the future (Richards, 2010).

Advantages of Web 2.0 Tools

Web 2.0 is a concept that emerged with the evolution of the internet and offers users a platform where they can produce, share and interact with content (McLoughlin & Lee, 2007). This platform provides the following advantages:

- Supporting the constructivist learning approach in education ensures that students become individuals who can actively produce and use

information instead of passive information consumption (Horzum, 2010).

- It provides efficiency in education by increasing the permanence of the learning process (Korucu & Yücel, 2015).
- It makes the learning process of the learner more enjoyable through peer teaching (Mete & Batıbay, 2019).
- It encourages cooperation and interaction to raise individuals according to age (O'Reilly, 2007).
- It allows individuals to access the most up-to-date information at flexible time intervals (Jarret, 2008).
- Web 2.0 tools are user-friendly applications worldwide that can be used easily.

These advantages show that Web 2.0 tools significantly contribute to educational changes and developments. It encourages students to cooperate and interact while supporting their learning processes by enabling them to become active participants. It also provides a flexible learning environment, allowing users to access up-to-date information easily. Web 2.0 tools provide a more interactive, participatory and up-to-date experience in education.

Disadvantages of Web 2.0 Tools

Some disadvantages of Web 2.0 tools can be:

- Information security and privacy principles are essential, and users' personal information (e-mail, mobile phone number, date of birth, etc.) can be collected and operated on Web 2.0 tools. This may threaten users' privacy and bring security risks (Ergun, 2019).
- Web 2.0 tools may have some flaws with the continuous production and sharing of content. This can lead to the spread of false information, increased internet harassment and, at times, a proliferation of harmful content.
- It may be challenging to reach quality content due to the large number of individuals using Web 2.0 tools. Problems like information pollution and unverified content may arise (Arabacı, 2021).
- The pressure to consistently produce and share content can be challenging for teachers. Web 2.0 tools may require teachers' time and resources (Bower, Hedberg, & Kuswara, 2010).

These disadvantages indicate that caution should be exercised in using web 2.0 tools and that issues such as information security, content quality and teachers' burden should be considered. It is essential to be aware of these problems and take appropriate measures to minimize the disadvantages while enjoying the positive aspects of Web 2.0 tools.

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CURIOSITY AND STATE SCIENCE CURIOSITY IN SCIENCE EDUCATION

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Introduction

Science is a field of science that uses scientific methods to understand and explain the natural and physical world. Science education aims to develop students' interest, attitudes and motivation towards science, to understand the nature of science, to gain scientific process skills and to increase their scientific literacy level (Yılmaz et al., 2020). Curiosity in science education is students' desire to learn science or their tendency to investigate (Luce & Hsi, 2015). Curiosity is an important factor that enables students to be active, creative and critical in the science learning process. Curious students become more interested in science topics and phenomena, ask more questions, do more research, and acquire more scientific knowledge. Curiosity contributes to both cognitive and affective development of students (Higgins & Moed, 2018).

Studies on the effect of curiosity on the science learning process show that curiosity is related to different variables. For example, variables such as gender, grade level, family education level, and the place where science lessons are conducted can affect the level of curiosity (Mahama, 2022). It is also stated that there are different types of curiosity. For example, intellectual curiosity, about scientific knowledge; specific curiosity about a specific topic; Interpersonal curiosity is curiosity about information about other people (İnan Kaya, 2016). The effects of curiosity on the brain have also been studied. In a study, it was understood that curiosity activates the regions in the brain that are active in the case of reward expectation and that the information obtained as a result of curiosity is better preserved in the memory (Kurtbaş, 2011).

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In addition to the studies on the effect of curiosity on the science learning process, the importance of curiosity in science education is also emphasized (Spektor-Levy et al., 2011). Science education has always been a difficult field for students to understand due to its complex and abstract nature. For this reason, the role of models used in students' perception of abstract concepts and events, especially in science, is extremely important. Models help students by simplifying or embodying reality. Models also allow students to express and test their own understanding (Önal Karakoyun & Polat, 2022). Curiosity is needed to gain modeling skills in science education. Because the modeling process includes activities based on curiosity such as asking questions, forming hypotheses, experimenting, collecting and analyzing data. For this reason, students who gain modeling skills are also curious.

The importance of curiosity in science education is not limited to modeling skills. Curiosity also contributes to other purposes of science education. For example, inquisitive students better understand the nature of the sciences. The nature of science is ideas about how science develops, how it is applied and how it is evaluated (Jirout & Klahr, 2012). Curious students learn from different sources to understand the nature of science, become sensitive to social and ethical issues related to science, and pursue science careers. Curious students also increase their motivation, engagement and achievement in science education. The importance of curious students in science education is that it helps them to be better equipped and creative individuals both individually and socially.

Curiosity and Types of Curiosity

Curiosity is the desire or desire to learn about an object, event or situation that does not know, understand or interest the individual. Curiosity is a characteristic of an individual that exists from birth and continues throughout his life. Curiosity contributes to the mental development, creativity, problem-solving skills and quality of life of the individual. Curiosity makes it possible for an individual to gain new information, gain different perspectives, realize new experiences and establish new relationships (Lamnina & Chase, 2019).

The concept of curiosity has been discussed in different disciplines such as psychology, education, philosophy and sociology. Various theories and researches have been carried out on subjects such as the definition, measurement, types, sources, results and development of curiosity. It is accepted that curiosity has cognitive, emotional, behavioral and social dimensions. The cognitive dimension of curiosity includes information seeking and processing processes of the individual; emotional dimension, feelings such as excitement, interest or satisfaction towards the object, event or situation of interest; behavioral dimension, actions such as researching, asking or trying the objects, events or

situations that the individual is curious about; The social dimension includes interactions such as sharing, discussing or cooperating with others, objects, events or situations that the individual is curious about (Arnone & Small, 2011).

The importance and function of the concept of curiosity is increasing even more today. Being curious provides an advantage for individuals living in a world where information changes rapidly, technology develops and competition intensifies. Curious individuals learn more, develop more, innovate more and achieve more. Curiosity is the main motivation for learning. Curious students are eager and eager to learn what they do not know, understand or are interested in (Reio, 2012). Curiosity increases students' attention, interest, and engagement. Curiosity improves students' processes of searching, processing and transferring information. Curiosity supports students' creative, critical and independent thinking skills. Curiosity keeps students open to new ideas, experiences, and relationships. Curiosity helps students continue to learn for life. Curiosity is an emotion that exists in human nature and leads him to learn (Vardi & Demiriz, 2019). Curiosity can be defined as the desire to seek information about things that are new, uncertain or complex. There are different types of curiosity. One of them is intellectual curiosity, that is, an interest in scientific or abstract topics. The other is specific curiosity, that is, curiosity towards a particular area or object. Another is interpersonal curiosity, that is, curiosity about other people's behavior, feelings, or thoughts. Curiosity also has a state dimension. State curiosity is the curiosity that changes and is temporary depending on the current environment or situation (Bacanlı and Türk Kurtça, 2020).

State Curiosity

Curiosity can be defined as the human desire to seek information about things that are new, uncertain or complex. Just as there are different types of curiosity, there are also different dimensions. One of them is situational curiosity. State curiosity is the curiosity that changes and is temporary depending on the current environment or situation. State curiosity is related to the quality and intensity of the stimuli encountered by the individual. For example, a question, a problem, a puzzle, or an event that interests the individual may trigger state curiosity. Situational curiosity can increase an individual's learning motivation and performance (Bacanlı & Türk Kurtça, 2020). Different scales have been developed to measure state curiosity. The most widely used of these is the Situational Curiosity Inventory developed by Litman et al. (2005). This scale considers state curiosity in two dimensions and calls them interest/exploration and tension/tolerance. It has been shown that state curiosity has many positive results such as academic success, creativity, and problem solving (Acun et al., 2013).

Among the characteristics of stateful curiosity are the following (Bacanlı and Türk Kurtça, 2020):

- State curiosity varies depending on the quality and intensity of the stimuli faced by the individual. In other words, as the stimuli that attract the attention of the individual increase, the state curiosity also increases; As the stimuli that do not interest him decrease, his state curiosity decreases.
- Students' state curiosity may increase or decrease with the teaching methods and materials used by teachers. For example, if teachers ask questions that will interest students, present problem situations, create a discussion environment, relate to real life or benefit from different sources, students' state curiosity will increase.
- Students' state curiosity can also be affected by the physical and psychological characteristics of the learning environment. For example, if the learning environment is equipped with rich stimuli, safe, supportive and flexible, students' state curiosity will increase.
- Students' state curiosity may increase or decrease with the teaching methods and materials used by teachers. For example, if teachers ask questions that will interest students, present problem situations, create a discussion environment, relate to real life or benefit from different sources, students' state curiosity will increase.
- Students' state curiosity can also be increased with learning objectives presented at the appropriate difficulty level, taking into account individual differences. For example, if students set or choose a goal of the appropriate difficulty level, they will work harder to achieve this goal, be more curious, and learn more.
- State curiosity is related to curiosity, which is an individual's personality trait. In other words, the more curious the individual is as a personality, the higher the probability of state curiosity. In addition, curiosity, which is an individual's personality trait, may change with the frequency and intensity of situational experiences.

Science Curiosity and State Science Curiosity

There are studies showing that curiosity plays an important role in science teaching, students' gaining scientific literacy and understanding science subjects (Bathgate, Schunn, & Correnti, 2014). Curiosity is handled as two different types in the literature: While persistent curiosity refers to an individual's general tendency towards new and interesting information; state curiosity reflects the variability of curiosity that an individual feels in a particular situation (Chu & Fung 2022; Grossnickle, 2016).

In the science learning process, it is important to determine students' state curiosity and anxiety levels. Because when state curiosity and anxiety rise above a certain level, it can affect students' science task performance positively or negatively (Jirout & Klahr, 2012; Luce & HSI, 2015; Covington, 1992; Eysenck, 1992). In addition, state curiosity and anxiety are modifiable with appropriate educational interventions. For these reasons, it is emphasized that more studies should be conducted on state curiosity and anxiety in the science learning process (Jirout & Klahr, 2012; Luce & HSI, 2015). When examining state curiosity in the context of science education, it is necessary to consider the state dimension rather than the feature dimension of curiosity (Boyle, 1983; Sung et al., 2008). State curiosity is a curiosity that arises in a given situation and can change according to environmental factors. Being able to predict the level of state curiosity can allow it to be increased or decreased with various educational interventions.

Various methods can be used to increase the effect of state curiosity in the science learning-teaching process. For example, teachers can determine the topics that students are interested in, design activities related to these topics, or allow students to ask and research their own questions. In addition, teachers can create a safe, supportive and flexible learning environment equipped with rich stimuli to arouse students' curiosity. In addition, teachers can present or choose learning objectives at the appropriate level of difficulty and related to real life, taking into account the individual differences of the students. In this way, by increasing students' state curiosity, they can increase their participation and success in science education (Dolu, 2014; Çetinkaya, 2017).

Some Scientific Researches on Science Curiosity and State Science Curiosity

Demirel and Diker Coşkun (2009) aimed to examine the relationship between perceptual and informational curiosity, which are the two dimensions of the concept of curiosity put forward by Daniel Berlyne in their research. In the study, the curiosity levels of university students were measured by using the curiosity scale, the perceptual curiosity scale and the informational curiosity scale. The findings showed that there is a positive and significant correlation between perceptual and informational curiosity. In conclusion, this study supports that curiosity is an important source of motivation that affects the individual's information seeking and acquisition behavior.

Shiomi et al. (2015) investigated how a social robot affects the scientific curiosity of primary school children. In the study, 30 children interacted with a robot called Robovie during breaks in science classes. The robot is controlled by remote control and answers science questions to children and encourages them to ask science questions. Video recording of children's interactions with the robot, the number and content of scientific questions asked by children,

a questionnaire measuring children's scientific curiosity level, and semi-structured interviews with children were used as data collection tools in the study. The analysis of the data shows that the level of scientific curiosity and the desire to ask questions of children who interact with the robot increase. Children who interacted with the robot asked more scientific questions than children who did not interact with the robot. In addition, the content of the questions asked by children interacting with the robot was richer and deeper. Children who did not interact with the robot mostly asked questions about the technical features and functions of the robot. As a result of the study, it has been suggested that social robots can be a potential tool in arousing children's science curiosity. The study shows that social robots can positively affect children's attitudes and interests in science in educational settings.

Weible and Zimmerman (2016) conducted a research that started by stating that there are different approaches to define, measure and develop curiosity, which is an important aspect of science learning. The aim of the research is to develop and validate an attitude scale to measure young people's science curiosity. They followed a two-stage process to develop the scale. In the first stage, they made the language of a curiosity scale for adults suitable for young people and created new items based on science practices. In the second stage, they applied the 30-item pre-scale to 663 young people between the ages of 8-18 and performed factor analysis. The final version of the scale consists of three factors (stretching, hugs, and science applications) and 12 items. As a result of the validity and reliability analyzes of the scale, it was seen that the scale is an appropriate tool to measure the science curiosity of young people and can be used in different learning environments. Researchers stated that the scale can provide clues on how to support curiosity in science education research and practice.

Luce and Hsi (2014) aimed to investigate how students express their curiosity about science and how this is related to their interest in science. In the study, a case of 19 sixth grade students participating in a summer science program was examined using a qualitative research method. During the program, students photographed the things they found interesting and wrote questions or comments about them. In addition, semi-structured interviews were made with the students and they talked about their interest in science. In the research, the questions and comments in the photograph diaries were coded to determine the types and frequencies of students' expressions of curiosity, and it was shown that students expressed curiosity about the nature of objects, phenomena or subjects in different ways. For example, some students asked about cause-effect relationships, some made teleological explanations, and some drew attention to inconsistencies in their observations. In the study, it was also found that the expression patterns of curiosity were related to students' interest in science.

For example, it was determined that students who expressed more curiosity were more interested in science. In the study, it was emphasized that creating opportunities to capture and support students' curiosity about science, based on these findings, is important to increase their interest in science. It was also stated in the study that curiosity is not a result of learning science, but a prerequisite.

Gruber, Gelman, and Ranganath (2014) aimed to investigate how curiosity affects science learning and how curiosity motivates it. The content of the study covered the definition, measurement, types and dimensions of curiosity and the effects of curiosity on learning, decision making and healthy development. The method of the study is a psychological and neuroscientific research method, and various intriguing stimuli were presented to participants from different age groups. The data collection tools of the study were curiosity scale and neuroimaging, and participants' levels of curiosity about the presented stimuli, brain activities, behaviors and memory performances were recorded. The data analysis method of the study was statistical tests and brain imaging techniques, and the relationship between the scores of the curiosity scale and the activity in the dopamine-secreting regions of the brain and behavioral and cognitive outcomes were tested. The findings of the study showed that the dopamine-secreting regions of the brain were more activated in response to the stimuli that participants were curious about, increasing learning. The results of the study indicated that curiosity plays an important role in learning science and that curiosity makes learning science both effective and enjoyable. In addition, the study offered some suggestions on how to arouse and support curiosity.

In his study, Blue (2022) aimed to investigate how curiosity plays a role in learning science and how curiosity can be encouraged in science classrooms. The study conducted semi-structured interviews with 12 primary school teachers using a qualitative research method and talked about teachers' methods of stimulating curiosity, its challenges and benefits. In addition, the study observed the lessons that teachers made in their classrooms and identified strategies to encourage curiosity. The study showed that teachers foster curiosity in different ways. For example, some teachers have attracted students' attention by using strong facts, some have encouraged asking questions, some have gamified, and some have given students the opportunity to make choices. In addition, this study found that encouraging curiosity increased students' scientific literacy. For example, students who were encouraged to wonder asked more questions, did more research, learned more, and made more sense. The results of the study indicated that curiosity plays an important role in learning science and that curiosity can be encouraged in science classrooms by different methods. In addition, this study emphasized that methods of stimulating curiosity should be adapted according to students' interest, motivation and participation levels. The study also provided examples and resources for the application of curiosity stimulating methods.

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GEMS PROGRAM: AN APPROACH THAT SUPPORTS CREATIVE AND DEEP LEARNING IN MATHEMATICS EDUCATION

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Abstract

The GEMS program was established in 1984 by the Lawrence Hall of Science at the University of California. This program aims to encourage students to love science and mathematics education at an early age with fun activities and to offer the opportunity to experience all science processes actively. Activities such as creating giant soap bubbles, solar heat experiments and fingerprint detection are all part of the GEMS program that aims to spark students' imaginations. In the GEMS program, science and mathematics are combined with scientific processes. Although this program starts from preschool and continues until the tenth grade throughout the world, it is mainly limited to the preschool period in our country. This study aims to introduce and present a literature review of the Creative and Deep Learning (GEMS) Program in mathematics education.

Keywords: *GEMS program, Science and Mathematics Integration, Scientific Process Stages*

Introduction

Today, in a period in which scientific knowledge is rapidly advancing with technological developments, raising primary school students as science literate has become an important goal (Ministry of National Education [MEB], 2013). With the constant changes in the world, the importance of education is increasing, and societies have realized that educated individuals have a fundamental impact on the development of society by making education compulsory with this awareness (Nayıroğlu, Tutak, & Tutak, 2021). For this purpose, each student is expected to develop their skills of making sense by observing their environment

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and learning how to access information. However, according to many studies conducted worldwide, our country has not achieved the desired level of success in this field. According to the TIMSS 2011 report prepared by Yücel, Karadağ, and Turan (2013), it has been determined that students with high mathematics achievement are also successful in different areas of mathematics and cognitive processes. However, it is stated that the mathematics achievement score in our country is generally below the average. According to a study by Karaer (2006), some students do not like science lessons because they have insufficient knowledge of mathematics subjects. Students with this negative attitude will inevitably fail in science lessons. In addition, the achievement status arising from the relationship between the science and mathematics fields is essential (Uzun, Bütüner, & Yiğit, 2010). Teaching science through lessons based on questioning, collaborative initiatives, and making sense of the world is possible. In order to gain scientific process skills, methods such as experimentation, observation, group work and learning environments by doing and living should be provided in science lessons. However, it is crucial to associate the subjects in science lessons with mathematics so that students can interpret the information and make their knowledge permanent. In this way, students can make sense of information by using grouping, matching, measuring, and classification methods.

When the relevant literature is examined, it is seen that the integration of mathematics and science courses is insufficient. In addition, not providing a customized learning environment according to the needs of each student also emerges as a problem. According to the studies conducted by Tomlinson (2005), while students come to school with different experiences, prior knowledge, intelligence, interests, abilities and cultural differences, they are expected to learn the same things under the same conditions. Considering that every student is different, the expectation that all students will achieve the same level of success in the same exam should be questioned.

The Worldwide Great Exploration in Math and Science (GEMS) Program aims to overcome these problems. The GEMS program is implemented in many countries to increase students' attitudes toward learning and their level of success. The program is designed to appeal to every kindergarten to tenth-grade student. In our country, it is observed that this program is generally included in the preschool period and in some private schools. However, although the GEMS program is thought to be costly, it can be said that it is possible to achieve the program's objectives with inexpensive materials.

The merging of Mathematics and Science is described in terms such as integrating different subjects, inclusion and interdisciplinary connection. According to Liderman and Niess (1997), this unification process means

harmoniously mixing different fields and creating a unified structure in which two subjects can be handled separately. Recent studies have emphasized the importance of focusing on multidimensional problems and interdisciplinary relationships.

In this direction, various studies have been carried out to combine different disciplines. Studies have shown that mathematics and science can be combined regarding application areas and scientific problem-solving approaches (NRC, 1996, Taşkın et al., 2005). In a study by Denmark (1988), it was stated that mathematics course is the center of many types of research and essential studies and should be combined with different disciplines to be noticed by students. Roebuck and Warden (1998) also highlight that "students at all levels should develop their mathematical knowledge in order to conduct scientific research".

According to the information cited by Deveci (2010) from Rutherford and Ahlgren (1989), the primary purpose of science and mathematics education is to focus on science literacy rather than understanding these disciplines separately. Fundamental studies should include links between science and mathematics. Students should perceive mathematics as a part of scientific work while observing, exploring, making hypotheses and predictions, communicating and discussing, interpreting and transferring information.

Through science and mathematics activities, students actively learn concepts such as classification, measurement, grouping, sorting, matching, and spatial position while gaining scientific process skills. In this way, students acquire a learning curiosity, develop their practical thinking skills, develop their verbal skills and become valuable individuals for society (Koçyiğit, 2007). In another study, it was emphasized that science and mathematics education is vital in gaining mental and high-level skills such as research, discovery, inquiry, estimation, analysis, synthesis, cooperation, discussion, problem-solving, joint decision making and entrepreneurship (Güven, 1989; cited in Sarıtaş, 2011).

According to Gallagher (1979), basic skills in science and mathematics are observing, reaching information, measuring and calculating information, interpreting information with tables and graphs, making predictions based on results, and presenting an opinion. Thanks to the combination of mathematics and science, students can experience great convenience in understanding the advancing world in the age of technology, following events and putting forward new ideas like a scientist. Technology and computer concepts are essential in daily life, business life and education for modern societies and education systems (Tutak, İlhan, & İç, 2018).

There are many projects, especially in the GEMS (Great Exploration in Math and Science) program, to combine these two courses by addressing the common points of mathematics and science (Deveci, 2010). This study aims to

provide general information about the GEMS program, which includes topics such as scientific process skills, inquiry, cooperation and making sense of life by combining mathematics and science.

In this sense, the GEMS program's objectives, content, process and evaluation methods are explained by giving place to the studies carried out in the world and our country. The number of studies on the GEMS program, which is based on integrating mathematics and science, is limited in our country. A study by Sarıtaş (2011) focused only on the preschool period. However, when the literature is examined, it is seen that the GEMS program can be applied from preschool to tenth grade. For this reason, this study is essential in creating literature knowledge in a general framework and being a source for future studies.

Purpose of the Study

This study aims to examine and present the program's effects on mathematics teaching by conducting a literature review about the Creative and Deep Learning (GEMS) Program in mathematics education.

Method of Study

In this study, the document analysis method, one of the qualitative research methods, was used. Document analysis examines the existing written source of the researched subject (Hitchcock & Hughes, 1995). Document analysis is also defined as examining visual materials containing information about the event or phenomena planned to be investigated (Yildirim & Simsek, 2008; Çelik et al., 2022). The primary purpose of document analysis is to examine the obtained documents in a theory-oriented, systematic and data-based manner (Sağlamöz & Soysal 2021).

What is GEMS?

The GEMS program was established in 1984 by a science center called Lawrence Hall of Science at the University of California (Barrett, Blinderman, Boffen, Echols, House, Hosoume & Kopp, 1999). This program aims to make students love science and mathematics at an early age with fun activities and to experience all the processes of science through active learning. GEMS offers courses, seminars and guidebooks for teachers and families as a quality and flexible syllabus. In addition, it is continuously developed with an international communication network and is used as a complementary program to the school curriculum (Barrett et al., 1999).

The objectives of the GEMS program were expressed by Barber and Bergman (1988) as follows:

- Gaining scientific process skills by combining mathematics and science,
- Students' understanding of the basic concepts of mathematics and science,
- Developing positive attitudes towards mathematics and science,
- To teach students the importance of mathematics and science skills,
- Students can use skills such as independent learning, critical thinking, questioning, analysis, synthesis, making assumptions, making inferences, producing new ideas like a scientist,
- Families taking an active role in the learning-teaching process,
- Ensuring the permanence of learning with practice-oriented activities,
- Gaining the awareness of lifelong learning.

In line with these goals, the GEMS program aims to provide students with an in-depth learning experience in mathematics and science and to enable them to understand scientific processes. At the same time, it is aimed that families and teachers are actively involved in implementing the program.

Approaches Adopted by GEMS

Besides the activity and skill lists, the approaches it adopts are also crucial in the GEMS program. The curriculum describes a particular view of science and builds its foundations on this view. GEMS activities begin with inquiry as it conveys to students that science is a process of inquiry. It also reflects that science is a "joint venture" as it encourages team progress. Students' cooperative way of making sense of what is happening in the environment reflects the view of "finding the meaning of the world." For example, on bubbles, children in teams try to determine the size of the giant bubble by measuring the size of the bubbles made with detergent and water with blocks. They try to solve the problem by collaborating in teams. In this way, students try to make sense of events (URL1).

The GEMS program is based on constructivist learning theory and is based on the element of curiosity. It adopts a guided exploration and learner-centered approach that puts students at the center of learning (Barber, 2001). With this approach, the content of GEMS relates to scientific ideas, processes, and learning objectives that represent the nature of scientific curiosity.

GEMS activities enable the development of skills and access to scientific knowledge through scientific means by establishing interdisciplinary connections. Mathematics and science are intertwined with other fields of science, such as language, art, history, music and theater (Barrett et al., 1999).

The GEMS program is a program that addresses multiple fields and adopts multiple intelligence and learning styles approaches. The activities prepared using various disciplines allow students with different abilities, intelligence, interests and knowledge levels to meet their needs. It contributes to each student's learning process as it is suitable for visual, auditory and tactile learning styles. In this way, educational equality is ensured for every student. Therefore, the GEMS program offers an excellent opportunity for students who learn later or have learning difficulties compared to other students (Barrett et al., 1999).

When we look at the basics of the differentiated curriculum, the American scientist Tomlinson put forward in recent years, there are many similarities with the GEMS program. Among these similarities are principles such as providing education by considering the students' different interests, abilities, knowledge and intelligence levels, putting the students at the center of learning and the importance of examining a subject in depth. In this context, the GEMS program also addresses the differentiated curriculum.

Content of GEMS

According to the GEMS program, the primary goal of the activities is to attract students' attention. Therefore, GEMS events are designed with readily available and inexpensive materials. The main goal is for everyone to be able to carry out these activities using available resources. The program emphasizes flexibility to ensure that all students participate in activities. Teachers can choose activities appropriate for the grade level, shorten or lengthen the duration, provide repetitions, and provide an opportunity to explore the topic in depth (URL2).

GEMS activities allow students to explore on their own. These activities include inventions ranging from chemical reactions in a zippered bag to creating colossal soap bubbles, solar energy experiments to fingerprint detection, and treehouses to egg structures (Huber and Burton, 1995). Guidebooks were provided to teachers for the activities prepared by the Lawrence Hall of Science center within the scope of the GEMS program. In these books it is aimed to examine a subject in depth. These books, which contain directions at every stage, are designed to be used alone or with the existing curriculum (URL2).

GEMS Process and Application

Unlike traditional teaching methods, GEMS activities begin with an action. Instead of giving students a concept directly, an action is performed. Students find themselves in an event and begin to question. Once they have an idea about the subject, they start asking questions.

Taking action before the explanation activates the students independently and enables them to develop their critical thinking skills. Students who begin to

question with critical thinking gain the necessary experience to understand the concepts and ideas underlying the subject (Barber & Bergman, 1988). GEMS activities offer a more directive approach to learning, allowing students to see how scientists do their work. For this purpose, students are expected to take action on their own in an environment where they stand out and are encouraged to understand the underlying concepts and think critically.

In the GEMS program, applying the acquired questioning behavior in daily life and providing lifelong learning is at the forefront (Barrett et al., 1999). Teachers help students gain the necessary skills by guiding them in this process. It is ensured that students receive guidance to access information and are supported when they have difficulties. Students who feel supported learn to question, draw conclusions and generate new ideas by performing activities (Barrett et al., 1999).

Even the simplest activities can be started with a problem, and the stages of the scientific process can be taught to students under the guidance of teachers. In the GEMS program, mathematics and science are combined with scientific processes. These processes are essential for scientific and mathematical inquiry. Students develop their inquiry skills by using scientific processes to develop their ability to ask questions, make observations, collect data, draw inferences from the collected data and generate new ideas. In this way, their lifelong learning is supported (Barrett et al., 1999).

The ability to question develops in parallel with the ability to ask questions. In the studies, it has been determined that the students who ask good questions have a high level of inquiry skills and access to information. It is emphasized that learning to ask good questions is the most challenging part of education. For example, “How many states does water have?” rather than one-answer questions like “Why does water expand in cold weather?” Thought-provoking questions such as these increase creativity. Students are given the habit of asking comprehensive questions that will increase their thinking skills, and it is ensured that GEMS activities reach their goals.

Evaluation in GEMS

The GEMS program allows students to reflect on their knowledge confidently and do self-assessments. Therefore, assessment is vital to learn what students know, continue learning accordingly, identify better learning paths, and ensure that the program fully serves its purpose.

Evaluations within the program are usually provided through portfolios that hold all the strategies together. In some preschools, teachers have a portfolio of observations for each student. These portfolios contain examples of work done throughout the year and various activities students have done with their skills

and talents. In this way, families can follow and evaluate the learning process. As a result of these studies, the teacher can evaluate the development of the students concretely by looking at the portfolios (Sarıtaş, 2011).

The GEMS program aimed to reach approximately 100,000 students from 125 different countries in a worldwide project. Approximately 9,000 employees are involved in this project, including education professionals, experts and members, and it is implemented almost everywhere in the world (URL3).

Although the GEMS program is implemented in many countries worldwide, it is mainly used in preschool periods and as an additional curriculum in some private schools in our country.

In a school in our country, GEMS units prepared by Lawrence Hall of Science were integrated with the existing curriculum. This integration was carried out by selecting certain studies by examining the achievements of the classes. 1-2-3. For primary school students, GEMS activities are carried out by combining the achievements of life science and mathematics lessons. These activities, for example, the "fingerprint" activity in 1st grade, the "paper towel test" activity in 2nd grade, and the "fluid research" activity in 3rd grade. In this way, it aims to provide students with scientific and mathematical skills. GEMS activities are carried out in the 4th and 5th grades by associating science and mathematics achievements. In addition to the existing science experiments, activities involving mathematical concepts such as "vitamin C testing" and "microscope research" are held. In this way, students have the opportunity to learn both science and mathematics subjects together. Similarly, GEMS activities are carried out in the 6th, 7th and 8th grades by providing mathematics-science integration. This application reflects an approach that aims to develop students' scientific and mathematical skills according to the achievements of the classes.

Result and Suggestions

As a result, studies have emphasized the importance of students gaining scientific process skills and combining them with mathematical skills. Mathematics and science integration can positively impact students in making sense of scientific processes, questioning, collaborating and making sense of life. The GEMS program aims to provide students with the qualities of questioning, cooperation and making sense of life by combining mathematics and science with other disciplines. In this way, it can contribute to the development of lifelong learners.

GEMS activities can be prepared with readily available and low-cost materials to appeal to different student profiles. The GEMS program, popular with various applications worldwide, can be used as a stand-alone curriculum or to support existing curriculums. This approach, supported in the relevant

literature, provides opportunities for researchers to design a GEMS program model or to work on integrating GEMS units prepared by the Lawrence Hall of Science center into the existing program.

In this context, it can be suggested that the related researches and studies continue for the further dissemination and implementation of the GEMS program. Developing students' ability to make sense of life and question life by combining their scientific process skills and mathematical skills will form an essential basis for lifelong learning.

Although there is no ready-made GEMS program for teachers and administrators, it is possible to organize activities where they can conduct in-depth studies with their efforts. For this purpose, a particular time of the week can be devoted to activities that will provide students with scientific process skills. With the support of the Ministry of National Education, it may be possible to expand such activities throughout the country.

In addition, it may be suggested that teachers work on multidimensional thinking techniques to encourage students to question. In the evaluation process, it is vital to ensure the participation of students in order to develop their inquiry skills. In addition, performing the actions before teaching the concepts and making sense of the concepts by asking questions during this action process can be achieved through learning experiences. At this point, families need to support students, especially in the preschool period; it has been emphasized in many studies that family support is adequate for children's success. Family support can increase students' self-confidence. For this reason, it can be aimed at gaining family support, especially with the activities to be done with families.

As a result, teachers and administrators can organize GEMS-like activities where they can delve deeper into their efforts. It is possible to expand such activities with the support of the Ministry of National Education. Teachers must work on multidimensional thinking techniques and involve students in the assessment process to develop their inquiry skills. Students' success and self-confidence can be increased with their families support.

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VALUES EDUCATION AND MATHEMATICAL VALUES IN MATHEMATICS EDUCATION

Fazilet ÇAKAREL[1]

Abstract

Values education in mathematics education is an approach that incorporates ethical and social values into mathematics teaching. This approach aims to help students understand their ethical and social responsibilities by associating them with concepts and mathematical knowledge. On the other hand, mathematical values refer to essential concepts emphasized in mathematics lessons that students think to use in their mathematical thought processes. This study aims to investigate how mathematical values and general values education can be applied together and their interactions in mathematics education by scanning the literature. While mathematical values express the values emphasized in mathematics lessons, general values education aims to provide students with skills and understandings that include moral, ethical and social values. This study was conducted to provide a basic framework for values education and understanding of mathematical values in mathematics lessons and to support research in mathematics education.

Keywords: *Mathematics Education, Mathematical Values, Values Education*

Introduction

Values are essential elements that people believe, want and are accepted as a limit for behavior (Aydın & Gürler, 2014). It forms the basis of behavior and guides attitudes. It is also a measure used to evaluate behavior. Values determine individuals' ability to adapt to society (Özensel, 2003). The continuation of society is possible by transferring its values to future generations and reflecting these values to the behavior of new generations by adopting them. With the constant changes in the world, the importance of education is increasing, and societies have realized that educated individuals have a fundamental impact on

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the development of society by making education compulsory with this awareness (Nayıroğlu, Tutak & Tutak, 2021). The mathematics curriculum (MEB, 2018) aims to develop students' higher-order thinking skills. However, the curriculum does not emphasize adequate strategies, activities and materials to support the acquisition of these skills. More opportunities and guidance should be provided to develop students' higher-order thinking skills (Erdoğan, 2019).

Learning mathematics and mathematical thinking are intertwined with affective learning (Dede, 2006). The desire of individuals to learn mathematics and gain mathematical skills is based on many reasons. Therefore, learning and teaching mathematics is of great importance. Mathematics learning is the most potent tool needed for the order and organization of the universe. The mathematical achievements of individuals vary depending on many factors. These factors have a significant impact on the acquisition of mathematical skills (Altun, 1994). One of these factors is affective factors. Affective factors are used as tools to achieve cognitive goals. It is thought that the levels of gains for cognitive goals can be measured more easily (Seah & Bishop, 2000). Affective factors must be addressed in lessons difficult for students to understand, especially in mathematics lessons (Dede, 2006). The Ministry of National Education has given importance to the concept of values in mathematics teaching in the secondary school mathematics curriculum updated in 2009 and after (MEB, 2013, 2017, 2018).

Values and affective factors in mathematics education should be emphasized in this context. Values and affective factors should be integrated into mathematics teaching to increase students' motivation to learn and develop their mathematics skills. Emphasizing values and considering affective factors in mathematics teaching programs should be designed to strengthen students' mathematical thinking skills and develop a positive attitude towards mathematics learning. It is also essential that teachers and educators receive training on how to integrate values and affective factors in their mathematics lessons. Thus, mathematics education can increase students' mathematical achievement by contributing to developing values and affective factors.

Purpose of the study

This study investigates how values education and mathematical values can be applied and their interactions in mathematics education. The study aims to provide a framework for integrating values education into mathematics teaching, which aims to help students understand their ethical and social responsibilities and mathematical knowledge. In addition, the study aims to determine the mathematical values emphasized in mathematics lessons and examine the strategies to combine these values with general values education.

This study aims to contribute to research on values education and mathematical values in mathematics education.

Method of Study

In this study, the document analysis method, one of the qualitative research methods, was used. Document analysis examines the existing written source of the researched subject (Hitchcock & Hughes, 1995). Document analysis is also defined as examining visual materials containing information about the event or phenomena planned to be investigated (Yildirim & Simsek, 2008; Çelik et al., 2022). The primary purpose of document analysis is to examine the obtained documents in a theory-oriented, systematic and data-based manner (Saglamoz & Soysal 2021).

Values Education in Mathematics Education

This literature study emphasized the importance of a different approach to applying values education and mathematical values together. Values education is a process that requires long-term planning and should be transferred by relating it to real life (Çağlayan, 2013). The science of mathematics is accepted as one of the most significant common values of the human mind. Mathematics is a practical, robust, universal science transmitted throughout history, transcending national borders (Nzeocha, 2009). At the same time, it is a source that forms the basis of all sciences by transcending religion, language, race, gender and country distinctions (Ulusoy & Dilmaç, 2015).

Mathematics is an essential tool that enables individuals to reveal and use their skills and to gain a systematic and intelligent thinking system (Bulut, 1988). Mathematics is a valuable resource for individuals who can understand its true face and use it to discover the unknown (Baki Baki, Güven, Karataş, Akkan, & Çakıroğlu, 2011). Values education aims to add value to the mathematical events they encounter daily by offering a different environment to students in mathematics lessons (Yücedağ, 2010). This approach aims to bring value to students by combining daily life events with numerical operations instead of educating values directly. A program designed in this way offers an approach that can provide mathematics learning, develop a positive attitude towards mathematics, provide an enjoyable mathematics learning process and see the importance of mathematics in daily life. Essential aspects of this program design include teaching mathematics and values by associating them with daily life.

It is recommended to use this approach to teach values and mathematical values in mathematics education. Emphasizing values in mathematics lessons by associating them with daily life can contribute positively to students' mathematics learning and internalization of values. This study aims to support the effective integration of values into mathematics lessons by inspiring more research and curriculum development in mathematics education.

Mathematical Values in Mathematics Education

Sam and Ernest (1997) classified the values related to mathematics teaching into three categories. These:

i) Epistemological Values: Values such as precision, systematicity and rationality that include the properties, acquisitions and evaluation of mathematical knowledge. They show the theoretical aspect of mathematics.

ii) Social and Cultural Values: These are values such as cooperation, justice, and understanding the value and necessity of mathematics that support the individual's responsibilities towards society regarding mathematics education.

iii) Personal Values: Values that affect the person as a student or an individual, such as patience, confidence and creativity.

Bishop, FitzSimons, Seah, and Clarkson (1999) defined mathematical values as values produced by mathematicians in different cultures and inherent in mathematical knowledge. Since values differ depending on the culture, mathematics teachers in different cultures who apply the same mathematics program may not be able to teach the same values in classroom practices (Bishop, Clarkson, FitzSimons, & Seah, 2000). Therefore, mathematical values are values developed as a lesson in a culture (Bishop, 1999). Individuals from different cultures understand and adopt mathematical values differently (Bishop et al., 1999). Mathematical values are essential to culture. Even if the same curricula are applied to individuals raised in different cultures, the values adopted by teachers in classroom practices may differ. Although mathematical values stem from the nature of knowledge, cultural differences have caused these values not to be learned in the same way by individuals from different cultures (Bishop et al., 2000). As a mathematical knowledge, the Pythagorean theorem may have different proof methods in different cultures. Therefore, we can say that one value does not have an advantage over the other. Bishop (2001) explained the mathematical values produced by mathematicians who grew up in different cultures but did not claim that these values are universal or related to mathematics in any culture.

In the 1980s, studies on the importance of values in mathematics education were carried out by Alan Bishop. Based on the relationship between mathematical concepts and education, these studies focused on two basic concepts: mathematics education values and mathematical values arising from the nature of mathematics itself. In addition, Bishop et al. (1999) mention a third class of values as general educational values. These value classes are not formed independently; on the contrary, it is stated that some values may be included in several of these classes. Below is shown by Bishop (1999) with a schema structure in Figure 1.

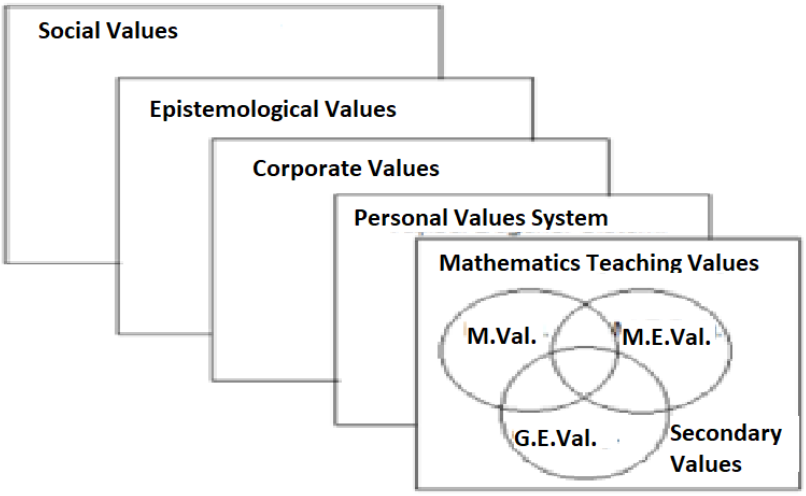

Figure 1. Common Interaction of Different Types of Value Affecting Mathematics Education (Özdemir and Doğan, 2022).

In this context, it is essential to understand and evaluate values and mathematical values in mathematics education. The fact that individuals raised in different cultures perceive mathematical values in different ways requires mathematics teachers to take these differences into account in their classroom practices. It is crucial that mathematics education programs and teaching methods can effectively convey mathematical values, taking into account cultural diversity.

Result and Suggestions

This literature study investigates how values education and mathematical values can be applied and their interactions in mathematics education. The different approaches and methods examined reflect a holistic perspective that includes teaching values not only in the classroom but throughout the school, family and society. Studies show a strong interaction between values education and mathematics education. Mathematics teaching should aim to help students understand their ethical and social responsibilities by emphasizing mathematical values. For this, conveying ethical and social values associated with mathematical concepts is vital to students. Among the approaches to teaching values, there are various approaches such as knowledge-based approaches, teacher-student and parent-child relationship-based approaches, behavior management and communication-oriented approaches, and peer interaction strategies. All of these approaches offer essential strategies for teaching and internalizing values. The general plans made by the Ministry of National Education and the Board of Education and Discipline guide the education of values. However, the difficulties encountered in implementing these plans and

in designing programs for teaching values still continue. Based on the results of this study, the following suggestions can be offered for effective teaching of values in mathematics education:

1. Teachers and educators should be trained in values education. Teachers should be guided on how to integrate values, effective communication strategies and methods that can be used to emphasize mathematical values.
2. examples of mathematical values and student-centered activities should be used in mathematics lessons. Students should develop their ability to solve mathematical, ethical, social and cultural problems and use thought processes related to values.
3. The active participation of the school and the family should be ensured. Values teaching should be carried out in the classroom and the school environment and in cooperation with the family. Activities such as school events, seminars and family information meetings should be organized to support the spread of values in all areas of life.
4. Programs and resources for teaching values should be developed. Resources, sample activities and materials should be provided to guide teachers in emphasizing values in mathematics lessons.

Considering these suggestions can contribute to the effective teaching of values in mathematics education and improve students' knowledge and skills regarding ethical and social values. In addition, this study can contribute to developing more knowledge and understanding of values education in mathematics education by encouraging the continuation of related research.

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GUIDANCE AND MOTIVATION IN MATHEMATICS EDUCATION

Gözdenur SANSAR KAYA[1]

Abstract

This study aims to systematically review the existing literature to understand the importance and impact of guidance and motivation in mathematics education. Mathematics is an essential branch of science in our lives and is used in many areas, such as directing talents and gaining logical thinking (Bulut, 1988; Baykul, 1999). In this context, the study emphasizes the importance of teachers creating an environment that will enable students to experience a sense of achievement in the classroom environment and increase intrinsic motivation. This literature review focuses on current research to understand the role and impact of guidance and motivation in mathematics education. In addition, the study aims to identify strategies used to increase mathematics achievement. In the literature, good practice examples and suggestions will enable teachers to be effective in mathematics education. By emphasizing the importance of guidance and motivation in mathematics education, this study provides a basis for teachers, educators and researchers to conduct further studies in this field. As a result, it is emphasized that guidance and motivation in mathematics education play an essential role in improving students' mathematical skills, arousing their passion and increasing their success.

Keywords: *Mathematics Education, Motivation, Guidance*

Introduction

Although mathematics is an integral part of our lives, it is perceived as a difficult lesson for many students in our country and negative attitudes towards mathematics are displayed. Students are worried and lack motivation because they think they will not succeed in mathematics (İspir, Ay, & Saygı, 2011). Mathematics motivation can be defined as students' willingness to learn mathematics and their active participation in mathematics-related studies.

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Studies have revealed that there is a positive and significant relationship between mathematics achievement and mathematics motivation (Eklöf, 2007; Kesici and Aşılıoğlu, 2017; Md. Yunus & Ali, 2008; Shores & Shannon, 2007; Üredi & Üredi, 2005; Yıldırım, 2011). Highly motivated students deal with math problems more persistently and spend more time (European Commission, 2011).

Low math motivation leads to apathy and low participation in learning math. In time, this situation causes the mathematics lesson to be perceived as a meaningless lesson, and therefore, a negative attitude towards mathematics is formed in the students. Reducing students' negative attitudes and developing a positive attitude towards mathematics are among the educational goals. Many factors affect students' failure during mathematics education. These include individual differences such as perception of mathematics self-efficacy, mathematics anxiety, mathematics motivation, mathematics attitude and learning styles. Examining and understanding these learning styles makes it possible to carry out various activities that will enable students to better connect with mathematics, not be afraid of mathematics, and better embrace mathematics topics.

Motivation ensures that students learn and understand mathematics at all levels. Motivation is an essential element of the learning process. Therefore, the motivation dimension should be addressed in teaching environments. It should be noted that motivation has more dimensions than a simple structure. People have different types and amounts of motivation (Ryan & Deci, 2000). Therefore, it is seen that motivation is a multidimensional concept and has different types.

Purpose of the research

The purpose of this research; this study aims to investigate the effect of guiding and motivating students in mathematics teaching. Motivation is effective and vital in all areas of life. One of this research aims is to examine the effect of proper guidance and the motivated student on achieving success in the mathematics course.

Research Method

In this study, the document analysis method, one of the qualitative research methods, was used. Document analysis examines the existing written source of the researched subject (Hitchcock & Hughes, 1995). Document analysis is also defined as the examination of visual materials containing information related to the event or phenomena planned to be investigated in an orderly manner (Yıldırım & Simsek, 2008; Çelik et al., 2022). The primary purpose of document analysis is to examine the obtained documents in a theory-oriented, systematic and data-based manner (Sağlamöz & Soysal 2021).

Guidance in Teaching Mathematics

Today, contemporary education is based on an approach based on the student's individual differences. With the constant changes in the world, the importance of education is increasing, and societies have realized that educated individuals have a fundamental impact on the development of society by making education compulsory with this awareness (Nayıroğlu, Tutak, & Tutak, 2021). Each student is different from the others with their innate talents, interests and hereditary characteristics. In addition, the environmental conditions of each individual differ from each other. Its effectiveness has been questioned over time, with its traditional understanding of education, curriculum and teacher-centered approach. This has led to an orientation towards an area where every student is further developed in all aspects, and education systems are increasingly moving towards a student-centered understanding. The rapidly developing technology with the industrial revolution has increased the knowledge in societies and has also changed the quantity and quality of workforce needs. Hamamcı, Murat, and Çoban (2004) stated that the diversification of labor force needs in society and understanding the differences between individuals lead to the emergence of the concepts of individual according to the job or job according to the individual. These developments have made it necessary to make educational plans in contemporary education, considering the students' differences and society's needs. While these plans are being made, it is necessary to consider the student as a whole and be supported in many ways. For this reason, the understanding of "student-centered education" has been adopted in contemporary educational institutions to ensure students' holistic development. This approach requires the implementation of Psychological Counseling and Guidance services called "student personality services" as well as educational and administrative services.

This intellectual change in education has led to the emergence of the "student-centered education" approach and is accepted as a critical stage in the historical development of education. Developments have made it necessary to plan education following the needs of societies, taking into account the interests and abilities of students. In realizing these plans, it is necessary to consider the student as a whole with all aspects and to be supported and developed multi-faceted. In contemporary educational institutions, ensuring students' holistic development requires the implementation of Psychological Counseling and Guidance services called "student personality services" as well as educational and administrative services (Tan, 1974). These services have emerged with the changes in the needs and expectations of individuals in the contemporary world, as well as the differentiation of approaches in the roles and duties of educational institutions. The fact that a student-centered education approach replaces traditional education has made it compulsory to organize Psychological

Counseling and Guidance services at every level of the education sector. In this way, the development of the students as a whole has been ensured, and the education process has been directed more appropriately to their needs.

Motivation in Teaching Mathematics

Motivation and Mathematics Motivation

Motivation is a factor that directs the behavior of individuals and is effective in their learning processes. Budak and Demir (2016) define *motivation* as students' effort, time and willingness to fulfill their tasks. Dede and Yaman (2008) emphasize that motivation affects students' learning styles, creativity and academic success. Motivation is an essential fundamental concept in learning and should be addressed in educational settings.

İspir, Ay, and Saygı (2011) highlight that high-achieving students may have different motivations for learning mathematics. Külünk Akyurt (2019), on the other hand, defines mathematics motivation as students' active participation in mathematical activities, volunteering and trying to learn mathematics. Students with high motivation in learning mathematics are more willing to solve math problems and put in more effort than other students.

Low-motivation students show low participation in mathematical activities and reluctance towards the lesson. In time, this situation may create a negative attitude toward the mathematics lesson in the students and cause them to perceive mathematics as an unnecessary lesson (Kesici, 2018). The two dimensions of motivation in mathematics learning appear as intrinsic and extrinsic. Motivation is a force that directs an individual's behavior toward a goal. On the other hand, mathematics motivation is closely related to the concepts of learning and teaching and focuses on its effect on mathematics achievement. For example, not all students should be forced to the same type and amount of mathematics lessons (Halmatow, 2014).

Intrinsic Motivation

A purely self-focused focus often leads to impulses such as the need for novelty, challenge, or aesthetic value. Educators state that intrinsic motivation is more beneficial and leads to better learning outcomes than "extrinsic motivation," which we will discuss later. When students have intrinsic motivation, they can make learning mathematics easier.

External Motivation

Extrinsic motivation is temporary motivation that refers to energy by showing a specific behavior as if it were doing it. This is cheating. It is more common when the freedom brought by intrinsic motivation needs to be modulated to adapt to the demands of the environment, especially after early

childhood. There are some subtypes under extrinsic motivation, and they are defined as:

1. External Regulation refers to the behavior performed to meet an external demand or obtain a reward.
2. Introverted Regulation: People sometimes perform behaviors they have done to avoid anxiety, to avoid guilt, or to see their self-worth and pride increase. This type of motivation is closely related to self-esteem and persistence.
3. Integrated Regulation: Considered the most autonomous form of extrinsic motivation. In this type of motivation, the person combines his observations about himself, his values and his needs. Adopts and accepts the performance of a task.

These subtypes represent different aspects of extrinsic motivation and the different sources of motivation it contains.

Positive Motivation

Intrinsic motivation is about initiating a series of activities to achieve something that is desirable and has a positive connotation. In this type of motivation comes success or well-being in performing the task. For example, suppose a student enlists the help of his teacher to learn the math formula and gives him unconditional support and congratulations. In that case, the student will be more likely to repeat this behavior because solving questions will become more fun for the student. This will ensure that the student understands and reinforces the subject more by providing continuity.

Negative Motivation

Negative motivation is used as a way to avoid undesirable consequences. For example, failing while trying to solve a math question can negatively affect a person. In order to forget about this situation, we can follow a path such as turning to another activity instead of solving the math problem. However, such motivation may only be effective in the short run and may create discomfort. Hence, it is an approach that is generally not recommended.

Motivation or Loss of Motivation

Demotivation or loss of motivation refers to a person's lack of will to start an action. This may occur because the person feels that a particular activity is unimportant or does not feel competent enough to perform that activity. For example, where you work, your boss gives you a job and the deadline for that job seems very difficult. In this case, you may lose motivation by thinking the work will not be enough. Similarly, a student trying to solve a math question may lose motivation due to needing help to solve the questions or giving

wrong answers. Many people have also experienced demotivation, often under challenging processes like the pandemic.

Result

Studies show a positive relationship between guidance and motivation in mathematics learning (Dede & Argün, 2004). Situations such as the student's withdrawal from the lessons, developing a negative attitude or fear of failure may cause the student to move away from trying. However, it has been revealed that the student has a better learning experience by providing the proper guidance and increased motivation. At the same time, with the proper guidance and motivation, students will be more successful in mathematics and reach their personal goals more quickly. With these successes, motivation increases, and the student becomes more willing to try. A ready and motivated student experiences a more effective learning process. In addition, motivation strengthens the student's achievements and prevents them from getting bored in the learning process. Motivation is essential in the learning process and should not be neglected, especially in challenging subjects such as mathematics.

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MATH EDUCATION AND BRAIN TEASERS

Hacer GEÇİM[1], Büşra NAYIROĞLU[2]

Abstract

This study aims to examine the relationship between mathematics education and intelligence games. Mathematics education improves students' mathematical thinking skills and increases their logical and analytical thinking abilities. Intelligence games, on the other hand, are games used to encourage cognitive skills, improve problem-solving abilities and increase mental flexibility. This study investigated how mathematics education and intelligence games interact with each other and how they can improve students' mathematical abilities. For this purpose, a literature review was conducted and the results of existing studies were examined. Mathematics education is essential in providing students with abstract thinking skills and making them interact with mathematical concepts. Intelligence games, on the other hand, encourage students to think mathematically by improving their problem-solving skills. The relationship between mathematics education and intelligence games can increase students' mathematical abilities by enabling them to understand better and apply mathematical concepts. According to the results of the literature review, it was seen that the combination of mathematics education and intelligence games increased students' mathematical thinking skills. Brain teasers can increase students' motivation and reduce math anxiety by encouraging the application of the topics learned in math lessons. In addition, it was stated that intelligence games can be more challenging and exciting for students with mathematical abilities. It can be used to improve students' mathematical abilities effectively. This study aims to help teachers and educators working in mathematics education know how intelligence games can be used in the learning process of mathematics.

Keywords: *Mathematics Education, Intelligence Games, Mathematical Ability*

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Introduction

Technology and computer concepts are essential in daily life, business life and education for modern societies and education systems (Tutak, İlhan, & İç, 2018). The education system is changing rapidly today and is affected by developments in science and technology. Keeping up with this change and developing the innovative thinking and solution-producing abilities of individuals depends on the level of progress of their skills and attitudes (Aslan, 2019). Developing cognitive abilities such as the effective use of the mother tongue, problem-solving skills and logical reasoning has an essential place in order to be individuals who not only follow the change but also actively direct the change (Baykul, 2003). With the constant changes in the world, the importance of education is increasing, and societies have realized that educated individuals have a fundamental impact on the development of society by making education compulsory with this awareness (Nayıroğlu, Tutak, & Tutak, 2021). The mathematics curriculum (MEB, 2018) aims to develop students' higher-order thinking skills. However, the curriculum does not emphasize adequate strategies, activities and materials to support the acquisition of these skills. More opportunities and guidance should be provided to develop students' higher-order thinking skills (Erdoğan, 2019).

Today, various alternative teaching methods and approaches are used in educational institutions to develop skills such as problem-solving, logical reasoning and multi-dimensional thinking, which are high-level life skills of learners. One of these alternative approaches is intelligence games (Adalar & Yüksel, 2017). Intelligence games can be used as an effective tool to develop problem-solving skills (MEB, 2013). Students who solve problems with intelligence games through games can develop a more positive attitude toward math lessons and math problems. Students demonstrate a creative and patient approach while solving problems by developing higher-order thinking abilities. They also learn communication skills using math. Problems improve problem-solving abilities, increase motivation, and support learning mathematics (Koçak, 2011). Therefore, developing problem-solving skills in students can also affect their motivation and attitudes toward mathematics.

Adding the "Selective Intelligence Games" course to the secondary school curriculum by the Ministry of National Education in the 2012-2013 academic year and implementing these activities is an essential step in developing the skills mentioned above. However, there are not enough studies in the literature on the effectiveness of the intelligence games curriculum (Şanlıdağ, 2022).

Problem Status

In the 21st century, students are expected to be able to use high-level thinking skills such as problem-solving, critical thinking, creative thinking and

communication skills and to use information and communication technologies effectively. Mind games are one of the games that potentially contribute to developing these higher-order thinking skills and increase school achievement. Mind games require individuals to use different thinking skills and strategies to solve problems (Demirel & Yılmaz, 2016). In recent years, with the innovations made in our education system, intelligence games have started to be taught as an elective course. However, it is seen that the studies on this subject are limited to the literature reviews.

Purpose of the research

This study aims to examine the interaction between mathematics education and intelligence games and investigate how students can improve their mathematical abilities.

Research Method

In this study, the document analysis method, one of the qualitative research methods, was used. Document analysis examines the existing written source of the researched subject (Hitchcock & Hughes, 1995). *Document analysis* is also defined as examining visual materials containing information about the event or phenomena planned to be investigated (Yildirim & Simsek, 2008; Çelik et al., 2022). The primary purpose of document analysis is to examine the obtained documents in a theory-oriented, systematic and data-based manner (Saglamoz & Soysal 2021).

Mathematics Education and Teaching

What is Mathematics?

Mathematics appears consciously or unconsciously in many different areas of our daily lives. We can say that we are intertwined with mathematics, from daily activities such as looking at our watch and shopping on the Internet to more technical fields such as the operation of vehicles, radar systems, map making, and accounting (Şanlıdağ, 2020). The definition and meaning of mathematics has been a question that has occupied mathematicians throughout history. Altun (1989) shows the reasons, such as the diversity of sources in the formation of mathematics, the difference in the purpose of mathematics education and the understanding of mathematicians. Crilly (2012) states that mathematics is a versatile and broad subject in the 21st century.

Mathematics is a part of our lives, from budget management to operating systems of electronic devices, from the operation of medical scanners to daily calculations. Mathematics teaches the rules of correct thinking, enables us to establish concrete relationships with abstract concepts, accelerates social and scientific development, and plays a vital role in the development of human intelligence (Şanlıdağ, 2020).

The question of what mathematics is is a question that has occupied thinkers since the Ancient Greek period, and still, no satisfactory answer has been found (Yıldırım, 2015). Yıldırım (2015) defines mathematics as the science of revealing, determining and logically proving properties of abstract objects such as numbers, points, sets and functions.

Mathematics is central to scientific research and technological developments and has become a fundamental element of human culture (Mankiewicz, 2002). Akman (2002) sees mathematics everywhere and as combinations of different concepts. When we think that mathematics is a science of investigation and reasoning, that it is a universal science and that it is related to all other branches of science, we can say that the subject expands even more (Işık, 2002).

Mathematics Education

Mathematics education is an activity that is not just about calculations and formulas. Mathematics should be seen as a field that is not limited to numbers. Mathematics education is a field that can develop high-level behaviors such as analysis, communication, generalization, and creative and independent thinking (Aşkar, 1986). Mathematics is a tool we need and use in every field of daily life. For this reason, mathematics education should start from pre-school until higher education programs and should be included in every aspect of our lives (Demir, 2017).

Mathematics education is carried out with various approaches using traditional and new methods and techniques. While a teacher-centered approach is adopted in the traditional method, new approaches encourage student-centered education. In the traditional method, memorizing the information given by the teacher comes to the forefront, ignoring the students' existing knowledge. This situation may prevent students from profoundly understanding the subject and developing their thoughts (Erdoğan, 2000).

The mathematics education reform aims to create a problem-solving-oriented classroom environment for teachers and encourage students to learn interactively. In addition, it is vital to create learning activities that can enable the rediscovery of mathematics and develop teachers' guiding skills in this process (Inharjanto & Lisnani, 2018).

Mathematics education aims to develop students' high-level skills, such as analytical thinking, communication, generalization, creativity and independent thinking, rather than just developing their computational skills. For this reason, mathematics education is tried to be more effective with various reform approaches.

Mathematics Curriculum

The rapid change in science and technology has transformed the needs of society and individuals and has brought about innovations and developments in learning-teaching theories. This change defines individuals who can produce information, use it functionally, solve problems, think critically, be entrepreneurial, be determined, have communication skills, empathize and contribute to society and culture. Curriculums aimed at raising individuals with these qualifications have been prepared in a simple and understandable structure, which considers individual differences rather than mere knowledge transfer and aims to gain values and skills. In line with this purpose, learning outcomes that are aimed to be acquired holistically and at once, as well as repetitive acquisitions and explanations, are included in the curriculum (MEB, 2018).

The Mathematics Curriculum aims to develop students' mathematical literacy skills and use them effectively, to understand and use mathematical concepts in daily life, to easily express their thoughts and reasoning in the problem-solving process, to use mathematical terminology and language correctly to explain and share their mathematical thoughts logically, to use the meaning and language of mathematics to make sense of the relations between people and objects and the relations of objects with each other, to develop metacognitive knowledge and skills, to be able to express their own cognitive knowledge and skills, to be able to express their own learning processes consciously, to be able to represent and represent learning processes in different ways consciously. While learning mathematics aims to achieve general objectives such as developing a positive attitude towards mathematics and developing a self-confident approach to mathematical problems, developing the characteristics of being systematic, careful, patient and responsible, developing the skills of conducting research, producing and using information, recognizing the relationship of mathematics with art and aesthetics, valuing mathematics with the awareness that mathematics is a typical value of humanity (MEB, 2018).

The 2018 curriculum aims to train students who can solve problems, have different ideas, actively participate in the lesson, and are involved in mathematics. The program emphasizes providing appropriate teaching areas to support students in developing their ability to solve new problems, combine their existing knowledge with what they have just learned, and produce different solutions. In addition, it is emphasized that reasoning skills are essential and the primary skills the program wants to develop (Şanlıdağ, 2020).

Brain Teasers

Combining games with classroom environments is vital in helping students become individuals with the qualifications required by their age (Ayar et al., 2023). Intelligence games are also important in educational games (Şanlıdağ, 2020). Intelligence games allow individuals to discover their potential, make quick and correct decisions, produce unique solutions and constantly improve themselves (Devecioğlu & Karadağ, 2014). These games help students develop their intelligence while having fun, opening their minds, learning new things and reaching new horizons (Yöndemli & Doğan Taş, 2018).

Intelligence games consist of three different steps. The first level, the beginner level, involves learning the rules of the games, acquiring essential knowledge and skills, playing beginner-level games and solving puzzles. The second level, the intermediate level, includes

- making logical deductions,
- starting at the right place in puzzles,
- applying basic strategies in strategy games,
- playing intermediate games and solving puzzles.

The third step, the advanced level, includes creative thinking, analysis, developing original strategies, evaluating and generalizing. Playing advanced games, solving puzzles and benefiting from the experiences of others are also included in this step (MEB, 2013).

Students who make intelligence games a part of their education must be able to construct problems by associating them with real-life materials, not just shapes and numbers (MEB, 2013). The addition of the "Selective Intelligence Games" course to the secondary school curriculum in the 2012-2013 academic year by the Ministry of National Education and the implementation of these activities can be considered an essential step in developing these skills (Şanlıdağ, 2020).

Intelligence Games Curriculum

The intelligence games course aims to enable students to discover and develop their intelligence potential in line with the general objectives specified in the Basic Law of National Education. Thanks to this course, it is aimed that students to develop different and original strategies in the face of problems, make quick and correct decisions, create a systematic mindset, and gain skills to work individually, as a team and in a competitive environment within the scope of intelligence games and develop a positive attitude towards problem-solving (MEB, 2013).

The mind games course contributes to the development of students' problem perception and evaluation skills, creating different perspectives, making quick

and correct decisions when faced with a problem, acquiring the habit of focusing on a subject and a solution, and improving their ability to use reasoning and logic effectively (MEB, 2013).

In line with the behaviors specified in the TTKB's (2013) curriculum, many skills, such as generating ideas based on logic, creating action strategies using abstract symbols, developing grouping skills, solving problems using teamwork skills, making inferences from experiences, comprehending the movement and relations of three-dimensional objects, developing reasoning skills through simulation, and developing three-dimensional thinking and reasoning skills are targeted with the intelligence games course (TTKB, 2013).

The skills targeted by the mind games lesson are similar to the mathematics lesson. One of the most effective ways to make math class fun is to add various games to the lesson. While playing games, students use their thinking skills and realize they need math. Games also help them understand math concepts. In this context, intelligence games are essential to make mathematics fun (Büyükkeçeci, 2014).

Studies show that the mind games course positively affects mathematical problem-solving attitudes and reflective thinking skills. It was determined that the groups that were given elective intelligence games to the students achieved higher scores in the mathematical problem-solving attitude and reflective thinking skill scales than the control group (Şanlıdağ & Aykaç, 2020). This shows that the elective intelligence games course effectively increases secondary school students' mathematical problem-solving attitude and reflective thinking skills.

Mathematics Education and Intelligence Games

It is a common prejudice that the mathematics course is perceived as a problematic and challenging for students to understand. In order to overcome this prejudice, teachers need to make mathematics fun by emphasizing that mathematics is in life. For this, enriching the lesson with various games is an effective method. While playing games, students think and try to find solutions using mathematics. Games also help them to understand mathematical concepts (Büyükkeçeci, 2014).

Intelligence games are an effective tool that includes real problems in a gamified way and provides students with problem-solving skills (MEB, 2013). Quick and accurate reasoning is required to reach the goal in mind games. Reasoning is an essential mental skill used throughout life, along with systematic problem-solving. Reasoning and logic are essential in the mathematics curriculum (MEB, 2013).

Using brain teasers and puzzles in math class is an effective way to motivate students to learn. Such games, mathematical recreation and puzzles have excited and aroused many people throughout history. Games allow students to participate in thinking and planning strategies actively. Competitive games increase student participation. However, teachers who use games should pay attention to the fact that weak students have a chance to be successful from time to time (Doğan, 2014).

There is a widespread belief that there is a close relationship between mind games and math achievement. Intelligence games can also contribute to success in mathematics as they involve strategic, flexible and versatile thinking. Brain games can be based on mathematics and the application of mathematical concepts. In addition, mind games are also associated with problem-solving skills. Mathematics intelligence games are an effective method that can help students maintain their mathematical skills (Şanlıdağ, 2020).

In general, brain teasers have great potential to make math class fun and enable students to have a positive relationship with math. These games help students improve their thinking skills and better understand mathematical concepts.

Result and Suggestions

This study's results show that using intelligence games in mathematics lessons effectively improves students' mathematical skills, increases their problem-solving skills, and makes mathematics fun. Intelligence games enable students to recognize and develop their intelligence potential. These games help students develop different and original strategies while improving their ability to make quick and accurate decisions. In addition, mind games improve their ability to work individually, in teams and a competitive environment, enabling students to develop a positive attitude towards problem-solving. Mind games in mathematics class encourage students to actively use their mathematical thinking skills. Games enable students to understand mathematical concepts and see mathematics as a discipline they can use in life. In this way, students' prejudices about mathematics are overcome, and the mathematics lesson becomes more interesting. In addition, there is a close relationship between intelligence games and mathematics. Intelligence games contribute to the development of mental skills such as mathematical problem-solving skills, reasoning and using logic.

For this reason, intelligence games can be used as an effective tool to increase mathematics achievement. As a result, using intelligence games in mathematics lessons is an important method to improve students' mathematical skills and make mathematics fun. Teachers' effective use of mind games in their lessons helps students overcome their preconceptions about mathematics and

improve their mathematical thinking skills. This increases students' success in mathematics and enables them to establish a positive relationship with mathematics.

Based on the results of this study, the following recommendations can be made:

1. Intelligence games and puzzles should be used to make the math lesson fun. These games allow students to understand math concepts while improving their thinking skills.
2. Teachers should emphasize that mathematics is a discipline we encounter in all areas of life and convey the importance of mathematics to students. It should show students that mathematics is simple and that everyone can succeed.
3. The intelligence games course enables students to recognize and develop their intelligence potential. Thanks to these games, students can develop different and original problem strategies.
4. Intelligence games improve students' ability to make quick and accurate decisions. These games help students form a systematic mindset and use reasoning skills effectively.
5. Intelligence games improve the skills of working individually, in teams and a competitive environment. Students develop a positive attitude towards problem-solving and improve their cooperation skills through these games.
6. Using games in the mathematics lesson motivates the students to mathematics and makes the lesson more interesting. Games encourage students to use their mathematical thinking skills.
7. There is a close relationship between intelligence games and mathematics. For this reason, intelligence games can be used as an effective tool to increase mathematics achievement.
8. To overcome students' preconceptions about mathematics, it is vital for teachers to make mathematics lessons fun and exciting. Intelligence games can be used effectively for this purpose.
9. Developing skills related to intelligence games, such as mathematical problem-solving skills, reasoning and using logic, can increase students' mathematical success.
10. Teachers can help students maintain and improve their math skills using math brain teasers. Brain teasers help students develop a positive attitude toward mathematics and help them understand mathematics.

These suggestions show that using intelligence games in mathematics lessons effectively improves students' mathematical skills and makes mathematics fun.

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A LOOK AT STEAM

Hakan YILDIRIM[1]

Abstract

STEAM, which we often hear in many countries today, is formed by the combination of the abbreviations of English words Science (science), Technology (technology), Engineering (engineering) and Math (mathematics). STEM+A education is an educational approach expanding in scope and gaining importance by adding art to STEAM fields. STEAM education aims to compare students with learning-guiding problems to raise students with 21st-century skills from kindergarten to university. In the age of technology, individuals are expected to be productive and innovative. For this reason, STEM education aims to provide interdisciplinary integration by bringing together science, mathematics, engineering and technology disciplines. STEAM education aims to bring together teachers and students with technology and encourage multifaceted development in the fields of science, technology, engineering and mathematics. The STEAM education approach is an education model that will help future generations to be successful in the fields of STEAM by helping digitalization and technology-based thinking (Stohlmann, Moore, & Roehring, 2012). This study presents what STEAM education is and its place and importance in mathematics education with a research study created by scanning various sources.

Keywords: *Stem, Science, Technology, Engineering, Mathematics*

Introduction

Today, the education system of many countries aims to educate students as innovative individuals, problem-solving, can contribute to economic and social developments, and have 21st-century skills. Technology and computer concepts are among the most critical elements in daily life, business life and education for modern societies and education systems (Tutak, İlhan, & İç, 2018).

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Advances in technology and the requirements of the 21st century increase the need for productive students who think, question, research and invent. In this context, STEM (Science, Technology, Engineering, Mathematics) education, which enables students to see the information they learn in science, technology, engineering and mathematics courses, gains importance (Azkın, 2019).

With the constant changes in the world, the importance of education is increasing, and societies have realized that educated individuals have a fundamental impact on the development of society by making education compulsory with this awareness (Nayıroğlu, Tutak, & Tutak, 2021). Mathematics plays a vital role in solving complex problems encountered in daily life. One of the primary purposes of mathematics teaching is to provide students with problem-solving skills (MEB, 2017). The mathematics curriculum (MEB, 2018) aims to develop students' higher-order thinking skills. However, the curriculum does not emphasize adequate strategies, activities and materials to support the acquisition of these skills. More opportunities and guidance should be provided to develop students' higher-order thinking skills (Erdoğan, 2019). However, nowadays, mathematics alone may not be enough to solve complex problems. To solve such problems, a multi-faceted, integrated and interdisciplinary method of thinking is required. The secondary school mathematics curriculum aims to raise students who can solve problems, apply mathematics to their daily lives, make modeling, establish interdisciplinary relationships, and support their mathematical knowledge with materials when needed (MEB, 2017). In order to achieve these goals, it can be thought that new teaching approaches suitable for our education system are required. Recently, approaches such as mathematical modeling and STEM education have attracted attention (MEB, 2016). STEM education has an integrative structure in which science and mathematics contents are blended with engineering and technology (Akgündüz et al., 2015). Raising a high-quality generation is one of the main goals of STEM education (Çorlu & Çorlu, 2012). Developing countries like Turkey need individuals who can adapt to industry and technology and have high innovation skills (TÜBİTAK, 2004).

STEM education enables students to approach problems with an interdisciplinary perspective and gain knowledge and skills (Şahin, Ayar & Adıgüzel, 2014). Advocates of an integrated approach state that subjects involving real-world problems can increase students' interest, success, and motivation and, as a result, encourage their desire to pursue a career in STEM fields (Honey, Pearson, & Schweingruber, 2014).

Purpose of the study

This study aims to explain what STEAM education is and its place and importance in mathematics education.

Method of Study

In this study, the document analysis method, one of the qualitative research methods, was used. Document analysis examines the existing written source of the researched subject (Hitchcock & Hughes, 1995). Document analysis is also defined as examining visual materials containing information about the event or phenomena planned to be investigated (Yildirim & Simsek, 2008; Çelik et al., 2022). The primary purpose of document analysis is to examine the obtained documents in a theory-oriented, systematic and data-based manner (Saglamoz & Soysal 2021).

STEAM and Research

STEAM education supports students to prepare for real life in a student-centered learning environment by developing them in critical thinking, problem solving and creativity (Lathan, n.d.). Students participating in this program not only learn the subject but also learn how to study, how to research, how to analyze, how to experiment and how to produce creatively. Some of the opportunities that STEAM education offers to students are as follows (Bruton, 2017; MEB, 2016):

- Students are encouraged to ask thought-provoking questions, discover answers and apply what they have learned to engage in the creative learning process.
- Helps students develop 21st-century skills such as critical thinking, creativity, collaboration, social skills, technology literacy and productivity.
- It provides opportunities for students to solve problems through systematic and critical thinking and to apply new knowledge or past experiences.
- It provides a meaningful collaborative environment that allows students to work in teams, exchange ideas, discuss problems, share responsibilities and encourage each other.
- It provides students with hands-on and experiential learning opportunities by using different tools and materials.
- It encourages students to be productive by increasing their self-confidence and motivating them to participate and contribute to learning.
- It develops students' curiosity and inquiry skills and reveals their ability to invent or design innovative products due to their research.

Unlike traditional education, STEAM not only teaches a subject but also concerns how students will apply the subject in real life and how they will use it in the future. Unlike traditional education, STEAM is focused on teaching

about a subject and how students can apply the subject in real life and use it in the future. These innovative approaches are reflected in the roles of teachers as a change, and the roles of teachers can be determined as follows:

- To provide rich student-centered learning experiences,
- Focusing on real-world problems,
- Integrate all subjects,
- Adopting collaborative learning,
- Allowing more than one correct answer,
- To support a non-threatening learning environment,
- Redefining failure as a necessary part of learning,
- Involving students in teamwork,
- Participating in training for their professional development.

It is stated that teachers need a certain amount of training in order to adapt to new roles and responsibilities (Pang & Good, 2000). For this reason, the Ministry of National Education (MEB) has been organizing in-service STEM training for teachers since 2013 (Özsoy, 2017). Although STEAM education explores the same core concepts as STEM, it takes STEM one step further by emphasizing the creative process and art.

STEAM education is promoted worldwide, and large amounts of funding are allocated (Daugherty, 2013). In Turkey, interest in STEM education has increased in evaluating poor performance in PISA (Program for International Student Assessment) and TIMSS (International Mathematics and Science Trends Survey) exams. The Ministry of National Education conducted a study to evaluate teachers' views on including STEM education in our education system. Most participants (91.97%) believed that inquiry-based STEM education is necessary. The majority of the participants (91.96%) thought that STEM education is vital for the country's economic development (MEB, 2016). As a result of this research, our teachers are highly aware of the importance of STEM education. The Ministry of National Education has compiled studies to support STEM education in the STEM Education Report (MEB, 2016). The steps that should be included in the Action Plan to support STEM Education in the report are as follows:

- Establishment of STEM Education centers,
- Conducting STEM education research in these centers,
- Educating teachers through STEM education,
- Updating curricula for STEM education,
- Creating suitable teaching environments and providing course materials for STEM education in schools.

Public institutions, universities, foundations and many other stakeholders come together to support STEAM education in Turkey. For example, the Turkish Industrialists and Businessmen's Association (TUSIAD) supports STEAM training to improve cognitive processes and production skills rather than labor and muscle strength. The Scientific and Technological Research Council of Turkey (TÜBİTAK) carries out projects and organizes competitions to ensure the emergence of successful students and teachers in STEM education (MEB, 2016). Universities have also established structures such as STEM centers (METU), laboratories (IAU) and conduct scientific research (Uyanık & Günşen, 2017).

In a study conducted by Gülhan and Şahin (2020), the metaphorical perceptions of secondary school seventh-grade students about STEAM fields were examined. The research was carried out on 135 students who were asked to complete five sentences. The obtained data were evaluated by content analysis, and the results were examined. Different aspects of science and technology, mathematics, art and engineering emerged in students' perceptions. It has been determined that some students have a lack of engineering knowledge. The results of this study support the suggestion that students' perceptions of these areas can be improved by using the holistic structure of STEAM education.

In a study conducted by Gülen and Yaman (2018), activities focusing on daily life problems were organized in the classroom environment with the integration of language skills, science-technology-engineering and mathematics disciplines, and student product files were created. The research aims to enable students to use their approach skills by using STEM-integrated argumentation activity texts and to obtain information about student levels with the products obtained from these activities. In the study, the experimental modeling method was used to understand the cause-effect relationship and the data were collected with product files. Student product files containing STEM-integrated argumentation activity forms, including electrical conduction problems, were examined and evaluated. Twenty students participated in the study, and a seven-week study was carried out. The results showed that the students' approach skills were high, and they adopted this approach. As a result of the research, it is recommended to use this approach in science education.

In a study conducted by Kolsuz (2018), the effect of STEAM education on the attitudes of third-grade primary school students toward science and students' views on STEAM applications were tried to be determined. The study used a quasi-experimental design with a pretest-posttest control group. Semi-structured interview form was used for qualitative data, and a content analysis technique was used for quantitative data. The results showed that STEAM applications changed students' perspectives and increased their motivation toward the lesson (Kolsuz, 2018).

Result

Considering the constantly renewed, developing and changing world order in education, it is unthinkable that education should be based on a monotonous narrative and be far from practice and production. It has become imperative to follow up-to-date approaches to develop 21st-century skills and train students with these skills. STEM+A (STEAM) education is an educational approach that aims to adapt to the new world order and encourages interdisciplinary connections. It aims to prepare students for real-life problems by combining science, technology, engineering, art and mathematics. Studies show that these interdisciplinary transitions positively affect students' attitudes and success. In order to increase success and obtain creative products, STEAM education should be given more importance and developed in schools and educational environments. Making the teachers in this field better equipped for STEAM education will positively affect the process. The primary purpose of education is to raise individuals who can solve their life problems, think creatively and be productive. Therefore, the need for models that develop 21st-century skills is increasing daily.

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GAME AND GAMIFICATION IN MATHEMATICS EDUCATION

Hasan AY[1]

Abstract

There is a direct correlation between countries' development levels and their education success. To develop a country, we must raise education to the highest levels. With the constant changes in the world, the importance of education is increasing, and societies have realized that educated individuals have a fundamental impact on the development of society by making education compulsory with this awareness (Nayıroğlu, Tutak, & Tutak, 2021). For this, we must constantly keep up with innovations in education. In order to reach higher levels of education, we must focus on methods that enable students to learn meaningfully and permanently. Mathematics is one of the courses in which students have difficulty in meaningful and permanent learning. Mathematics is perceived as a course that students struggle with due to its abstract structure.

In order to solve this problem, we need to embody mathematics and make students love it. Games and gamification can be used to embody and make learning mathematics more fun. This study aims to examine the use of games and gamification in mathematics education through studies in the literature. Games and gamification are essential approaches to provide a meaningful and effective learning experience in mathematics education. Analysis of studies in this area shows that this approach has many advantages for learning mathematics. Games and gamification help students better understand math concepts and improve their problem-solving skills. It also contributes to developing mathematical thinking, collaboration, problem-solving and critical thinking skills. As a result, learning environments integrated with games and gamification facilitate students' mathematics learning, increase their interest in mathematics and encourage mathematics studies. Therefore, it can be ensured that teachers benefit more from this approach in lessons by organizing

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in-service seminars on this subject. In addition, increasing such studies can contribute more to the field.

Keywords: *Mathematics Education, Game, Gamification*

Introduction

Mathematics is a complex subject for many students. However, in a changing world, students who understand and deal with mathematics will have more options and opportunities to shape their future (Umay, 2001). Lecture or question-answer methods are generally used in mathematics education (Berkant & Gençoğlu, 2015; Soylu, 2009). However, for effective teaching, it is necessary to draw the student's attention to the lesson without breaking their connection with the lesson, and the students should be motivated in this direction. It will be meaningful for students to learn and use them permanently instead of just the information they learn and forget in the mathematics lesson. For this, the method of learning by doing plays an important role. Students can experience and apply mathematical concepts concretely thanks to educational computer games. This way, learning is supported positively (Çankaya & Karamete, 2009).

Technology and computer concepts are among the most critical elements in daily life, business life and education for modern societies and education systems (Tutak, İlhan, & İç, 2018). Mathematics anxiety in students arises from their negative experiences throughout their education. This anxiety primarily causes students to feel insecure and have low motivation. On the other hand, insecurity and lack of motivation cause students to avoid mathematics from primary school and this course to fail. In this context, correctly using elements such as motivation, cooperation, and competition in the games and the motivations such as the desire to win, desire and reward will reduce these negative situations and strengthen the education. Therefore, it can potentially increase the permanence of knowledge and interest in the lesson and reduce the problems of mathematics anxiety, lack of motivation and confidence (Eray, 2022).

As games and gamification actions increasingly enter our lives, the use of games and gamification to attract attention is increasing (McGonigal, 2011; Werbach, 2013). For the teaching process to be more efficient, it is vital to develop a perspective on the student's perspective because there is constant change and the habits of the younger generation (Bozkurt, 2014). Teaching with games and gamification can increase students' interest and motivation, helping them to actively participate in the lessons and facilitate the learning process (Akın & Aıcı, 2015; Kapp, 2013). When game elements are integrated into mathematics activities, it can be ensured that children participate in

mathematics lessons more meaningfully and willingly (Parks, 2014). In multicultural classrooms, game-based math activities encourage the emergence of creative mathematical ideas by encouraging non-verbal interaction and the use of mathematical language (Lillemyr, Sobstad, Marder & Flowerday, 2011; Parks, 2014). Integrating game-based applications into mathematics teaching programs supports students to feel comfortable, increase their motivation and actively participate in activities (TTKB, 2018).

Play is a tool that allows the child to learn through his own experiences (Yavuzer, 2007). Play is a part of real life and the most effective learning process for children, in which the child participates willingly and with pleasure, not for a specific purpose, performed with or without rules, forming the basis of physical, cognitive, language, emotional and social development (Aral, Gürsoy, Köksal, 2001). The game helps the child know himself, discover his talents and develop his sharing skills (Başun & Doğan, 2020). For this reason, the importance of games and gamification in practical mathematics education is increasing.

Problem Status

Mathematics is one of the most problematic courses in our country. Although there are various reasons for this, the most important one is that mathematics has an abstract structure. Considering that students are in a concrete period, especially in the first years of education, it is obvious how many problems the abstract nature of mathematics will cause. One of the points to be considered in mathematics education is to embody mathematics. Clearly, the more importance given to concretization in mathematics education, the more meaningful and permanent the education will be. Various ways can be tried, and teaching methods can be developed to concretize mathematics. Concrete teaching objects can be used as well as technology. You can also benefit from gaming and gamification. Suppose mathematics education subjects can be taught using games and gamification. In that case, both students' learning will be more meaningful and permanent, and students' attitudes towards mathematics can increase positively. Therefore, this study examined the use of games and gamification approaches in mathematics education by scanning the literature.

Purpose of the research

This study examines the use of games and gamification approaches in mathematics education by scanning the literature. In this direction, first of all, the definitions and basic principles of the concepts of game and gamification in mathematics education are presented. Then, by analyzing the studies in the literature, the advantages and effects of the game and gamification approach in mathematics education were examined. This analysis addressed issues such as

how games and gamification can be used in different learning environments, their effects on students' mathematics learning, and their contribution to the development of mathematics skills.

Method of Research

In this study, the document analysis method, one of the qualitative research methods, was used. Document analysis examines the existing written source of the researched subject (Hitchcock & Hughes, 1995). Document analysis is also defined as examining visual materials containing information related to the event or phenomena planned to be investigated orderly (Yildirim & Simsek, 2008; Çelik et al., 2022). The primary purpose of document analysis is to examine the obtained documents in a theory-oriented, systematic and data-based manner (Saglamoz & Soysal 2021).

Game

For many years, the game was seen as a tool for children to spend their energy, not to misbehave and to meet their imitation needs, but today it is considered a learning method (Güneş & Yünkül, 2021). It is stated that the game is a form of learning and has a structure suitable for the needs of today's students (Karamert, 2019). In addition, using games in education positively contributes to students' cognitive, emotional, physical, social and language development (Güneş, 2010). In terms of cognitive development, the game supports children's reasoning skills, establishing cause-effect relationships, focusing their attention, setting goals, developing different solution strategies, and multidimensional thinking (Özyürek & Çavuş, 2016). In terms of emotional development, children experience and express emotions such as sadness, joy, desire, imagination, fear and anger during play (Zengin, 2002). In other words, the child learns to gain power through play, to direct this power, to control success, defeat, excitement and emotions (Aksoy, 2010).

Regarding physical development, almost all children playing games make movements such as jumping, jumping, holding, pulling, and running. These movements show supportive effects on children's physical development. Regarding social development, children gain many features, such as learning the rules through play, tolerance of different ideas and situations, accepting defeat, belonging to a group and communicating and understanding others (Altunay, 2004). In addition, the game develops vocabulary and gives the child the habit of speaking comfortably and expressing his thoughts, and encourages asking questions and learning new words (Zengin, 2002). All these are essential grounds for gamification in educational environments.

Gamification

Gamification is influencing, connecting and motivating individuals, groups or communities to guide behavior and effect desired outcomes (Wang, 2011). Gamification processes are used in many areas, such as increasing sales, product promotion or changing the behavior of users. One of these areas is education. In education, there may be difficulties in reaching the goals in the teaching process due to differences such as students' academic background, learning capacity, speed and personal learning preferences. With correctly designed gamification applications, students can be in an environment where they can realize their learning, learn in a motivated way and review their learning when necessary (Yalçın, 2018). Gamification is an effective method of bringing students together. Gamification processes carried out with individuals or teamwork in the classroom environment help the students to regain their motivation and contribute to the formation of integrity (Yılmaz, 2020).

Related Studies

Games help students consolidate their knowledge individually or as a group by making exercises and activities more enjoyable. Mathematics and games are closely related because of their structural similarities and intertwinedness. Games include mathematical methods since childhood (Uğurel & Moralı, 2008).

In an experimental study conducted by Beyhan and Tural (2007), the effect of game-based mathematics teaching on access was examined using the Control Group Pretest-Posttest model. This research was carried out with 3rd-grade students in a primary school in the Buca district of İzmir province. While the game-based teaching was applied to the experimental group, the lesson was taught with the traditional method in the control group, and data were collected from both groups using an access test developed by the researchers. The study results show a significant difference in access between the experimental and control groups in favor of the game-based teaching experimental group.

In a study conducted by Biriktir (2008), an experimental method with a pretest-posttest control group was used in order to determine the access levels of the experimental and control groups in the study titled 'The Effect of Teaching with Games on the Teaching of Geometry Subjects in Elementary 5th Grade Mathematics Course'. The reach of the experimental group, which was taught with games, was higher than the control group. As a result of the data analysis, a significant difference emerged in favor of the experimental group.

Canbay (2012) studied the effects of educational games on academic achievement, motivational beliefs, and self-regulatory skills by working with a 7th-grade student. An achievement test developed by the researcher and a scale

to measure motivational strategies were used as data collection tools. While the students in the experimental group learned the subject of polygons with educational games, the traditional method was used in the control group. As a result of the analysis, it was found that the educational game teaching method had a significant effect on academic achievement, self-regulatory strategies and motivational beliefs and contributed to the permanence of knowledge.

In Soylu's (2001) master's thesis study, the effects of using educational games in the teaching of mathematics lessons were investigated under the title of "Educational-Teaching Games that Can Be Used in Teaching Mathematics Lessons (I. Phase 1, 2, 3, 4, 5th Grade)". The study aimed to increase students' learning by making the abstract mathematics lesson more exciting and creating a student-centered lesson environment. When the data obtained were analyzed, it was determined that mathematics teaching supported by educational-instructional games was more permanent, more accessible and more fun compared to other methods. It has been observed that by providing an interactive learning environment in which students participate actively, mathematics subjects are better understood, and learning takes place more deeply. This study academically supports that the use of educational games in mathematics lessons has positive effects on the mathematics learning process by increasing the motivation of the students.

Altunay (2004), in his master's thesis study under the title of "Effect of Play-Assisted Mathematics Education on Student Access and Permanence", investigated the effect of game-supported mathematics education on students' success in mathematics courses and the permanence of what has been learned. According to the research results, there were differences in favor of the experimental group on the mathematics course supported by the game applied in the experimental group, student achievement and permanence of the learned compared to the traditional teaching method applied in the control group. Teaching mathematics supported by games has effectively increased students' mathematics achievement and made the learned information more permanent. These findings emphasize the importance of using the game-supported teaching method in mathematics lessons.

Result and Suggestions

The results of the studies reveal that the use of gamification in mathematics education generally produces positive results and contributes to the student's learning processes. Many studies also support that the game-based teaching method has positive effects on academic achievement, attitude and learning processes (Arcagök, 2021; Arslan, 2016; Boz, 2018; Talan, Doğan, & Batdı, 2020; Erhel & Jamet, 2013; Suh, Kim & Kim, 2010; Harter & Ku, 2008; Ke, 2008;

Songur, 2006; Wouters & van Oostendorp, 2013). Games and gamification in mathematics learning environments can enable students to develop in cognitive and affective areas. In this way, it can support meaningful and permanent mathematics learning. Teachers are essential actors who will prepare and implement these environments, but they may face various difficulties and may lack time and resources in planning and designing gamification tools. For this reason, it is vital to encourage the effective implementation of gamification in lessons by supporting teachers, such as in-service courses.

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CREATIVITY AND MATHEMATICAL CREATIVITY

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Abstract

This research aims to examine the relationship between mathematical creativity and conceptual creativity. *Creativity* can be defined as producing new and original ideas by using innovative thought processes and solving problems with different approaches. Mathematical creativity is the process in which creative thinking and approaches are used to solve mathematical problems. This study includes research from various disciplines and sources to understand the relationship between creativity and mathematical creativity. The literature review includes studies on how creativity can be fostered in areas such as mathematics education, mathematical problem-solving skills, development of mathematical abilities, and teaching mathematics. Research shows that various strategies can be used to develop mathematical creativity. These strategies include problem-based learning, games and puzzles, math activities that encourage creative thinking, student-centered teaching methods, and mathematical modeling. In addition, the role of teachers in mathematics education and the assessment tools that students can use to explore their creative potential were also examined. This study draws on research to evaluate the impact of creativity on mathematics teaching and learning and to offer practical suggestions for developing mathematical creativity. The relationship between creativity and mathematical creativity is complex and multifaceted. Encouraging creativity in mathematics education can help students develop mathematical problem-solving skills and increase their mathematical abilities. The results of this study can be an essential resource for mathematics teachers, researchers and education policymakers and can shed light on future research.

Keywords: *Creativity, Mathematical Creativity, Creative Thinking*

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Introduction

Today, skills such as reasoning, creative problem solving and creative thinking in curricula come to the fore with the change of qualifications and skills needed in individuals. Especially in mathematics courses, mathematical creativity is essential for developing high-level skills. By its nature, mathematics provides a suitable environment and basis for developing creativity (Nadjafikhah et al., 2012). However, studies on mathematical creativity are rare (Leikin et al., 2013; Sriraman et al., 2013), and the concept of creativity in mathematical activities must be clearly stated. Mathematical creativity is not just a static feature of gifted people but an active feature that can be developed for a wide range of students when appropriate tools and environments are provided (Leikin, 2009; Silver, 1997). It is crucial to consider the education level of each individual in the definitions of mathematical creativity (Piirto, 2004).

In definitions of mathematical creativity, problem-solving skills are associated with mathematical creativity and stand out as an essential component (Haylock, 1987; Kwon, Park, & Park, 2006). For example, mathematical creativity can be defined as developing different solutions (Leikin, 2009), or it can be considered as the ability to solve unusual problems (Haylock, 1987).

With the constant changes in the world, the importance of education is increasing, and societies have realized that educated individuals have a fundamental impact on the development of society by making education compulsory with this awareness (Nayıroğlu, Tutak, & Tutak, 2021). The mathematics curriculum (MEB, 2018) aims to develop students' higher-order thinking skills. However, the curriculum does not emphasize adequate strategies, activities and materials to support the acquisition of these skills. More opportunities and guidance should be provided to develop students' higher-order thinking skills (Erdoğan, 2019). Based on the idea that creativity, like high-level skills, is not an innate unique ability, it is stated that studies with groups without any unique talent diagnosis will play an essential role in improving mathematical creativity/productivity skills (Silver, 1997). It is thought that the data obtained from such studies will contribute to realizing the goals set out in the PISA, TIMSS and MEB 2023 vision document and will be an essential resource for practitioners in developing and evaluating mathematical creativity.

Purpose of the study

This study aims to examine the relationship between the concept of creativity and mathematical creativity.

Method of study

In this study, the document analysis method, one of the qualitative research methods, was used. Document analysis examines the existing written source of the researched subject (Hitchcock & Hughes, 1995). Document analysis is also defined as the examination of visual materials containing information related to the event or phenomena planned to be investigated in an orderly manner (Yildirim & Simsek, 2008; Çelik et al., 2022). The primary purpose of document analysis is to examine the obtained documents in a theory-oriented, systematic and data-based manner (Saglamoz & Soysal 2021).

What is Creativity and Mathematical Creativity?

Creativity is one of the most critical skills of individuals in an age where information and technology are rapidly advancing in the 21st century. Individuals with creative thinking skills are needed to advance a country based on scientific development (Ayllon et al., 2016). Considering the effect of creative thinking on problem-solving skills, Stenberg (2017) emphasized that individuals should develop this skill to cope with the problems in the changing world. Individuals with developed creative and critical thinking skills are critical in adapting to changes in the economy and contributing to the economic development of the country (Altın & Saracaloğlu, 2018). For this reason, creativity is among the skills expected from individuals and is also emphasized in curricula. The Organization for Economic Development and Cooperation (URL 1) emphasizes the necessity of creativity for students to be ready for the future and states that creative thinking skills are needed to develop new products, thoughts and methods. The American National Council of Mathematics Teachers (NCTM, 2000) draws attention to creative thinking skills by emphasizing the importance of students' ability to approach the same problem from different perspectives and flexible thinking skills.

The Turkish Competence Framework (URL 2) has defined eight key competencies that every individual must acquire. Among these competencies, "taking the initiative and entrepreneurship" emphasizes creativity: "It expresses an individual's ability to transform his thoughts into action. Creativity includes innovation, risk-taking, and the ability to plan and manage projects to achieve goals." Creativity is stated as "raising all the members of the Turkish nation as constructive, creative and productive people" (MEB, 2009) among the general objectives of Turkish National Education. Similarly, in the Mathematics Curriculum (MEB, 2018) updated in 2018, the importance of creativity was emphasized with statements such as "...originality and creativity are the main expectations from teachers".

Characteristics of the Creative Individual

A creative individual has characteristics that act with a sense of curiosity, can invent, are patient, have an adventurous thinker, have a developed imagination, are open to experiments and research, and can reach synthesizing judgments. Definitions of creativity and creative thinking may vary depending on disciplines, approaches and schools, but there are common concepts about the general characteristics of the creative individual (Saban, 2004; Starko, 1995; Artut, 2001; Getzels & Csikszentmihalyi, 1976; Linderman, 1997).

Dimensions of Creativity

Researchers interested in creativity have suggested that creativity consists of four primary dimensions. These dimensions are fluency, flexibility, originality and influence (Duman & Çelik, 2011; Fisher, 1995; Rawlinson, 1995; Ersoy & Başer, 2009; Torrance, 1962).

Fluency refers to the ability to use the information stored in memory fluently and quickly when needed. Fluency is also the ability to find solutions and develop multiple ideas quickly. For example, the ability to generate different words from the word "meteorology," such as "razor," "meat," "cress," "myth," "purple," and "and ether" is an example of fluency.

Flexibility: Emphasizes free thinking by breaking existing patterns when solving a problem. Flexibility means presenting creative behaviors differently, making changes within the task, and changing strategy while performing a task. Lack or absence of mental flexibility is a negative factor for other personality traits and critical thinking ability. Mental rigidity can lead to a lack of the ability to think critically and many personality traits.

Originality is the ability to produce different and unusual solutions to a problem. It refers to showing unique and original responses to the event or issue. "For what purposes can waste paper be used?" If the solution given to the question is the same as someone else's, it is incorrect to talk about originality. For example, "What can be added to make a laptop more functional?" The ability to produce different and innovative solutions to the question is an example of originality.

Influencing: It is the potential of ideas put forward due to the creative thinking process to influence and direct other people. Creative individuals can influence, inspire and create change with their ideas.

These four dimensions represent different aspects of creativity, and having these characteristics in creative thinkers is vital.

Stages of Creativity

The creative thinking process may sometimes proceed in different order, and sometimes jumps or parallels can be observed between the stages. The stages of creative thinking and the general characteristics of these stages are explained below (Aslan, 2001b; Doğan & Şahin, 2007; Yıldırım, 1998; Bentley, 1999; Erlendsson, 1999; Rawlinson, 1995; Ersoy & Başer, 2009; Yavuzer, 1994):

1. **Preparation Phase (Discovery):** It is the phase that includes a conscious, systematic and logical approach to problems. The need or targeted situation is identified and defined. Information and material related to this situation are collected. By actively observing events, objects, and thoughts, individuals accumulate knowledge and material for problem-solving. This can be achieved through reading, discussing with experienced people, participating in discussion environments and working in different fields.
2. **Incubation Phase (Game):** In this phase, individuals continue to work on the problem while contemplating other outcomes and tasks. After the preparatory phase, individuals enter a period of relaxation. Solving problems can happen subconsciously from time to time. This may occur more often when individuals do an activity related to a problem they are not interested in and may even occur while asleep. At this stage, where original and new views emerge, deep thinking, contemplative thinking, subconscious processes, sensing and visualization abilities are active.
3. **Introversion Stage (Creativity-Enlightenment):** The stage in which the thought, solution or thing to do about the solution of the encountered problem suddenly emerges. The individual can make extraordinary discoveries or develop new approaches to the problem or material. Alternative solutions to problems become apparent in the mind, they are animated, and solutions are found. In this exciting phase of creative thinking, creative individuals thrive. Ideas can arise suddenly or slowly but surely.
4. **Evaluation Stage (Confirming Results - Bringing Solutions):** It is the stage where the ideas, solution proposals and approaches put forward in the previous stage are analyzed, tested, valid and sufficient, and necessary corrections are made. At this stage, where logical and conscious thinking is dominant, solutions to problems are tested, and problems and deficiencies are eliminated. This process, the most challenging stage of a creative endeavor, requires courage, self-confidence and determination. Creative individuals continue implementing their creative ideas when encountering temporary or insurmountable obstacles.

The creative thinking process is a process in which these stages can progress interactively and dynamically and differ according to each individual's experience.

Activities Used to Determine Creative Thinking Skills

Emphasizing the development of creative thinking in learning environments poses challenges in evaluating creativity. These difficulties bring with them the difficulties encountered in defining and measuring creativity. The need to evaluate creative thinking necessitated the measurement of creative thinking through paper-pencil tests with the development of psychometric approaches.

Focusing on divergent thinking, which is the basis of creative thinking, Guilford (1967) suggested psychometric tools to evaluate creative thinking. Torrance (1974) developed the Torrance Tests of Creative Thinking based on these studies. These tests, which consist of two parts, verbal and formal, include tasks based on divergent thinking and problem-solving skills.

One of the tests developed to evaluate creative thinking in mathematics is the Creative Ability in Mathematics Test (CAMT) (Balka, 1974). This test uses six criteria determined through interviews with mathematicians, mathematics educators, and teachers to measure creative thinking in mathematics.

Tests developed to measure creative thinking aim to evaluate individuals' divergent thinking, problem-solving skills and creativity levels in mathematics. However, it should be noted that there are difficulties in making a measurement that covers all creativity. Creative thinking is a multifaceted and complex process, so the multiplicity and diversity of assessment tools and methods are essential. In this way, measuring and evaluating creativity in different dimensions and aspects may be possible.

Development of mathematical creativity

In evaluating mathematical creativity in this study, creativity measures that use the generally preferred components of "fluency" and "flexibility" are used. Therefore, it is crucial to evaluate the development of mathematical creativity, especially regarding these components. Fluency and flexibility are frequently used components to measure mathematical creativity. Therefore, the progress of mathematical creativity and the impact of activities can be evaluated by emphasizing the development of these components. In this way, the contribution of problem-posing activities to mathematical creativity can be examined in more detail. Evaluation based on fluency and flexibility components can be an essential criterion to show the progress in students' mathematical creativity skills and understand the activities' effect.

Creativity in Mathematics Education

Mathematical creativity is associated with the originality and usefulness of the ideas produced (Plucker & Beghetto, 2004; Sternberg & Lubart, 1999). However, Sriraman (2004) stated that mathematical creativity may only sometimes be beneficial. In this context, it is controversial to associate mathematical creativity only with new and original works. This point of view reflects even the point that creativity is accepted only as the domain of mathematicians. In this case, it is not possible to develop creativity in schools.

However, the perspective of genius, which is far from the applications in the field of education, has raised some questions (Silver, 1997; Sriraman, 2004). In this context, the relationship between students solving a previously known problem in new ways and mathematical creativity was questioned (Sriraman, 2005). Mathematical creativity arises only when finding a new idea that does not exist purely mathematically.

According to the 4C model emphasizing creative thinking levels (Kaufman & Beghetto, 2009), creativity levels are classified as "big-C (big-C)," "small-c (little-c)," "mini-c," and "proc." The small-c category focuses on daily activities, while the mini-c category covers the creativity inherent in the learning process. This category highlights that mathematical creativity can be developed in learning environments.

In response to the traditional genius point of view, the view that mathematical creativity is not limited to just a few exceptional individuals and that all students can exhibit mathematical creativity has emerged (Silver, 1997). It is emphasized that students can also show mathematical creativity. Hadamard (1945) stated that the student's work trying to solve a problem is not different from the work of the mathematician and that there is only a level difference. Luria (1970) stated that students can create new solutions and ideas in their learning paths. In this context, contemporary approaches have defined *creativity* as a tendency to think and act creatively (Leung, 1997; Silver, 1997). In this way, while mathematical creativity was once thought of only as a characteristic of mathematicians, it has been directed toward students' creative thinking in learning environments (Singer & Singer, 2011).

Result

When the research and literature on mathematical creativity are examined, the following results and suggestions emerge:

- Mathematical creativity is associated with the generation of new and original ideas. However, it is understood that creativity depends not only on originality but also on criteria such as usefulness and importance.

- Developing creative thinking skills can contribute to the increase of mathematical creativity. For this reason, students can be encouraged to produce creative solutions by offering problem-posing-based activities.
- It is essential for mathematics teachers to use strategies that support mathematical creativity. Teaching methods that allow students to explore different solutions can be applied. In addition, teachers can encourage creativity by asking questions that encourage students to think from different perspectives and enable discussions.
- The importance of creativity should be emphasized in mathematics curricula and curricula. Opportunities should be provided for students to develop their creative thinking skills, and they should be faced with various mathematical problems.
- Various measurement tools should be used to evaluate students' mathematical creativity. It is essential to evaluate students' creative thinking and mathematical creativity with paper-pencil tests and different assessment methods such as projects, tasks and performance assessments.
- Multidisciplinary approaches should be adopted to support students' mathematical creativity. In addition to mathematics lessons, students should be encouraged to approach mathematical problems from different perspectives by establishing links between art, science and other disciplines.
- To develop students' mathematical creativity, it is essential to ensure their active participation in activities such as workshops, math clubs, competitions and projects. Such activities can provide environments that will improve students' problem-solving skills and creative thinking.
- Teachers and education administrators should constantly emphasize the importance of mathematical creativity and provide professional development opportunities. Teachers should be supported to renew themselves, discover new teaching methods and tools, and make mathematics lessons creative and exciting.

Research on the importance and development of mathematical creativity shows that it is essential to use teaching approaches that support students' creative thinking skills and to diversify assessment and evaluation methods. Creative and exploratory mathematics learning environments can contribute to developing students' mathematical creativity. It is also an essential step for mathematics teachers to emphasize the place of creativity in their education programs and to offer creative thinking opportunities to students.

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ATTITUDES OF STUDENTS PREPARING FOR LGS EXAM TOWARDS MATHEMATICS

Muhammed YILDIRIM[1], İbrahim Enam İNAN[2]

Abstract

In the education system, it should be aimed that students develop their ability to use academic knowledge in real life. Problems and environmental effects students encounter while learning mathematics may reduce their interest in mathematics and cause them to develop negative attitudes. This, too, may fail. The Turkish education system should be compatible with a new vision to minimize these concerns and change individuals' attitudes toward mathematics. According to Akdemir (2006), the effect of mathematics experiences is essential in students' development of positive or negative attitudes towards mathematics. Since attitudes play an essential role in forming behaviors, there may be a relationship between mathematics achievement and attitude toward mathematics. Changing students' attitudes toward mathematics positively may affect their mathematics achievement. In high school transition exams such as LGS, it is essential to go beyond the non-routine new-generation question styles and traditional question patterns that will improve students' reasoning, association and problem-solving skills. Such questions can positively affect students' attitudes towards mathematics while preparing for the LGS exam and increase their interest in mathematics learning. This study aims to reveal why the mathematics attitude in the High School Entrance Examination (LGS) exam is vital in light of the relevant literature. According to the literature, there was a positive significant relationship between the attitudes of students preparing for the LGS exam towards mathematics and the scores they got in the LGS exam.

Keywords: *LGS exam, Attitude towards mathematics, Attitude of students*

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Introduction

Throughout history, it is accepted that mathematics has played a significant role in establishing and maintaining civilizations. For thousands of years, people have used mathematical methods to understand nature's workings, explore the universe, and control nature (Karaçay, 1985). Today, mathematics increases its value as an essential branch of science that enables us to take new steps in the age of technology. Technology and computer concepts are essential in daily life, business life and education for modern societies and education systems (Tutak, İlhan, & İç, 2018). Technological advances can make human life easier, but people with mathematical thinking and problem-solving skills will always be necessary. For this reason, mathematics teaching aims to develop students' problem-solving skills with different perspectives and mathematical thinking and application skills (MEB, 2018a).

With the constant changes in the world, the importance of education is increasing, and societies have realized that educated individuals have a fundamental impact on the development of society by making education compulsory with this awareness (Nayıroğlu, Tutak, & Tutak, 2021). In particular, mathematics course is an essential criterion in national exams such as the High School Entrance System (LGS) central exam. LGS central exam is used to select students who will study in qualified high schools, and eighth-grade students take this exam. Students placed in qualified high schools according to their success scores stand out from their other academic and mathematical skills (MEB, 2018b). Mathematics questions in the LGS exam attract attention with their complex and lengthy question roots. These new generation questions consist of questions in which formulas and reminders are given to students, associated with daily life, visuals are used frequently, and they measure not only the students' knowledge of the operation but also their logic, reasoning and interpretation skills. Such questions may be unusual for students, parents and teachers, and this may cause negative attitudes and low motivation in students who will take the exam (Kılıç, 2022).

As a result, mathematics teaching has a vital role in the development of students. Mathematical thinking and problem-solving skills will be helpful in all aspects of students' lives; therefore, learning mathematics is a continuous process. Determining the factors that affect students' academic success is vital to increase academic success. For example, it is emphasized that students who develop a positive or negative attitude towards mathematics in primary school affect their success in mathematics in their future academic life. Therefore, students must develop a positive attitude toward mathematics and improve their skills.

Problem Status

International exams such as the Program for International Student Assessment (PISA) and the International Survey of Mathematics and Science Trends (TIMSS) are essential in evaluating education systems and students' academic success. These exams include studies to determine not only academic achievement but also students' affective characteristics. For example, in PISA 2012, students' interest in mathematics, mathematical behaviors, instrumental motivations, mathematical self-perceptions, mathematics work ethic, mathematics self-efficacy perceptions, problem-solving determination and openness to problem-solving are examined. In the TIMSS exam, studies are carried out on students' participation in mathematics lessons and their attitudes toward mathematics. With the emergence of philosophical studies on mathematics learning, its structuring and the effects of cognitive, affective and physical barriers, it is possible to state that these subjects have begun to be examined in mathematics. In particular, the attitude towards mathematics has attracted the attention of many researchers in the field of education, and many studies have been conducted on the relationship between the attitude levels of students in different age groups and academic achievement (Savaş, Taş and Duru, 2010; Şentürk, 2010; Tuncer and Yılmaz, 2018; Doğan and Barış, 2010; Koca, 2011; Tocci, 1991).

This study aims to reveal the importance of the attitudes of the students who will take the LGS exam towards mathematics through a literature review. Studies show a positive relationship between students' mathematics attitudes and their mathematics scores in the LGS exam. This situation reveals that mathematics attitude can affect students' exam success and is crucial to mathematics learning.

Purpose of the research

This study aims to reveal why the attitudes of students who take the LGS exam towards mathematics are essential through a literature review.

Method

In this study, the document analysis method, one of the qualitative research methods, was used. Document analysis examines the existing written source of the researched subject (Hitchcock & Hughes, 1995). Document analysis is also defined as examining visual materials containing information about the event or phenomena planned to be investigated (Yildirim & Simsek, 2008; Çelik et al., 2022). The primary purpose of document analysis is to examine the obtained documents in a theory-oriented, systematic and data-based manner (Saglamoz & Soysal 2021).

Definition of Attitude Concept

Attitude is a mental, emotional and behavioral reaction predisposition due to an individual's knowledge, emotion, motive, or any object, subject, or event in his or her environment (İnceoğlu, 2010). This concept can vary according to the fields in which it is used and attracts the attention of many researchers. It is a word of Latin origin meaning "ready for action" (Hızlı, 2013). In the Educational Terms Dictionary of the Turkish Language Institution, attitude is defined as an individual's behavior in the face of people, events and inanimate objects (TDK, 2018). Pesen, Odabaş, and Bindak (2000) defined attitude as a person's tendency to react positively or negatively to a stimulus. Özgüven (2000) defines attitude as "an individual's emotional readiness or tendency that results in accepting or rejecting a thought, situation, other person or persons, or institutions." Thurstone (1928), on the other hand, expressed attitudes as the tendencies of a complex whole, such as people's wishes, feelings, beliefs, fears, and prejudices. Looking at the definitions, it is a common point that attitude is a tendency to react.

Tezbaşaran (1997) draws attention to the fact that the attitude can be positive or negative, as well as its severity. Tavşancıl (2002) mentioned the following while listing the characteristics of attitudes:

- Attitudes are not innate.
- They are acquired as a result of experiences.
- They are not temporary.
- They ensure a fixed relationship between the person and an object.
- They help us understand the environment in the learning process and cause positive or negative behaviors.

In general terms, attitude is a person's tendency in his attitude, which is a prerequisite for exhibiting a particular behavior.

Individuals usually attribute specific meanings to the events occurring around them. They project these meanings as acquired individual experiences. Beliefs and approaches are formed as a result of these experiences. These beliefs and approaches are called attitudes (Yenilmez & Özabacı, 2003). In everyday life, individuals who develop a positive attitude towards an object or situation approach and support it. If he develops a negative attitude, he will walk away from it. However, if the current conditions prevent moving away from the object of which a negative attitude is developed, the individual may experience conflict. For example, an individual who develops a positive attitude towards the mathematics lesson is excited to enter the lesson, does his homework on time, and wants to do more. If he develops a negative attitude, he does not want to attend class, does his homework by force or cannot complete it, and looks

for excuses not to attend class. He has conflicts with himself when he has to do homework (Ülgen, 1995).

Attitude is defined as the tendency of individuals to react to the phenomena and objects around them and consists of a combination of mental, emotional and behavioral elements (İnceoğlu, 2010). The characteristics of the attitude can be listed as follows based on its different definitions (Tavşancıl, 2002):

- Attitudes are not innate; they are acquired through experiences.
- Attitudes are permanent for a certain period; they are not temporary. Individuals have the same thought in specific periods of their lives.
- Attitudes ensure the regularity of relations between individuals and objects.
- A bias determined by attitudes occurs in the human-object relationship. Once individuals have formed an attitude about an object, they cannot look at that object impartially.
- The formation of a positive or negative attitude about an object occurs due to comparing that object with other objects.

There are social attitudes as well as individual attitudes.

- Attitudes can cause positive or negative behaviors (Tavşancıl, 2002).

Positive attitudes towards mathematics contribute to the individual's daily life and academic success. However, developed negative attitudes can cause both a decrease in academic achievement and many damages that affect the individual's daily life. Due to the negative attitudes developed, the individual's mathematical knowledge and skills may need to be improved below expectations. The reason for this low success is the attitudes formed as a result of the anxieties developed by the individual towards mathematics.

Key Elements of Attitude

Inceoglu attitude; explains that it consists of three essential elements as emotional, mental and behavioral (İnceoğlu, 2010).

Emotional Element: As a result of individuals' experiences, knowledge and experience, positive or negative emotions occur in individuals. This emotion formation constitutes the emotional element of attitudes. Positive or negative attitudes of individuals indicate that the stimulus is encountered. There is a strong connection between the emotional element and values and experiences. The values and experiences of individuals determine the direction of the response to the stimulus.

Mental Element: The individual encounters many stimuli around him and regulates these relations with his mental activities. The individual establishes relationships with each other after the grouping process of the

stimuli. This relationship accelerates the adaptation process of individuals to the environment. The element related to individuals' mental activities and thoughts is the mental element. The mental element includes the experiences, knowledge and ideas of people, situations, events and objects that significantly influence the formation of the attitude.

Behavioral Element: It is the behavioral tendencies of individuals towards stimuli. Observation of these tendencies is possible by observing the movements and expressions of the individual. It is the manifestation of the behavioral element and the emotional element. It will be possible to learn the individual's opinion and feeling on a subject only when he becomes a behavior. Therefore, it can be accepted that there is a cause-effect relationship between the emotional and behavioral components. Attitudes; Although learning is permanent, it can change with the experiences gained.

Attitude Towards Mathematics

Mathematics has been translated into Turkish from the French word "mathématique." It has been defined as the common name of sciences based on numbers and measures, such as arithmetic, geometry and algebra (TDK, 2018). Mathematics has become a universal language by nourishing and enriching different civilizations and has played a vital role in developing science and technology. At the same time, mathematics allows people to make sense of the world and gain different perspectives. As humanity developed mathematics, mathematics also contributed to the development of humanity. While mathematics aims to discover an individual's abilities and gain logic and reasoning abilities, it plays a role in every aspect of people's lives (Bulut, 1988). One of the essential reasons mathematics is valuable is that it improves an individual's ability to think critically, design and reason in problem-solving (Altun, 2006).

Mathematics is a course that is thought to be more difficult than other courses that students are afraid of and challenging to understand. This can make mathematics a feared subject. The mathematics they experience at some point in their lives effectively shapes students' attitudes toward mathematics, either positively or negatively. When we believe in the power of attitudes in forming behaviors, there may be a relationship between mathematics achievement and attitude toward mathematics (Akdemir, 2006). Students' attitudes that develop due to their experiences and feelings about mathematics are essential in mathematics education because permanent learning and the applicability of what has been learned depend on individuals' positive attitudes towards that field or discipline. Information learned about any subject can be forgotten over time, but attitudes and behaviors towards that subject are not easily forgotten (Bekdemir, 2007). Students' ability to develop a positive attitude towards

mathematics depends on their belief that they can be successful in mathematics. At the same time, the presence of parents and teachers with the student can help them to have a positive attitude.

On the other hand, changing a negative attitude can be pretty tricky because changing an attitude is a complex process (Karagöz, Arslan, Bardakçı, Demir, & Yemez, 2016). Therefore, mathematical attitudes do not always remain the same in individuals; they change over time. One of the most critical attitudes that can be taught to individuals in schools is to gain high-level thinking skills because these skills are essential for our age.

Studies on Mathematics Attitude and LGS Attitudes in Mathematics in the Literature

Kılıç (2022) conducted research on 75 female and 85 male students who were preparing for LGS. This study aims to obtain information about eighth-grade students' attitudes toward mathematics, academic motivation levels and LGS central exam scores. The first sub-problem of the study, "What is the level of the eighth-grade students' attitudes towards mathematics?" addresses the question. Students' attitudes were measured using the Attitude Towards Mathematics scale. The descriptive analysis of the measurement tool was interpreted using the array width formula developed by Tekin (2009). The average of the mathematics attitude scores of the students participating in the study was found to be 3.19. According to these findings, it was concluded that the eighth-grade students' attitudes toward mathematics were at a "moderate" level. This result is in line with the findings in studies such as İnan (2014), Katrancı and Şengül (2019), and Tan (2015), supporting that middle and high school students' attitudes toward mathematics are moderate or relatively high. However, studies such as Deniz and Çıtdır (2020) have also reached findings that describe secondary school students' attitudes towards mathematics at a high level.

In their study called "The Effect of Mathematics Anxiety and Motivation on Students' Mathematics Achievement," Süren and Kandemir (2020) aimed to determine whether there is an effect of anxiety and motivation levels on the mathematics achievement of secondary school eighth-grade students and, if any, the level of this effect. In addition, students' anxiety and motivation levels were examined together with some demographic variables (such as gender, preschool education, support and training courses, and private teaching institution) in the study. According to the research results, it was determined that eighth-grade students of secondary school had high levels of mathematics anxiety and motivation. A positive and moderate relationship existed between mathematics anxiety and motivation toward mathematics. However, it was determined that both the level of mathematics anxiety and the level of motivation predicted

success. The predictive power of math anxiety level is higher than motivation level.

Fırat (2019) found a positive moderate relationship between the internal motivations of secondary school students and the sub-dimensions of liking and utility of the attitude and a weak relationship between their extrinsic motivations and the sub-dimensions of liking and benefit of the attitude. The results show parallelism with the findings of this study. Looking at the research results, loving something and thinking it is beneficial for oneself increases the individual's willingness to do that thing internally. In addition, when the relationship between the LGS central exam scores of the eighth-grade students and their attitude towards mathematics was examined, a moderately significant positive correlation was found between the LGS central exam score and the level of attitude. It was determined that there was a positive and moderately significant relationship between the "love and benefit" and "anxiety and belief" sub-dimensions of the attitude scale and the LGS central exam score.

The research carried out by İslamoğlu (2020) aims to examine the differences in the High School Entrance System (LGS) among 600 eighth-grade students studying in secondary schools in the city center of Eastern Anatolia and 50 science teachers in the same school. The "High School Entrance Examination System Evaluation Scale" developed by Şad and Şahiner (2016) was used in the research. According to the results obtained, significant differences were observed between the variables such as students' gender, age, parent education status and going to private teaching institutions and some scale items. Likewise, significant relationships were found between the gender and professional experience of science teachers and some scale items. Participating students and teachers had similar views on the strengths of LGS. However, the insufficient aspects of LGS were also emphasized according to the research results. It has been stated that this situation affects the students' motivation negatively, creates anxiety, fear, and lack of information, and there are drawbacks to using the grades taken from the institution during the transition to high school. This study presents various perspectives on LGS and the experiences of students and teachers. In addition to the positive aspects of LGS, the findings also highlight areas for improvement.

Result and Suggestions

In light of the literature, several methods can be applied to change the attitude towards mathematics positively. Among these, associating mathematics with concrete examples used in daily life, emphasizing that solving mathematical problems can be enjoyable, associating mathematics lessons with other lessons and providing support to students in mathematics lessons play an important role. Using these methods, students' mathematics attitudes can be made positive, and

their exam success can be increased. In addition, the teacher-student relationship is an essential factor affecting students' attitudes. The bond and communication teachers establish with students can positively or negatively affect students' attitudes toward the lesson positively or negatively. However, the results of a study conducted at the secondary education level may differ from other studies. This may be because the central exam subtests are associated with more than one course. Since the students were prepared for this exam with the support of more than one teacher rather than associating it with the mathematics lesson, they may have needed help determining their attitudes towards it alone**.**

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COMPUTATIONAL THINKING AND INTEGRATED FIELDS APPROACH IN MATHEMATICS EDUCATION (STEAM)

Özkan TÜRKAY[1]

Abstract

This research aims to examine the role of the STEAM (Science, Technology, Engineering, Art and Mathematics) approach in mathematics education. STEAM is an approach that aims to integrate the arts, science, technology and engineering disciplines into mathematics courses to enable students to become more creative, critical thinkers and problem solvers. This research emphasizes that the potential advantages of the STEAM approach in mathematics education allow students to understand mathematical concepts more deeply, develop their abstract thinking skills and make connections with real-world applications. The literature review highlights the effects of the STEAM approach in mathematics education and its positive results on student achievement. It has been seen that this approach provides a more exciting and understandable environment for students to learn mathematical concepts, increases student motivation and makes learning more enjoyable. In addition, it was stated that the STEAM approach contributed to developing skills such as critical thinking, problem-solving, cooperation and communication. This study emphasizes the importance of the STEAM approach in mathematics education and helps future researchers understand the potential of STEAM integration in mathematics teaching.

Keywords: *Mathematics Education, STEAM, Science, Technology*

Introduction

In order to ensure the welfare of the developing technology and the increasing human population, the importance of fields of expertise such as science, technology, engineering and mathematics is increasing (Aslan-Tutak, Akaygun, & Tezsezen, 2017). Technology and computer concepts are among the most critical elements in daily life, business life and education for modern

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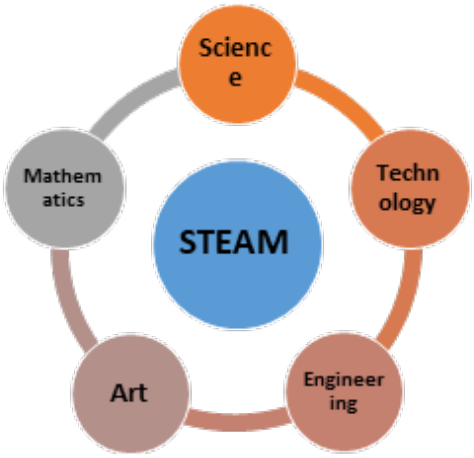
societies and education systems (Tutak, İlhan, & İç, 2018). In this context, STEM (Science, Technology, Engineering, and Mathematics) stands out as an approach where these disciplines unite and form a whole (Bybee, 2010). The concept of STEM initially emerged as a broad definition covering the concept of science and was later redefined as the concept of STEAM by adding the expression "Art." STEAM is a multi-component educational approach recognized as a way to invest in the future for economic prosperity and a good life. This approach can be implemented in schools in line with the curriculum and after-school STEAM communities. In the rapidly developing and changing world in the century, we live in, education has also been significantly affected (Yıldırım & Selvi, 2016). The STEM approach benefits individuals by offering hands-on learning by combining different disciplines. It is thought that the transition to STEAM by adding art to STEM will improve individuals' research, interpretation, criticism and analysis abilities while at the same time revealing their productivity (Boy, 2013).

It is emphasized that STEM is one of the most critical elements that should be included in the education system for the development of a country, leading to science and economic growth (Lacey & Wright, 2009). Countries must integrate the STEM education model into their education policies to achieve growth and development best (Yıldırım, 2018). For this reason, it is observed that STEM-oriented programs are implemented in many countries around the world in line with technological developments and needs (Çepni & Ormancı, 2017). For example, while China integrated STEM education into university programs, considering that science education is essential for education systems, Russia included STEM education in university programs, considering the need for experts in fields such as mathematics and engineering (MEB, 2016).

When essential features of the definition of STEM are examined;

- It mainly includes science and mathematics achievements,
- It includes engineering perspective and skills,
- Although student-centered, team unity and work are required (Moore, Johnson, Peters-Burton, & Guzey, 2015).



Purpose of the study

This study examines and investigates the STEAM approach's contribution to mathematics education in light of the literature.

Method of Study

In this study, the document analysis method, one of the qualitative research methods, was used. Document analysis examines the existing written source of the researched subject (Hitchcock & Hughes, 1995). Document analysis is also defined as examining visual materials containing information about the event or phenomena planned to be investigated (Yildirim & Simsek, 2008; Çelik et al., 2022). The primary purpose of document analysis is to examine the obtained documents in a theory-oriented, systematic and data-based manner (Saglamoz & Soysal 2021).

Steam Tutorial

According to Bybee (2010), although STEAM education needs to be clearly defined, it includes various branches of science. It usually focuses on science, technology, engineering and mathematics. Because these disciplines are intertwined in our daily lives, STEAM education provides these disciplines as a whole and enables students to understand the world holistically (Durger, 2010). Yakman (2008) defines STEAM education in two different ways. First, STEAM education is an education that includes science, technology, engineering and mathematics, adding other fields to its standards. Secondly, STEAM education is a holistic education that purposefully includes current issues and teaching topics (Park & Ko, 2012).

It is seen that the subject content of all the fields that make up STEAM education is at the bottom of the pyramid. The contents of this step also serve as

the basis for the disciplines specified in the next step. The "multidisciplinary" level represents the areas in which STEM education is adopted. In the integrated step, STEM education is defined as integrated with art. The top rung of the pyramid represents lifelong learning. The suitability of the steps of this pyramid in practice varies according to the level of education. The content at the primary level is related to high school and professional education, the multidisciplinary level is suitable for the secondary school level, and the integrated level is suitable for primary and secondary education (Park, Ko, 2012; Oh, Lee, Kim, 2013; Batı, Çalışkan, & Yetişir, 2017).

According to a study by Williams (2011), it is stated that STEAM education uses Engineering and Technology to enable and improve students' Science and Mathematics learning and adopts a new approach by using these disciplines. In today's world, perceiving and evaluating different disciplines is crucial. For this reason, students should be familiar with STEAM disciplines starting from primary school, be better prepared for these areas and receive training to increase the number of students. This shows that STEAM education is not limited to just a few disciplines (Ostler, 2012).

Another study by Bequette and Bequette (2012) stated that the components (S, T, E, A, M) in STEAM education are in a natural systematic relationship. This relationship is based on a process that defines the fields of science, technology and engineering. Therefore, the most complex and vital part of the organization of STEAM content is determining how to reflect the following seven critical topics in each chapter. These topics are:

1) Basic science, technology and engineering should be systematically consistent with the current curriculum. In addition, STEAM activities can be organized separately or together with STEAM areas.
2) Various ideas based on science, technology and engineering encourage students to think creatively within creative STEAM education. This diversity of creative thinking can be found in various technologies used to teach fundamental scientific theories.
3) For practical and creative teaching, teachers need various creative tools. In creative STEAM education, developing various creative methods, using creative learning tools and doing creative experiments are essential. However, the term "creative experiment" has been used a lot lately. Creative experiments should be based on the STEAM concept.
4) An essential aspect of STEAM education is to develop the ability to see the big picture. For example, we see a forest with its tools while exploring.

5) In today's world, where technology changes rapidly, it is essential that the information in science, technology and engineering is constantly up-to-date. For this reason, STEAM education should offer an up-to-date education that can adapt to changing integrated technologies.
6) STEAM provides practical and realistic training to predict the future systematically. This systematic approach is based on science, technology, engineering, and other fields such as politics, environment, society and economic relations. Integrated thinking ability and creativity are also essential elements.
7) The concept of integrated design in engineering can play a fundamental role in STEAM education. This design-based concept allows students to develop themselves as ethical, social, helpful and managerial in group work. It can also provide students with systematic scientific, engineering and technology experimentation skills. The aim of STEAM education is not only to train talented scientists and engineers but also to train future politicians and community leaders.

STEM education enables students to learn different disciplines simultaneously and develop their skills in establishing interdisciplinary relationships, thinking from multiple perspectives, developing fast and rational solutions, and taking responsibility in group work (Wang, 2012). It has also been determined that STEM education is important in teaching science and mathematics (Hartzler, 2000; Yamak, Bulut & Dündar, 2014). According to studies, STEM education increases students' interest in science and mathematics, improves their desire for research, and ensures the internalization of learned information; that is, it encourages effective learning (Schaefer, Sullivan & Yowell, 2003).

In recent years, the importance of STEM education in Turkey has increased. Studies have been started to train teachers in this field, and training programs and curricula have been created (MEB, 2016). However, studies show that teachers who provide STEM education need more educational content and practice equipment. This prevents the formation of full consciousness and awareness in students who receive STEM education (Çiftçi, 2018). Therefore, to implement STEM education effectively and efficiently, it is necessary to organize education programs and train teachers in line with them (Aydeniz, 2017).

STEAM education, on the other hand, often uses many disciplines. However, it is based on the disciplines of Mathematics, Science and Technology, and by presenting these disciplines as a whole, it is an approach that centers the individual and encourages collaborative learning (Herschbach, 2011; Israel, Maynard & Williamson, 2013). This educational approach emphasizes the importance of Science and Technology in an increasingly competitive

environment and attracts attention (Berlin & Lee, 2005; Kuenzi, 2008; Reiss & Holmen, 2007).

The Place of Mathematics in STEAM Education

The importance of STEAM education is also revealed in international exams, especially in exams such as TIMSS, which measures Mathematics and Science literacy, and PISA. This international student assessment program coincides with the high school period. When PISA reports are analyzed, it is seen that our country scores below the OECD average in the fields of Science and Mathematics. These results show that our country needs serious reform studies in Science and Mathematics (PISA, 2012). For this reason, STEAM education has become and continues to be an essential field of study for our country.

In the 21st century, rapid development in science and technology progresses in parallel with economic competition. Countries and individuals need to regulate their social and professional lives to have a say in this increasingly competitive environment. With the constant changes in the world, the importance of education is increasing, and societies have realized that educated individuals have a fundamental impact on the development of society by making education compulsory with this awareness (Nayıroğlu, Tutak, & Tutak, 2021). One of the most important of these steps is the innovations to be made in the field of education. Today, individuals who research, criticize, design innovations and are creative are becoming individuals who will contribute to these developments. For this reason, new projects in the fields of Science and Mathematics should be worked on, and educational programs and research should be carried out by the changing world conditions (Fan & Ritz, 2014).

In an age where science and technology are developing rapidly, countries that can produce innovative technology can create new business areas by standing out in economic competition. Individuals with 21st-century skills contribute to producing a qualified workforce and innovative technology. In this way, individuals contribute to science and technology by being constantly active and participating. Individuals contribute to themselves, their country, and the scientific world (Kennedy & Odell, 2014). The mathematics curriculum (MEB, 2018) aims to develop students' higher-order thinking skills. However, the curriculum needs more emphasis on adequate strategies, activities and materials to support acquiring these skills. More opportunities and guidance should be provided to develop students' higher-order thinking skills (Erdoğan, 2019).

Since mathematical modeling must deal with real-life problems and relate them to different disciplines, it acts as a bridge between disciplines within the STEM approach (Doğan et al., 2018; English, 2015; Kertil & Gürel, 2016).

Creating models and solving real-world problems using different disciplines and mathematics is possible with an interdisciplinary mathematical modeling approach. Many of today's occupations are expected to have 21st-century skills. Therefore, students need to acquire these skills. The STEM approach will help students grow as individuals who can analyze events, collaborate, have contemporary ideas, solve the problems they encounter, and constantly improve themselves (İdin, 2017). STEM education can enable individuals to evaluate events versatilely by developing their perspectives.

STEAM is integrating art into science, technology, engineering and mathematics. In cases where an inquiry-based learning approach is used in a mathematical problem, students' learning of concepts may depend on external factors, and the presence of STEAM environments in educational environments is important for these external factors (Thuneberg et al., 2018). STEAM efforts can cover different projects involving ecological practices, recycling projects, or topics such as sustainable society and the city.

Park (2012) examined the effects of robotic STEAM training on primary school students' science attitudes and mathematics learning behaviors. The study was carried out with 4th-grade students, and an approach was adopted in which robots were used in the heat transfer experiment in science lessons, robot components in drawing polygon lines in mathematics lessons, and robot components with shapes and colors in painting lessons. The research showed that students' mathematics learning behaviors and science attitudes improved more than the traditional method. For this reason, STEAM-based approaches can contribute to increasing interest in mathematics and science.

STEAM education includes hands-on learning activities and supportive art exhibits to support concrete solutions to abstract scientific and mathematical ideas. In this context, in a study conducted by Thuneberg, Salmi, and Fenyvesi (2017), it was found that students' attitudes towards science and technology according to their gender could be positively affected through applied learning activities and supportive art exhibitions at school. In addition, it has been observed that the level of knowledge and interest can be increased significantly with scientific festivals and science-art events, and these events can effectively reach a broad demographic group (Grimberg, Williamson & Key, 2019). A model of clay and blocks is given in Figure 1 as an example for students.

Figure 1. Engineering for Students: Clay and Block Structures (Dziengel, 2014).

In the application example in Figure 1 above, the STEAM training approach is based on the problem of building a solid and high structure (tower). The implementation process took place in the following steps:

Science: Students use scientific methods such as examining, observing, analyzing, discussing, questioning and comparing the historical process while creating their products. They collaborate on finding and relating differences and similarities and how the product can be created.

Technology: Students use technology to facilitate learning, conduct research, observe research, document, present, disseminate and carry to the future.

Engineering: Students develop and implement a strategy for designing and constructing a structure (product) from simple materials. It strengthens and stabilizes the structure by using engineering principles.

Mathematics: Students use their reasoning skills when solving problems. They observe mathematical concepts such as weight, measure, proportion and balance. They develop new mathematical knowledge and explore space and relationships in this process.

Art: Students emphasize aesthetic values while creating the structure (product). It determines the form, surface texture and colors of the building. They use their artistic thinking and creativity skills to add visual appeal to the building.

In this way, the STEAM approach, which brings together the disciplines of science, technology, engineering, mathematics and the arts, offers students the opportunity to develop their ability to think, collaborate, problem-solve and creativity from multiple perspectives.

Result

STEM (Science, Technology, Engineering, Mathematics - Science, Technology, Engineering, Mathematics) education, which emerged in the USA in the 1950s, "led all countries to invest in science, engineering and innovative technologies due to the competitive environment in production, invention and technological development among developed countries" (MEB, 2018). STEAM education, on the other hand, is an educational approach that should be applied to develop and compete in many ways for countries and societies. Needs that arise or may arise in real life should be made aware of children and applied in the school environment. For example, bringing STEAM applications to school-age students in different and future business fields, such as the animation sector, will provide economic and cultural competitive advantages.

The students wanted the STEAM application, which was carried out with the activities, to be implemented in other courses as well. The fact that they especially want such applications in mathematics lessons and that the application contributes more to the discipline of mathematics, and that they learn mathematics more easily with this application shows that STEAM application increases interest, motivation and learning. This is consistent with the findings that the STEAM approach improves academic achievement, creativity skills and emotional aspects in mathematics (Kim & Bolger, 2017; Watson & Watson, 2013). Mathematics education is based on theoretical knowledge and requires the practical and applied use of this knowledge. Therefore, mathematics education should be intertwined with daily life and require cooperation. STEAM activities facilitate this aspect of mathematics. It is ensured that knowledge is associated with real life, discussed and applied. STEAM activities positively affect students' attitudes towards the discipline of mathematics and enable students to learn mathematics subjects more permanently. In addition, activities provide effective learning environments and collaborative working opportunities, allowing students to relate to the discipline of mathematics. As a result of the application of STEAM activities to students who have a negative attitude towards mathematics and whose success level is affected, another finding is that students are more active and interested in mathematics, and therefore an emotional increase is experienced.

STEM and STEAM education brings together the disciplines of science, technology, engineering and mathematics, offering students the opportunity to develop their multidimensional thinking, problem-solving, collaboration and creativity skills. This approach contributes to social and economic development by enabling students to solve the problems and needs they encounter in real life. It has been observed that STEAM education provides significant contributions to students in the discipline of mathematics. They are presenting, discussing

and applying mathematical knowledge in the context of real-life increases students' interest and motivation in mathematics lessons. In addition, STEAM activities help the soft knowledge in mathematics lessons to become permanent and provide an effective learning environment and cooperation opportunity. These activities positively affect students' attitudes toward mathematics and increase their emotions. When STEAM education is applied in association with the discipline of mathematics, it improves students' mathematical abilities and increases their interest in mathematics. For this reason, it is essential to use the STEAM approach more widely in mathematics education and to design activities that will enable students to understand mathematical concepts by associating them with daily life. In this way, students will improve their mathematical abilities and use mathematics more meaningfully in their daily lives.

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WEB 2.0 TOOLS IN SECONDARY SCHOOL STATISTICS TEACHING

Recep ŞAHİN[1], Büşra NAYIROĞLU[2]

Abstract

Technological developments offer many opportunities, such as WEB 2.0 tools, to meet the expectations of encouraging learners' active participation in the teaching process and contributing to the content. WEB 2.0 tools are considered tools that can be used continuously in the teaching process with their features such as content creation, control and sharing (Hamlı, & Hamlı, 2021). Integration into education and training by leveraging developing technology opportunities offers a more effective learning experience. However, using technology in the classroom environment places the responsibility of content development on teachers. For this reason, it is essential to provide teachers with the necessary in-service training for this responsibility. This study, which draws attention to the use of technology to increase the effectiveness of mathematics education, initially focused on WEB 2.0 tools. In the continuation of the study, the importance and benefits of using WEB 2.0 tools in teaching statistics in the secondary school mathematics curriculum were emphasized.

Keywords: *Mathematics Education, WEB 2.0 Tools, Secondary School Statistics Teaching*

Introduction

With the constant changes in the world, the importance of education is increasing, and societies have realized that educated individuals have a fundamental impact on the development of society by making education compulsory with this awareness. Primary education is a fundamental and critical stage of education. Because students gain the essential knowledge and skills necessary to prepare for life in the future. Mathematics course also has an essential place among the courses at this stage (Baykul, 2005). The mathematics

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curriculum (MEB, 2018) aims to develop students' higher-order thinking skills. However, the curriculum does not emphasize adequate strategies, activities and materials to support the acquisition of these skills. More opportunities and guidance should be provided to develop students' higher-order thinking skills (Erdoğan, 2019). Mathematics plays as important a role as any other science in the contemporary advancement of societies and is a critical factor in achieving the desired level of sophistication. For this reason, students must have a positive attitude toward mathematics for effective and productive mathematics education (Taşdemir, 2009).

Mathematics is becoming increasingly important in education and daily life, so more effective teaching methods are being developed. One of the ways to teach math effectively is through the use of technology. According to a statement by the Ministry of National Education (MEB), the task of updating and diversifying the contents of mathematics lessons and preparing similar ones was given to teachers (Elmas & Geban, 2012). For this reason, teachers need to prepare up-to-date e-contents that are appropriate for the target audience and appeal to emotional and cognitive levels. For this purpose, the e-content development component, an essential factor in the success of the FATIH Project, is gaining importance (Polat, 2014). However, the content development process can become challenging without WEB 2.0 tools. Technology and computer concepts are essential in daily life, business life and education for modern societies and education systems (Tutak, İlhan, & İç, 2018). While the content developer has to spend time and effort, he should also have software and technological knowledge. At this point, WEB 2.0 tools, which are getting easier to use daily, can provide teachers with essential opportunities by providing rapid content development.

For this reason, in this study, WEB 2.0 tools for content development in technology-supported teaching in the teaching of statistics in the secondary school mathematics curriculum were mentioned and an overview was provided.

Purpose of the study

This study aims to emphasize the importance of using WEB 2.0 tools in teaching statistics in the secondary school mathematics curriculum. In addition, it is examined how WEB 2.0 tools can be used effectively in the statistics teaching process and how they can contribute to students' learning process.

Method of Study

In this study, the document analysis method, one of the qualitative research methods, was used. Document analysis examines the existing written source of the researched subject (Hitchcock & Hughes, 1995). Document analysis is also defined as examining visual materials containing information about the event or

phenomena planned to be investigated (Yildirim & Simsek, 2008; Çelik et al., 2022). The primary purpose of document analysis is to examine the obtained documents in a theory-oriented, systematic and data-based manner (Saglamoz & Soysal 2021).

WEB 2.0 Tools

The concept of WEB 2.0 was introduced by Tim O'Reilly and MediaLive International during brainstorming in 2004 (Bozkurt, 2013). O'Reilly defined WEB 2.0 as an informatics revolution (Atici and Yıldırım, 2010). WEB 2.0 tools allow individuals to easily create content on the Internet and contribute to existing content. According to the studies, these tools allow the creation, sharing, storage and evaluation of shared content with the cooperation of different participants (Altınok, Yükseltürk, & Üçgül, 2017; Aıcı & Yıldırım, 2010). In addition, WEB 2.0 tools make it possible to create and diversify existing content without technical difficulties (Elmas and Geban, 2012).

In a study by Hamlı and Hamlı (2021), the classification of WEB 2.0 tools according to their usage areas is given as follows:

WEB 2.0 tools are tools used for many purposes, such as content creation, sharing and collaboration. Here are some WEB 2.0 tools and their uses:

- *Animation and Video Creation Tools:* Tools such as Animaker, Biteable, Animoto are used to create cartoon animated presentations, animated presentations and impressive videos.
- *Survey Tools:* Tools such as Jet Survey, Survey Monkey are used to prepare online surveys and enable people to fill out surveys online.
- *Storage and File Sharing Tools:* Tools like Dropbox make it easy to store and share files online.
- *Digital Clipboard Tools:* Tools such as Padlet, Linoit provide the opportunity to present studies collectively and enable collaboration.
- *Concept Map and Drawing Tools:* Tools such as Mind Map AR, Bubbl. us, MindMeister are used to create mind maps and to prepare maps with different shapes.
- *Word Cloud Tools:* Tools such as Wordart, Wordcloudy are used to create remarkable word clouds by identifying relevant keywords.
- *Game Making Tools:* Tools such as Learningapps, Jigsawplanet, Wordwall prepare educational games and integrate them into lessons.
- *Exam Tools:* Tools like Kahoot, Socrative, Quizlet are used to prepare online exams and tests.
- *Video Conferencing Tools:* Tools such as Voki, and Teamlink provide online conversations and lectures (Hamlı & Hamlı, 2021).

These WEB 2.0 tools facilitate teachers' content development process and encourage the active participation of students in the teaching process (Hamlı & Hamlı, 2021).

MindMeister, one of the concept maps and drawing tools, can be used as a Web 2.0 tool to show the WEB 2.0 tools classification in Figure 1.

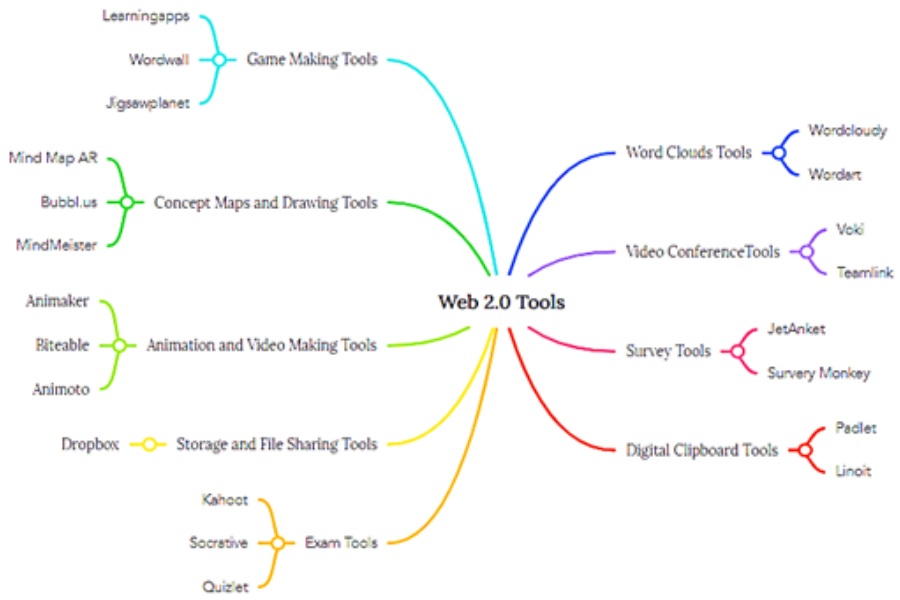

Figure 1. Classification of Web 2.0 Tools with MinMeister (Hamlı & Hamlı, 2021).

WEB 2.0 Tools in Secondary School Statistics Teaching

The primary purpose of the field of statistics learning is to enable students to gain the ability to tabulate the data they collect from their environment, transform them into different graphics, interpret them, and understand the figures, graphics and tables they encounter (MEB, 2009). In learning statistics in the new curriculum, students are guided to identify an appropriate research question and select a sample that can answer it. They are asked to display and interpret the data obtained from the chosen sample, with appropriate statistical representations, by putting them into tables. In addition, the ability to make inferences by calculating central tendency and dispersion criteria (arithmetic mean, median, mode, span, quarter span, standard deviation, etc.) on data sets is also emphasized (MEB, 2005, 2009).

The new program aims to gain skills such as interpreting skills, using appropriate central tendency and diffusion criteria, bringing a mathematical perspective to real-life situations, making predictions based on data, creating graphs and interpreting these graphs, and computational ability. It is aimed that

students become individuals who know what they are doing and why they are doing it by avoiding memorization.

In the secondary school mathematics curriculum, as in the primary school mathematics curriculum, the acquisitions related to statistics learning are included in the data processing learning area. In the 5th grade, the gains in which the students had the opportunity to question were added. In particular, skills such as creating research questions, collecting appropriate data and displaying and interpreting these data in graphs are learned. In addition, it is seen that the statistical content in secondary school is enriched with the title of "Data Analysis" and "Data Collection and Evaluation." This transition continues in the 7th and 8th-grade data processing learning area only with the title of "data analysis." Students are now expected to be able to compare and interpret multiple sets of data and generate ideas about results.

Creating a meaningful learning environment to improve students' data interpretation and comparison skills is essential. Web 2.0 tools can be influential because they enable students to participate more actively in learning and increase their motivation. They can also offer students a convenient and personalized learning experience by offering differentiated learning methods. Teachers can create technological content using WEB 2.0 tools and integrate it into their lessons.

For example, with "Animation and Video Making Tools," data groups related to statistics can be transferred to the computer environment through animated presentations and graphics, thus making it easier for students to review and analyze. With "Digital Clipboard Tools," students can be provided to share and present their statistical work in the virtual environment, which can contribute to peer learning. With the "Survey Tools," surveys that can be shared digitally can be prepared, and students can be asked to examine the statistical results of these surveys. With "Game Making Tools," the lesson can be more fun and exciting.

In this way, students can be more successful in comparing and interpreting data sets in teaching statistics. By using developing technology to realize meaningful and permanent learning, we make the learning process easier and more effective.

Result and Suggestions

Effective use of technology in mathematics teaching is one of the most important ways to make learning more meaningful and permanent. For this reason, it is necessary to integrate the developing technology with education correctly and effectively. The task of integrating technology into the lesson falls to the teachers. For this, it is important to design content suitable for the subject of the course. Web 2.0 tools can be used efficiently and effectively to design and share content suitable for the curriculum and adapt motivators.

For this reason, using technological tools to teach statistics in the secondary school curriculum is an important step. As emphasized in the study, it is possible to design the statistics teaching process with Web 2.0 tools. Thanks to these tools, content that is difficult in software can be quickly developed, and lessons can be made more effective. As stated in the national education program, widespread use of Web 2.0 tools and technology, in general, is of great importance. Studies show that the subjects students struggle most are mathematics and geometry. This difficulty is related to the abstractness of mathematics and geometry. At this point, the more widespread the integration of Web 2.0 tools into the education process, the easier the students' mathematics and geometry learning processes are observed. However, the use of technology should be expanded in other courses. Teachers need to provide the necessary training through in-service courses at this stage.

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CODING IN MATHEMATICS EDUCATION

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Abstract

In recent years, coding education has gained significant importance. Coding is a tool that helps the right decision-making processes and enables us to reach high living standards. At the same time, it allows consciously consuming digital products and producing valuable products. Learning to code or having coding logic is an essential investment for anyone of any age to prepare for the future. In this way, society can be built on producing rather than consuming information applications. Coding education has become an essential issue in Turkey in recent years. This study examines the place of coding education in education policies in our country. Coding is a core competency for students, workers, and professionals in various fields. As an academic skill, coding is part of the logical thinking skill and is now considered one of the "21st-century skills". Many countries try to include coding in national or regional planning and school curricula. The Ministry of National Education in Turkey has decided to add the "Information Technologies and Software Course" to the programs starting from the 5th grade as of the 2012-2013 academic year. Within the scope of this course, it is recommended to use social coding environments based on sharing and co-development. Developing digital skills is essential to digital transformation, economic growth, enhancing citizen well-being and realizing the digital single market strategy. Therefore, there is a close relationship between development plans and education policies on coding education. This study aims to examine the use of coding in mathematics education. The method of the study is a literature review. As a result of this study, an in-depth understanding of the benefits of coding in mathematics education, its impact on students' mathematics skills, and teachers' needs for coding instruction

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will be obtained. Thus, a basic framework is presented to encourage coding in mathematics education and to guide further research in this area.

Keywords: *Mathematics Education, Coding, Mathematics success with coding*

Introduction

Computers were developed as a product of human intelligence. They can perform any operation humans can do (such as multiplying two different 6-digit numbers) more quickly. However, computers cannot make decisions and applications on their own. They work on the logic of taking the decision of a transaction from people and implementing it. Decisions made by people are expressed in code sequences called programming languages, transmitted to computers over a suitable platform and processed.

Programming languages have been developed since 1957. Programming languages such as Fortran, Algol, Cobol, Basic, Pascal, C emerged in this period. Especially after the 1980s, more advanced versions of these languages and high-level programming languages such as Delphi, Java, C++, C#, and Visual Basic that support object-oriented programming have been developed. These languages are widely used to create programs (Eryılmaz, 2003).

Today, coding skill has become an important competency for students and many people working in different business areas. Because the level of development, which is the determinant of economic development, is changing with the effect of the digital economy (European Commission, 2015a). Therefore, coding and programming skills are becoming more critical than ever for those working in every sector (Sagın & Seferoğlu, 2016). It is thought that those who develop new approaches to learning and teaching coding will be at the forefront. With the constant changes in the world, the importance of education is increasing, and societies have realized that educated individuals have a fundamental impact on the development of society by making education compulsory with this awareness (Nayıroğlu, Tutak, & Tutak, 2021). Many non-profit organizations have recently started to provide coding education with innovative and exciting educational methods (Code.org, 2015a). Likewise, many workplaces are seeking innovative approaches to people who can code (European Commission, 2015b).

Learning to code is frequently discussed worldwide, especially in developed countries. Many questions, such as what coding is, its benefits in education, its advantages for children and adults, and at what level this learning should begin, need to be answered about coding (Aytekin, 2018).

Coding skill is necessary to act according to needs today and in the future. Many people who complete their first coding experience as desired are happy

because they have added something and completed the application. As they achieve success, individuals are encouraged to come up with new solutions, see results, strive for better, and do even better. Studies show that having coding skills increases the ability to produce solutions to the problems encountered and that the mistakes made are realized and solved. In addition, it is essential for individuals with a particular interest or ability to start coding at an early age in order to improve themselves (Yecan, Özçınar, Tanyeri, 2017).

Today, it is essential for children to get acquainted with coding from an early age. In the 21st century, we are expected to develop ourselves as individuals who can think flexibly, solve problems, adapt to technology, cooperate and harmoniously, and have creative thinking (Seferoğlu, 2015). It is thought that people with these skills can benefit the world and the country's economy, and other fields, such as education and intensive studies, are continuing in this area (Florida, 2007).

Coding is simply communicating with a machine and making it do what is desired (Köroğlu, 2012). The concept of coding is defined as "the process of solving problems, establishing human-computer interaction and creating an application using commands given to the computer" (Aytekin, Çakır, Yücel, & Kulaözü, 2018). In our rapidly changing age and when technology impacts our lives, the younger generation needs to be taught how to develop different programs instead of just consuming them. Technology and computer concepts are essential in daily life, business life and education for modern societies and education systems (Tutak, İlhan, & İç, 2018). Students are not only expected to use technology but also to create a product by doing research, reading, learning and using the technology they use (Demirer & Sak, 2016).

Coding education is not limited to computer technologies only. Coding education allows students to produce creative ideas and solutions to their problems (Karabak & Güneş, 2013). Along with coding education, students develop skills such as creative thinking, critical perspective, learning and development throughout the process, as well as learning mathematical and cognitive concepts.

With the widespread use of technology in schools, it has become important to be familiar with educational software related to computer technologies in line with the needs of the age. At a time when computer technology is combined with software that meets the requirements of the age, coding software directs us to think with computers. Therefore, coding education has become necessary in line with the requirements of the 21st century. For this purpose, applications and software developed to provide coding education with various coding tools for different age groups are provided. It has become relatively easy to start coding education as early as four. In the study of Baz (2018), 25 different

coding software (Scratch, Code.org, Kodable, The Foos, Tynker, Box Island, Cargo-Bot, Daisy Dinosaur, Blockly, Move the Turtle, Bitsbox, Code Monkey, Code Combat, Lightbot, Grok Learning, Kidsruby, Bomberbot, Touch Develop, TechMind, Learn Green, Touch Develop, AllMind, Learn Green, Robo de) has been reached (Büyükkarcı, 2021).

Problem Status

Turkey is a country with a young population. With a good education, all young people can be well prepared for the society of the future. Today, technology has become an indispensable part of education for a good education. Although there are many reasons for using technology in education, the importance of globalization and the quality of the global workforce has been influential in the widespread use of technology in education and training processes. Considering the education system, keeping up with the developing world order, following new developments and integrating them in the education system is extremely important for developing countries.

For this reason, the fact that coding, one of the developing fields in recent years, has proven many benefits in mathematics education reveals that this field should be integrated into the lessons. In this way, it is aimed to make mathematics education more meaningful and to obtain maximum benefit in terms of students and the education system. Integrating coding into education is a targeted step.

Purpose of the study

This study aims to examine the use of coding in mathematics education.

Method of study

In this study, the document analysis method, one of the qualitative research methods, was used. Document analysis examines the existing written source of the researched subject (Hitchcock & Hughes, 1995). Document analysis is also defined as examining visual materials containing information about the event or phenomena planned to be investigated (Yildirim & Simsek, 2008; Çelik et al., 2022). The primary purpose of document analysis is to examine the obtained documents in a theory-oriented, systematic and data-based manner (Saglamoz & Soysal 2021).

Coding Languages

Java: Java, a programming language developed specifically for smart TVs, emerged in 1991. It has become one of the most popular languages in the world and has continued this success throughout the 90s. Large companies have used Java to develop their business and internet applications. It is easier to use a feature in Java and convert it to a line of code than in other languages. The

convenience mentioned here is not for the language itself but for the ability of the language as a whole to accomplish various tasks.

C: One of the oldest programming languages, C was designed in 1970. The C programming language was published in 1978. The C language formed the basis of all subsequent languages. C language has been used extensively in embedded systems. The world's most widely used system programming language is C and its derivatives. At least some of the electronic devices we use today are written in the C programming language. One of the significant advantages of the C language is that it can be translated into machine language. C++ and C# are also derived from the C language.

Python: Developed in 1989, Python stood out with its easy readability feature. Python's popularity has proliferated in the last 15 years and has become a popular language. It continues to be used in many technologies today. Thanks to Python's clean and simple syntax, writing and reading a program written by another person is much easier than other languages (Aytekin, 2018).

Why Coding Training?

- Today's young students, no matter what profession they choose, live in a time when they are expected to master technology.
- Considering the needs of the digital world, coding has become an essential skill like math and literacy.
- Coding is best learned at an early age. Learning to code is like learning a foreign language.
- The sooner children are introduced to concepts such as sequence, loops and conditions, the better they will absorb it.
- According to research, one out of every three children is introduced to electronic devices such as computers, smartphones and tablets before they even learn to speak.
- Coding education allows children to develop games, applications and other software they dream of.
- Coding aims to provide students with knowledge that will be indispensable to their future business life (Coding Club, 2023).

Learning to code provides students with the following gains:

- Informatics Literacy: It teaches how to use computers efficiently, not just for games, the internet and social media.
- Computational Thinking: Teaches organizing and applying thoughts.
- Cooperation: Develops the ability to cooperate with people from different countries.
- Creativity: It increases the ability to experiment and produce.

- Teamwork: Teaches the importance of working in harmony with friends.
- Sharing: This makes one realize that knowledge increases as it is shared.
- Interdisciplinary Interaction: It teaches to provide interaction between different disciplines by combining multiple courses.
- Programming: It aims to raise generations that can consume technology and produce it (Coding Club, 2023).

Benefits of Learning to Code

Coding is gaining importance as a new type of literacy in developing countries. The ability to express thoughts applies to coding as well as to express them in writing. Coding skills can create new job opportunities, build a career, and become a technology pioneer by developing technologies and software that shape the world. Children's coding education helps them develop skills such as solving problems called computational thinking, designing systems and understanding human behavior. Children learning to code can gain advantages through problem-solving, observing relationships, and analytical thinking. This enables children to make a big difference in coding and all areas and their daily lives. The answer to the "why" part of the question of why and when learning to code should start can be easily explained by the primary advantages of learning to code. Children's coding allows them to stay ahead of their competitors in their current and future professions and in all areas of life.

Teaching the basic coding principles helps children significantly improve their problem-solving skills and plays a significant role in their future careers. For example, the existence of people like Mark Zuckerberg, who learned to code at a young age and founded Facebook, which is known and used around the world using this skill, is an example of the importance of coding. Likewise, the fact that a world-renowned computer scientist like Bill Gates learned to code at the age of 13 and wrote his first programs is another example that emphasizes the importance of coding (Aytekin, 2018).

The Effect of Coding on Problem Solving in Mathematics

A study by Calder (2018) examined the effect of coding education received by 10-year-olds using Scratch on mathematical thinking and problem-solving skills. The students performed math-oriented game activities during the two-week implementation process and created various code designs. The data collection process used blogs based on students' learning experiences and student-teacher opinions. The findings showed that coding with Scratch facilitates the mathematical thinking process and positively affects problem-solving skills.

In a similar study conducted by Vatansever (2018), the effect of teaching coding with Scratch on problem-solving skills was examined with 226 5th and 6th-grade students. This study, which also benefited from student opinions, determined that block-based coding instruction had a moderately statistically significant effect on students' problem-solving skills. The study stated that it is recommended to use Scratch, a block-based coding software, to train students with problem-solving skills.

In a study conducted by Akçay (2015), the relationship between coding self-efficacy and problem-solving skills was examined. The research was carried out on 707 university students studying computer and instructional technologies at eight universities in Turkey. It has been determined that the students' coding self-efficacy level is medium, while their problem-solving skills are high.

Pullu's (2019) study examined the effect of coding education based on authentic tasks on problem-solving skills. It was studied with a total of 63 students consisting of experimental and control groups. After the pre-tests, the experimental group was taught coding activities based on authentic tasks, while the control group was given traditional coding training, and post-tests were applied. According to the data obtained from the problem-solving scale, it was seen that the experimental group achieved higher scores than the control group.

Some studies examining the effect of coding education on problem-solving show that no statistically significant effect was detected. Solmaz (2014) conducted a study on the effect of Alice, a block-based coding education, on students' academic achievement, critical thinking and problem-solving skills. Experimental and control groups were studied in a 7-week implementation period, and the findings showed that coding did not make a statistically significant difference in problem-solving skills.

In another study conducted by Kaya (2018), the effect of Alice block-based coding software on problem-solving perception was examined. An 8-week study was conducted with 63 university students, and the experimental group was given coding training with Alice, and the control group was given coding training with Java. As a result of the data analysis, it was determined that coding did not have a statistically significant effect on the perception of problem-solving.

In another study by Bala (2019), the effect of Scratch, block-based coding software on problem-solving skills was examined. An 8-week experiment was conducted with 22 middle school 6th-grade students, concluding that there was no statistically significant effect on students' problem-solving skills. However, it was stated that the student's views on teaching coding with Scratch were mostly positive (Sade, 2020).

These studies show that the effect of coding education on problem-solving is only sometimes statistically significant. Students' opinions and perceptions about coding education are also essential factors.

Using Coding in Mathematics

For many children, abstract mathematical concepts can be challenging and distract them from the subject. However, coding education allows children to understand better and connect by enabling them to visualize these abstract concepts. Coding requires analyzing and organizing data to develop logical thinking and problem-solving skills. It teaches solving problems by breaking them into smaller and manageable parts. Therefore, coding teaches the real-life application of mathematical thinking (Coding Club, 2023).

In this way, children develop problem-solving skills and visualize mathematical concepts concretely and practically. Coding provides an opportunity to use mathematical thinking daily, strengthening children's relationships with mathematics. In addition, children develop better analytical thinking and logical approach skills through coding education. This benefits them both in terms of math and general life skills.

Result

Many studies and literature reviews support the importance of coding education. Findings from these studies show that learning to code contributes to children's development of basic skills and plays a vital role in their future careers. For example, coding education provides children with problem-solving, designing projects, critical thinking and communication skills while enabling them to visualize mathematical thinking in a concrete and applicable way (Seferoğlu, 2015). Coding education also enables children to acquire and develop essential skills early. These skills include problem-solving, designing projects, generating new ideas and developing cognitive abilities. Therefore, the awareness of parents and educators about coding education is critical (Aytekin, 2018). Coding skill has recently become the new equivalent of concepts such as thinking and producing. People who know coding can create content such as stories, games, and animations. At the same time, the need for individuals who can program in many areas is increasing. Therefore, learning to code is becoming increasingly important and has begun to be included in educational curricula in many countries. Policymakers in this field support practices and studies such as Code.org and Scratch. There are many reasons for learning to code. Thanks to coding, students can support learning in different fields, such as Turkish and mathematics, and improve their problem-solving skills and abilities, such as designing projects (Aytekin, 2018). This study was conducted to emphasize the importance of coding education and to attract the attention

of educators and decision-makers. It is stated that it is foreseen that coding education will be included in more curricula in the future and that Turkey should keep up with this change. In this way, students who can respond to their age's economic needs and receive an appropriate education will be raised (Sagın & Seferoğlu, 2016).

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MUSIC IN MATHEMATICS EDUCATION

Saliha AKARSU[1]

Abstract

In recent years, the relationship between mathematics education and music has been a subject of great interest to researchers and educators. Studies examining the effects of music on mathematics learning reveal the great potential of music in improving students' mathematics skills. In this study, different dimensions of the use of music in mathematics education were investigated by scanning the literature. Music contains various mathematical structures, from the most basic to the most complex. Here, the relationship between musical elements ranging from sound structure to subjects such as scales, melody, rhythm, harmony and mathematics is examined. Understanding the mathematical relationships between musical notes allows students to develop mathematical thinking and modeling skills. In addition, rhythm, ratio, harmony and pattern in music can be associated with concepts such as numbers, proportions, functions and geometry in mathematics. These relationships help students understand mathematical concepts more concretely and meaningfully. The use of music in the development of mathematical skills is also covered. Students' involvement with music can support their mathematical abilities, such as numerical intelligence, logical thinking, problem-solving, and analytical skills. Music can be an effective tool in strengthening students' math skills. This literature review addresses different aspects of music integration into mathematics education. It offers suggestions to help educators use music effectively. Music can be a valuable resource in developing students' mathematical skills in mathematics education.

Keywords: *Mathematics Education, Rhythm, Music*

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Introduction

The relationship between mathematics and music is essential to increase knowledge and skills permanence and develop a positive attitude towards mathematics (MEB, 2009). These two disciplines have been intertwined for centuries, and their historical development shows parallelism. While music emerged with the rhythms played in religious rituals in primitive societies, mathematics started with counting objects (Esi, 2017). In this process, while many famous mathematicians were interested in music, musicians also showed interest in mathematics. For example, one of the greatest hobbies of the famous composer Bach is mathematics; The famous mathematician Pythagoras, on the other hand, is known as the person who found the octave and was successful in mathematics (Esi, 2017). In the Pythagorean school, music took place as a branch of mathematics (Bora, 2002).

The concretization of an abstract branch of science, such as mathematics through music can increase children's mathematical performance by facilitating their understanding and conceptualization processes (Booth, 2001; Snyder, 1997; Yağışan, Köksal, & Karaca, 2014). Therefore, studies dealing with the relationship between mathematics and music are included in the literature due to their potential to facilitate learning.

However, it is seen that the studies dealing with the relationship between mathematics and music are limited in our country. For this reason, it is essential to examine the studies dealing with the relationship between mathematics and music in our country. This study aims to describe the state of research on the relationship between mathematics and music in our country.

Purpose of the study

One of the fields in which mathematics and art are related is music. Throughout human history, many mathematicians have been interested in music. In this study, the relations between mathematics and music have been examined. It has been tried to explain with various examples that these two are an inseparable part of the other. It has been tried to emphasize that mathematics exists intertwined with music.

Method of Study

In this study, the document analysis method, one of the qualitative research methods, was used. Document analysis examines the existing written source of the researched subject (Hitchcock & Hughes, 1995). Document analysis is also defined as examining visual materials containing information about the event or phenomena planned to be investigated (Yildirim & Simsek, 2008; Çelik et al., 2022). The primary purpose of document analysis is to examine the obtained documents in a theory-oriented, systematic and data-based manner (Saglamoz & Soysal 2021).

Mathematical Structures in Music

An important feature distinguishing musical sounds from noise sounds is their ability to impart a distinguishable pitch or tone. Pitch is a parameter that determines the treble level of a sound. That is, the pitch (pitch) is perceived depending on the sound's fundamental frequency. A perceptible pitch depends on the degree to which the sound is periodic. A musical sound can be thought of as a periodic function of time. Noise sounds are usually irregular. A noise sound may consist of irregular and randomly varying frequencies. Such sounds do not have a periodic structure or a distinctive tone. For example, traffic noise or speech sounds in a crowded environment. It is difficult or impossible to detect a distinct pitch in such sounds. Therefore, musical sounds usually have a periodic structure and a distinct pitch, while noise sounds consist of irregular and non-periodic frequencies. This difference is a feature that helps us distinguish music in our musical experiences. A periodic graph of the g(t) function is given in Figure 1 below.

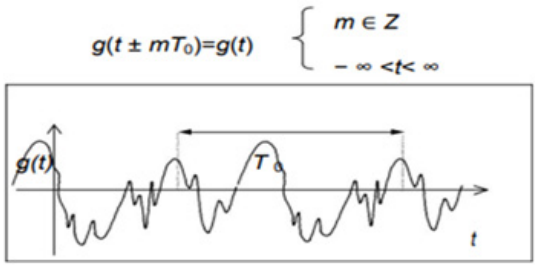

Figure 1. A periodic function g(t)

According to legend, Pythagoras came across blacksmiths working with hammers in a blacksmith's workshop. The sounds of the hammers resonate in harmony with each other. When Pythagoras weighed the hammers, he realized that their weight was in the ratio (12:9:8:6). It can be challenging to establish a direct mathematical relationship between hammer weights and fundamental frequencies of sounds; however, it is known that there is a definite relationship between the fundamental frequency of the sound depending on a taut string (Bora, 2002).

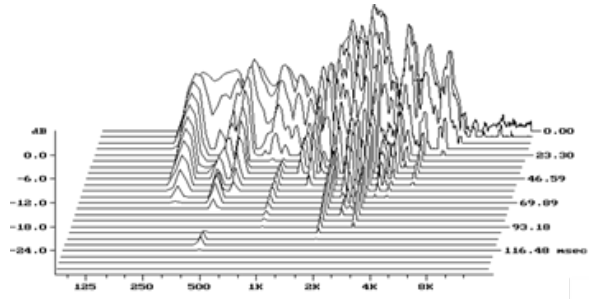

Figure 2. Time-frequency representation of a violin sound with a waterfall diagram

This diagram is a visualization where time is represented on the horizontal axis and frequency on the vertical axis. The sound of the violin is formed as a combination of vibrations at certain frequencies and this diagram shows the variation of these vibrations.

Result and Suggestions

With the constant changes in the world, the importance of education is increasing, and societies have realized that educated individuals have a fundamental impact on the development of society by making education compulsory with this awareness (Nayıroğlu, Tutak, & Tutak, 2021). Today, music's logical and computational structure makes it possible to use it in various processes, from production to analysis, by being used together with science and technology. Computer technology plays a significant role, especially in the field of music. Music can facilitate learning and make it fun by embodying an abstract branch of science, such as mathematics. Therefore, it is possible to develop mathematical abilities through music education.

In a study conducted by Shaw, when primary school sophomores were given a four-month piano training (along with mathematics teaching), an improvement was observed in learning success, especially regarding ratios and fractions (Göğüş, 2008). This study shows that teaching mathematics through music is an alternative method. However, scientific studies dealing with the relationship between mathematics and music at preschool, primary, secondary and high school levels are insufficient in our country.

Studies examining the relationship between mathematics and music should investigate the effects of different methods used in music and musical instrument use on students' participation in mathematics lessons, their perspectives towards mathematics, and their effects on students' performance, learning process and success. It is recommended that such studies be carried out by academicians working in different departments of universities with an interdisciplinary approach. In this way, the relationship between mathematics and music can be examined in more detail and methods that will contribute to learning processes can be developed.

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TEACHING MATHEMATICS IN SOCIOCULTURAL DIFFERENT CLASSES

Semra GÜNER ÇALAN[1]

Abstract

Turkey is one of the countries that receive the most refugee migration due to its location and wars. This led to children from different cultures and languages participating in classes and required teachers to change their educational practices. This study examines the mathematics learning processes of teachers with refugee experience and students with different language skills. Understanding how social and cultural factors affect mathematics teaching is essential in improving teachers' teaching approaches and increasing students' mathematics achievement. This study presents a sociocultural perspective on mathematics teaching in different classes. It is concluded that social and cultural factors play an essential role in mathematics teaching, and teachers must adapt their teaching strategies by considering these factors. This study constitutes an essential resource for future research to reduce inequalities in mathematics teaching and increase student achievement.

Keywords: *Cultural Diversity, Sociocultural Classroom Environment, Mathematics Teaching*

Introduction

Sociocultural differences refer to cultural values, beliefs, and behaviors among groups within the society resulting from nationality, ethnicity, age, gender, sexual orientation, economic status, education, religion, and occupation. Every society has its cultural understandings and lifestyles, and this leads to the emergence of different customs and traditions. Sociocultural factors are considered together with a society's social structure, environment and cultural norms. These factors affect many areas, such as individuals' thinking, value system, communication styles, educational approaches and social relations. With the constant changes in the world, the importance of

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education is increasing, and societies have realized that educated individuals have a fundamental impact on the development of society by making education compulsory with this awareness (Nayıroğlu, Tutak, & Tutak, 2021). Especially in the field of education, sociocultural differences have a significant impact on student's learning styles, language skills, cultural backgrounds and experiences. Therefore, teachers need to adapt their teaching strategies, considering sociocultural differences and meeting the needs of diverse learners.

Making mathematics learning fair and accessible for every student in culturally diverse classrooms requires focusing on fair mathematics learning opportunities rather than achievement differences (Gutiérrez, 2008). Mathematics learning opportunities address elements such as which mathematics subjects students learn and how they learn them (Esmonde, 2009). Mathematics education improves the quality of life regardless of the culture or society the individual is in (D'Ambrosio, 2003). However, it is known that students with various levels of language proficiency and different cultural backgrounds have difficulties in mathematics education. Studies have shown that the mathematics achievement of students with disadvantaged conditions (Flores, 2007) affects their mathematics attitudes and career goals (Martin, 2009; Mulvey & Irvin, 2018). Therefore, to ensure and maintain social justice in education, it is essential to take measures that enable students with various levels of language proficiency to learn mathematics like their peers. In this context, examining student, teacher and family experiences is essential for identifying and implementing such measures (Allexsaht-Snider & Hart, 2001).

Purpose of the study

The study aims to examine the subject of teaching mathematics in different classes in a sociocultural context, understand the effects of social and cultural factors on mathematics teaching, and develop teachers' teaching approaches by considering these effects. In addition, it is to determine effective teaching strategies and practices that consider sociocultural differences to increase students' mathematics achievement.

Method of Study

In this study, the document analysis method, one of the qualitative research methods, was used. Document analysis examines the existing written source of the researched subject (Hitchcock & Hughes, 1995). Document analysis is also defined as examining visual materials containing information about the event or phenomena planned to be investigated (Yildirim & Simsek, 2008; Çelik et al., 2022). The primary purpose of document analysis is to examine the obtained documents in a theory-oriented, systematic and data-based manner (Saglamoz & Soysal 2021).

How did sociocultural differences arise?

Migration is a phenomenon that occurs in every period of human history and is interpreted in different ways by different branches of science. Migration, a universal problem in the 21st century, refers to people leaving their settlements, countries or countries and settling in a new living space (Tekeli, 2011). The reasons for migration include economic factors, management style, war, unemployment, natural disasters, etc. is located. Migration is based on resetting people to another place in search of new opportunities, a universal feature of migration (Aktel & Kaygısız, 2018).

Forced migration is when people or groups have to leave their city, environment or country for various reasons. In such migrations, people's survival ability may be threatened and they are driven to seek a safe living space. The factors that cause forced migration are violence, war and natural disasters. For example, Syrian migration in our country can be given as an example of forced migration due to civil war and security concerns in their country (Karakaya, 2020).

Migration is a complex phenomenon related to the displacement of people for different reasons and the search for new habitats. Both voluntary migration and forced migration create significant problems and impacts at the global level. For this reason, interdisciplinary studies and solution-oriented approaches are needed to understand the phenomenon of migration, to develop policies for immigrants and to ensure the integration of immigrants.

Educational Status of Students Living in Turkey due to Migration

The civil war in Syria has led to one of the largest migration waves in history. By opening its doors to refugees in neighboring countries, Turkey keeps 3,665,946 Syrians under temporary protection as of 2021 (Ministry of Interior, 2021). Many of these refugees are children, and these school-age children have educational needs. However, some difficulties have arisen due to the rapidly increasing number of refugees. The educational rights of Syrian refugee children are part of these challenges.

Immigration and wars, regardless of century and geography, affected the children who suffered the most. Children who come to another country as refugees, leaving their homes, schools and friends behind due to war and migration, face many problems in the adaptation process. Education is crucial for these children to adapt and survive (Yavuz & Mızrak, 2016).

Before the civil war in Syria, the rate of students attending primary school was 99%, and the rate of students attending secondary school was 82%. However, according to UNICEF's estimations, most Syrian children are dispersed to different countries as refugees cannot receive education (UNICEF,

2020). In Turkey, approximately 600 thousand Syrian children are registered in the education system (Ministry of National Education, 2019).

Cultural education is vital for Syrian refugee children to receive education in their own culture and to adapt to society. For adaptation and social life, the numbers of all refugee children who receive and do not receive education should be examined, and it should be ensured that as many children as possible are included in education (Duman, 2016).

Turkey initially offered Syrian children the opportunity to receive education in Arabic so that they would not have any problems when they returned to their country. However, in line with the changing conditions, since 2014, efforts have been made to prepare the appropriate legal ground and create the infrastructure. Syrian children have started receiving Turkish education (Ministry of National Education, 2016). UNICEF and Turkey are working together and carrying out projects to minimize the impact of this crisis on children.

Studies on the Education of Refugee Students and Mathematics Education

Coşkun and Emin's (2018) study argues that refugee children and youth under temporary protection have a significant potential for the welfare and development of our country and may even be effective in the reconstruction of Syria. In this context, it is emphasized that refugee children under temporary protection should be included in the education process. In addition, the necessity of developing policies is emphasized for the children who receive education and training to receive quality and qualified education.

A study by Kayacık (2020) focused on the education of Syrian students in Denizli. In the research, semi-structured interviews were conducted with 20 teachers working in two schools where Syrian students are the majority. Through these interviews, the teachers' thoughts on the education of Syrian students, the problems encountered and solution suggestions were examined. The data obtained from the research were collected under five main themes. The first theme includes the problems experienced in the education of Syrian students. Seventeen participating teachers did not find it appropriate to include Syrian students who did not receive pre-education in regular education. The second theme deals with the problems experienced by the parents of Syrian students. All of the teachers stated that the students had problems with their parents. These problems are grouped under sub-headings such as lack of interest in families and communication problems due to not knowing Turkish. The third theme deals with the differences in the participation of Syrian students in classes. While 20 teachers stated they had difficulties in reading lessons such as Turkish, six teachers stated they participated more actively and at a better level.

Sarıer's (2020) study aims to investigate the problems that arise in the learning processes of refugee students and the solutions for these problems. The meta-synthesis method was used in the research by synthesizing qualitative research findings. This method allows data obtained from different studies to be compiled and synthesized. As a result of the analysis of the study, six main themes were determined, and these themes were grouped as "linguistic, cognitive, affective, socio-cultural, familial and structural problems". According to the research findings, refugee children experience communication problems based on language problems and have difficulty expressing their feelings and thoughts. It has been revealed that students struggle to express their thoughts about a problem or subject. In the findings of the study, it was seen that most of the teachers stated that international students were excluded by their friends, that they had problems in harmony in friendship relations, that they had difficulties in obeying the rules and that they were prone to violence. This situation reflects the problems that refugee students experience during the social integration process. This study focuses on the problems that refugee students encounter in their learning processes and solutions. The findings show that refugee students experience difficulties in language, communication, social integration and family relationships. On the other hand, the study's recommendations emphasize the support of language education and social integration processes. This type of research is an essential resource for improving the education processes of refugee students.

Considering the connection between mathematical thinking skills and problem-solving skills, supporting students' mathematical thinking processes is of great importance. In this context, focusing on and emphasizing mathematical terminology that will enable all students, including immigrant children, to understand and use the language of mathematics effectively is a method that strengthens communication (Olkun & Toptaş, 2007).

Although mathematics is a universal language that uses common symbols in the world, many teachers think teaching mathematics to immigrant students can be difficult. In mathematics education, appropriate activities can be organized in order to increase the success and motivation of the students in the classroom by minimizing the cultural incompatibility of the immigrant students by focusing on mathematical words and communication, making use of visuals and drawings, using gestures and mimics, and including refugee students in classroom activities (Kılıç, 2020).

Ensuring fair access for each student in mathematics lessons often needs to be clarified by providing the same education (Secada, 1989). Fairness, on the other hand, emphasizes the need for mathematics teachers to make content accessible to cultural and linguistic differences and to differentiate teaching

(NCTM, 2000). Ignoring students' cultural backgrounds and focusing only on sameness often creates patterns of math achievement. These stereotypes tend to interpret mathematical skills as deficient based on social characteristics such as race, class, ethnicity, gender, belief, and dominant language and include prejudices that some children can do mathematics (Gutiérrez, 2002). Therefore, our vision of access and equality in mathematics education should aim to provide fair learning opportunities sensitive to students' social and cultural backgrounds rather than sameness.

Arguing that mathematics is a universal activity, Gerdes (1998) argues that mathematical thinking occurs in all cultures and produces many mathematical ideas without everyone's awareness. Bishop (1988), who argues that mathematics is not independent of culture, stated six universal activities that appear more or less in every culture and play a fundamental role in the cultural development of mathematics: counting, positioning, measuring, designing, playing and explaining. He argues that these six activities are universal and that mathematics is a cultural phenomenon. Looking at the history of mathematics with a Western focus, we should not ignore that mathematics exists in every society and has a universal quality even if it is not developed (Bishop, 1988).

Result and Suggestions

Schools are where inequalities are seen the most, and teachers are responsible for balancing these inequalities and ensuring equality. Considering sociocultural differences, the right to education should be offered to all children equally.

In the articles reviewed, it is stated that one of the most common difficulties teachers encounter when teaching mathematics in sociocultural diverse classrooms is that students speak different languages and communicate problems in the classroom. Although mathematics is a universal language, in order to teach mathematics, the teacher must first communicate with children socially.

One of the priorities of the teachers participating in the study was that students with cultural diversity should learn Turkish first to learn mathematics, and most of the participants agreed with this view. Migration to our country due to Turkey's geopolitical position, civil wars in neighboring countries and the sanctions of foreign powers reveals the prediction that multiculturalism will increasingly continue. The reflections of this multiculturalism in educational environments should be considered, and studies should be developed on this subject. It is necessary to support teachers to develop tolerance towards cultural and social differences and to participate in in-service training in political and cultural fields by taking language training when necessary.

Teachers must focus on the communication and language problems they encounter while teaching mathematics in diverse sociocultural classrooms. The following suggestions can be considered in solving these problems:

1. It is essential that teachers develop a tolerance for cultural and social differences and develop their skills to teach in multicultural classrooms. Educators should respect students' diverse cultural backgrounds and view these differences as richness.
2. Since language problems can negatively affect mathematics learning, teachers should primarily teach Turkish to students and transfer mathematical terminology to students. This will help students develop mathematical thinking skills and communicate effectively in class.
3. Using visual and auditory materials such as visuals, drawings, gestures, and mimics in classroom activities will facilitate understanding mathematical concepts and communication. Teachers should embody mathematical subjects and enrich their learning experiences by involving students in activities.
4. Technology and computer concepts operate as one of the most essential elements in daily life, business life and education for modern societies and education systems (Tutak, İlhan and İç, 2018). Teachers should diversify their technological course materials and teaching methods by considering students from different cultural backgrounds in the classroom. Explaining mathematical concepts to students using examples and examples from their own cultures will make learning more meaningful.
5. The education system should provide training opportunities for teachers about sensitivity to cultural differences. In-service training activities in political and cultural fields should be organized, and teachers should be aware of cultural diversity.

As a result, an approach sensitive to the needs of culturally diverse students should be adopted in mathematics education. Teachers must focus on language problems and use various strategies to facilitate communication and improve mathematical thinking skills. In this way, a fair mathematics education can be provided for every student, and the principle of equality can be realized.

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HISTORY OF MATHEMATICS IN MATHEMATICS EDUCATION: A JOURNEY TO THE FUTURE IN THE LIGHT OF THE PAST

Suat ÖZTÜRK[1]

Abstract

Mathematics is a universal language and thinking discipline with a history of thousands of years. Mathematics education aims to develop students' mathematical thinking skills and to enable them to understand mathematical concepts. However, mathematics can be perceived as boring, not associated with daily life and an abstract lesson for students. Therefore, using the history of mathematics in mathematics education can help students explore the history of mathematics and develop their ability to relate mathematics to real life. The history of mathematics allows us to understand how mathematical ideas and concepts developed, how mathematicians made discoveries and how mathematical problems were solved. Learning the history of mathematics allows students to see the evolution of mathematical thinking and to understand how mathematical concepts have been shaped over time. This can help students gain a deeper understanding of mathematical concepts and provides context to math learning. Learning the history of mathematics also teaches students about the work of great mathematicians. There are many methods of teaching the history of mathematics. To teach students about the history of mathematics, teachers can tell engaging stories, present interesting mathematical problems, and encourage students to do their research. In addition, resources, books, videos and interactive materials related to the history of mathematics can be used. Using the history of mathematics in mathematics education helps students develop their mathematical thinking skills, relate mathematical concepts to real life, and give mathematics learning a more meaningful context. The fact that the history of mathematics provides a window for students to understand mathematical ideas and discoveries has excellent potential to develop mathematical literacy.

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Keywords: *Teaching Mathematics, History of Mathematics, Importance of Mathematics*

Introduction

In recent years, interest in using the history of mathematics in mathematics learning and teaching has been increasing rapidly (Baki & Tümer, 2013). Studies investigating the effectiveness of teacher training programs that give importance to teaching the history of mathematics reflect the interest in this subject (Charalambous, Panaoura, & Furinghetti, 2007). Efforts to include the history of mathematics in the mathematics curriculum are supported by various associations and organizations and are discussed in conferences and papers (Jankvist, 2009).

There are many reasons why educators are interested in the history of mathematics. Fauvel (1991) lists fifteen reasons to consider the cognitive, affective, and sociocultural aspects of incorporating the history of mathematics into the mathematics curriculum. Fried (2001) collects these reasons under three main themes. First, the history of mathematics humanizes mathematics. The history of mathematics encourages multicultural approaches, provides students with historical role models, and combines the study of mathematics with human emotions and motivations (Avital, 1995; Swetz, 1993). Second, the history of mathematics makes mathematics more interesting, understandable and accessible. The history of mathematics adds variety to teaching, reduces students' fear of mathematics and provides an understanding of the role of mathematics in society (Rickey, 1996). Third, the history of mathematics offers a different perspective on concepts, problems and problem-solving (Garner, 1996; Thomaidis, 1993). Learning the history of mathematics allows students to develop their mathematical thinking skills, understand mathematical concepts in depth, and relate mathematics to real life. With the constant changes in the world, the importance of education is increasing, and societies have realized that educated individuals have a fundamental impact on the development of society by making education compulsory with this awareness (Nayıroğlu, Tutak, & Tutak, 2021). The history of mathematics is an effective tool for understanding challenging topics in terms of the discovery and development of mathematical concepts, as well as making important contributions to mathematics teachers' mathematical and pedagogical preparation. The history of mathematics opens new horizons in students' minds and develops their perspectives on mathematics (Miller, 2002).

For teachers, the history of mathematics is vital in understanding mathematical concepts in depth and transferring them to students. The history of mathematics allows teachers and students to explore and evaluate mathematical concepts in historical processes. In addition, the history of

mathematics adds depth to the learning process by providing the opportunity to examine mathematical concepts from a cultural and sociological perspective. For students, topics such as Pythagoras' journey to learn mathematics, the importance of Khwarezmi as a mathematician using algebraic expressions, and the pyramids built by civilizations thousands of years ago take place in the history of mathematics. These stories enable students to appreciate mathematics more and understand its importance (Furinghetti, 2000).

Purpose of the study

This study aims to emphasize the importance of using the history of mathematics in mathematics education and examine the teaching methods based on the history of mathematics to increase students' motivation, understanding and conceptual awareness in the mathematics learning process. It also explores how the history of mathematics can contribute to developing students' understanding and appreciation of mathematics and deepen the discipline of mathematics by placing it in a historical context. In addition, it provides a resource for mathematics teachers and researchers to understand the importance of using the history of mathematics in mathematics education and enrich their teaching methods.

Method of Study

In this study, the document analysis method, one of the qualitative research methods, was used. Document analysis examines the existing written source of the researched subject (Hitchcock & Hughes, 1995). Document analysis is also defined as examining visual materials containing information about the event or phenomena planned to be investigated (Yildirim & Simsek, 2008; Çelik et al., 2022). The primary purpose of document analysis is to examine the obtained documents in a theory-oriented, systematic and data-based manner (Saglamoz & Soysal 2021).

Using the History of Mathematics in Mathematics Education

Mathematics started with human existence and it is accepted that it developed over time by establishing relations with different civilizations in the world and formed today's modern mathematics. Galileo said, "The universe is written in the language of mathematics". Mathematics knowledge is considered to be an essential requirement in order to understand the universe and to dominate the phenomena in the universe (Ülger, 2006; Başıbüyük & Soylu, 2019).

According to Swetz (1993), the history of mathematics is a branch of science with a rich cultural background that associates mathematics with societies and their needs. Should the history of mathematics be used as a goal or a tool in teaching mathematics? When considered as a tool, it is argued that the history of mathematics is a positive motivation for learners (Bütüner, 2015).

According to Bidwell (1993), using the history of mathematics as a tool in mathematics lessons can create a source of motivation for learners and increase the motivation of students who perceive the mathematics lesson as "dead", "boring," and "too abstract". Parallel to this idea, studies in the literature show that using the history of mathematics and the life stories of mathematicians as tools in mathematics lessons will increase students' motivation and enable them to participate more actively in the subject (Fauvel, 1991).

However, when the history of mathematics is used as a goal, it is argued that, together with the rich history of mathematics teaching, it is a great way to involve mathematics learners in the living world of mathematics (Bayam, 2012; Jankvist, 2009). Lim (2011) states that if the history of mathematics is used as a goal, it will help to understand the human value of mathematical knowledge and can impact value teaching. Baki (2008) states that a mathematics course enriched with the history of mathematics will help students think of mathematics as a constantly renewed science in an endless development cycle. It is argued that mathematics has a rich culture and that thanks to the mathematics course enriched with the history of mathematics, an opportunity to discover how it can shape human nature will be offered (Rickey, 1996). The use of the history of mathematics in mathematics teaching has many positive effects, such as improving students' mathematical thinking skills, increasing their problem-solving abilities, enabling them to make sense of the mathematics lesson, and enabling them to compare and evaluate mathematics subjects from past to present (Wilson & Chauvot, 2000).

For teachers and learners, the history of mathematics plays a vital role in the context of mathematics. As stated by Radford, Bernard, Fried, Furinghetti, and Sinclair (2014), the history of mathematics enriches teachers' perspectives, enabling them to discover aspects they did not realize during mathematics teaching and to transition from a product-oriented approach to a process-oriented approach. The history of mathematics helps teachers to integrate their mathematical knowledge with classroom work and helps them develop their creativity skills and realize why the taught subjects should be taught (Liu, 2003). This allows teachers to develop teaching methods and strategies (Furinghetti, 1997). As emphasized by Yıldız and Baki (2016), teachers need to be able to transfer the desired benefits to the learning environments while using the history of mathematics to enrich their mathematics lessons. It is stated that teachers should believe that the history of mathematics will make mathematics lessons more effective (Jankvist, 2009). The three different approaches stated by Jankvist (2009), namely the lighting approach, the module approach and the history-based approach, explain the purpose of using the history of mathematics in mathematics education. The lighting approach emphasizes the importance

of including historical information in textbooks and classroom settings. The module approach consists of units equipped with the history of mathematics. The history-based approach, on the other hand, does not directly focus on the history of mathematics but indirectly gives the history of mathematics (Bütüner, 2015).

Integrating the history of mathematics into mathematics lessons, "How can a mathematics lesson be enriched with the history of mathematics?" raises the question. The field literature has different approaches and methods for using the history of mathematics in mathematics education (Swetz, 1995; Jankvist, 2009).

Bidwell (1993) suggests that the history of mathematics can be used in mathematics education in three different ways. These are described as "introducing pictures and lives of mathematicians who shed light on history with encyclopedias, dictionaries, biographies or words and symbols that describe mathematicians," "use of historical materials during lecture," and "use of historical development process during a lecture or problem solving". Swetz (1995) stated that during mathematics education, "using the works and life stories of mathematicians that shed light on history," "introducing the origins of mathematical symbols and terms, concepts," "identifying historical problems and explaining their importance" and "visual visualizations such as historical short films-videos in the course"—emphasized that "using tools" should be brought together and presented. On the other hand, Tzanakis and Arcavi (2000) stated that the history of mathematics could be used in different ways in lessons, including extracurricular activities, historical problems, worksheets, movies and other visual aids, gamification of anecdotes or stories, mechanical tools, internet, historical packages, primary sources, historical chapters, experiential math activities, student research projects based on historical texts, errors, alternative understandings, point of view change, revision of hidden assumptions, and heuristic arguments. Fried (2001) proposes that the history of mathematics can be integrated into lessons in two ways: adding and adapting. While the addition method suggests telling historical sections and life stories of mathematicians or focusing on historical problems while teaching the subjects, the harmony method suggests arranging the content to be taught by a historical scheme (Fried, 2001).

In the study conducted by Yıldız and Baki (2016), 13 different ways of using the history of mathematics in mathematics lessons enriched with the history of mathematics were identified:

1. Using the prominent words in the historical development of mathematics.
2. Using the historical chapters in the textbooks related to the history of mathematics.

3. Using student research projects or performance tasks related to the history of mathematics.
4. Making use of the historical development of mathematical symbols or concepts.
5. Making use of the life stories of famous mathematicians.
6. Using lived anecdotes or stories that play an important role in the historical development of mathematics.
7. Making use of the meaning or origin of mathematical terms.
8. Using worksheets based on historical events or discoveries related to mathematics.
9. Making use of the problems that come to the fore in the historical development of mathematics.
10. Benefit from the gamification of anecdotes or stories about the lives of mathematicians or people who played an important role in the historical development of mathematics.
11. Using movies or videos about the history of mathematics or the life stories of mathematicians.
12. Making use of out-of-class activities related to the history of mathematics.
13. Benefiting from mechanical tools developed for use in mathematics in the historical development of mathematics (Yıldız & Baki, 2016).

These different approaches and methods enable students to have a deeper understanding of mathematics by effectively using the history of mathematics in lessons. It improves students' mathematical thinking skills and increases their ability to relate mathematics to real life by evaluating mathematical concepts and issues in a historical context. At the same time, it contributes to developing students' mathematical research skills and deep understanding of mathematical knowledge.

Result and Suggestions

Studies on the use of the history of mathematics in mathematics lessons support the view that it is quite effective in teaching some objectives while reflecting the view that it is not suitable for some objectives (Yıldız & Baki, 2016). The mathematics course, which will be taught in a learning environment enriched with the history of mathematics, can allow students to understand the nature of mathematics while learning it.

Learning with exploratory and historical perspectives helps students to learn more strongly and permanently (Lit et al., 2001; İdikut, 2007). The literature review shows that the teacher's emotional and cognitive readiness and

willingness for a mathematics lesson enriched with the history of mathematics is essential for a successful practice. In addition, it is stated as a prerequisite that the content used during the application is appropriate at a level associated with the history of mathematics (Bayam, 2012).

When the primary school mathematics curriculum is examined, it is seen that the history of mathematics needs to be revised (MEB, 2015; MEB, 2018). Although there are sections or achievements related to the history of mathematics in the programs, it needs to be specified how this subject will be handled and how it will be transferred to the students. This situation reveals the conclusion that mathematics programs are prepared without associating with the history of mathematics, and it is emphasized that the history of mathematics should be included in mathematics programs in future program development studies (MEB, 2017; MEB, 2018).

Teaching with exploratory and historical perspectives strengthens and makes learning exciting (Liu, 2003). For this reason, it is vital to bring mathematics literacy to students by integrating the history of mathematics into mathematics lessons. For teachers to use the history of mathematics effectively, they need to be prepared and select the appropriate content. Thus, students can develop a deep understanding of mathematics and increase their ability to relate mathematics to real-world events.

Studies on the history of mathematics in mathematics lessons argue that more than the life stories of mathematicians in history may be required, and historical problems should be used to teach effectively (Fried, 2001; Swetz, 1997). Fried (2001) states that the mathematics course enriched with the history of mathematics did not change the mathematics curriculum but only expanded the program by making it more comprehensive. For this reason, it is stated that with mathematicians such as life stories, anecdotes and posters, students may remain passive, and effective teaching cannot be achieved. Swetz (1997), on the other hand, emphasizes that teaching mathematics enriched with the history of mathematics should be done with historical problems. In this way, students can learn about the problems' continuity through historical problems. Historical problems can develop students' mathematical thinking skills and increase their ability to relate mathematics to real-world applications.

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USE OF AUGMENTED REALITY TECHNOLOGY IN SCIENCE EDUCATION

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Introduction

Science, physics, chemistry and mathematics courses are seen as difficult disciplines for students to understand. Educators who want to understand why students have difficulties and fail in these areas and who want to encourage students' meaningful learning continue their studies in different areas. Some of the topics that educators work on for this purpose are: Examining the attitudes, perceptions or opinions of teachers or prospective teachers on different subjects (Bagır et al., 2022), examining textbooks or questions in textbooks (Çelik et al., 2022; Nayiroğlu et al., 2021), examining the effects of computer use in education (İç & Tutak, 2018; Tutak et al., 2018), examining students' reasoning (Karakoyun & Asiltürk, 2021; Karakoyun & Asiltürk, 2022), examining teachers' inadequacies (Tutak et al., 2019).

It is emphasized in the literature that science education is closely related to the real situations in students' lives and that it should be handled in the context of daily life (Buxton, 2010; Dettweiler, Lauterbach, Becker, & Simon, 2017; James, & Williams, 2017; Fűz, 2018; Kangas, Vuojärvi , & Cyclander, 2018). James and Williams (2017) stated that the lack of motivation that students encounter in the learning process at school is a common problem and that students in the field of science education show weaknesses in terms of interest, in-depth understanding, application of school knowledge, and general attitude towards school learning. Ruether (2018) mentioned that the outdoor environment is a learning scene that contextualizes real life or the world, as well as a place where students can gain life skills and enjoy learning. For this reason, he advocated the idea that such environments provide students with the opportunity to conduct research in the field and develop their cognitive

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competences. In this context, the integration of resources in the field of outdoor education with classroom science education can effectively increase students' motivation and learning effectiveness towards science education.

In current education, many science textbooks cannot effectively contribute to students' understanding of complex phenomena in a more systematic and holistic way (Liu & Hmelo-Silver, 2009). Individuals live in a world determined by complex systems that are dynamic, self-organizing and constantly adapting (Jacobson & Wilensky, 2006). Complex systems are an important component of science education learning because they encompass key concepts in national science education standards and provide a framework that integrates multiple science disciplines (Goldstone & Wilensky, 2008). Science education curriculum should be able to respond to the student characteristics and needs required by the information technology age. Accordingly, the use of information and communication technology (ICT) ensures that students have the opportunity to learn everywhere and that teachers contribute to the development and implementation of the science curriculum. The integration of science education and digital technology helps students grasp abstract and difficult concepts (Vonderwell, Sparrow & Zachariah, 2009; Liou, Bhagat & Chang, 2016). This integration can be further enhanced by visually stunning augmented reality (AR) technology. AR technology allows science education to achieve learning goals by combining virtual reality and real situations (Arici, Yildirim, Caliklar & Yilmaz, 2019). The benefits of AR technology in science education are as follows (Sumadio & Rambli , 2010; Lin & Wang , 2012; Iordache, Pribeanu & Balog, 2012; Yoon, Elinich, Wang, Steinmeier & Tucker , 2012; Cai , Chiang & Wang , 2013; Atasoy , Tosik -Gün & Kocaman-Karoğlu , 2017; Wojciechowski & Cellary , 2013):

- To create an effective and productive learning environment;
- To increase student motivation, interest and participation;
- Influencing students' learning attitudes positively;
- Bringing students together with a perception of reality and a contextual learning experience

Augmented reality (AR) is a powerful technology in science education that helps students understand abstract, microscale, model and spatial concepts and improve their experimental skills. Augmented reality enriches the learning process by presenting students with scientific environments and models that are difficult to reach in reality, increases students' sense of immersion in their classroom experiences and awakens learning motivation. Augmented reality supported experiential teaching resources can be used as an innovative teaching strategy in science education. These resources enable students to learn by doing, transition from concrete experiences to abstract concepts, and build

scientific knowledge. Augmented reality plays an important role in solving the disciplinary problems of science education. In this context, the inclusion of AR technology in the science education curriculum design should support the learning process of students and facilitate the achievement of the curriculum goals of the instructors.

Augmented Reality (AR)

Augmented Reality (AR) is a technology that makes virtual objects appear as part of the real world (Azuma, 1997). AR is a rapidly developing technology that attracts great attention in both commercial and educational fields (Bower et al., 2014). Gartner, Inc. An IT research and consultancy firm named 'Technology' publishes a report and graph every year that shows the "maturity and prevalence of technologies" (URL-1). According to this report, AG has overcome the "pit of disappointment", which is the stage where a technology will either succeed or fail, and enter the "productivity plateau", where the technology will become widespread and commonplace in the next five to ten years (Panetta, 2017). Likewise, research on the use of AR for education has been increasing in the last decade. AR technology has been used in different subjects such as science, mathematics, language learning and visual art appreciation (Chen et al., 2017). These studies have shown that AR helps students learn information or abstract or complex concepts that cannot be seen in the real world or that require a special device. AR technology allows students to interact with invisible mechanisms and to notice changes and scientific details in the event over time (Yoon & Wang, 2014). AR technologies have also been identified as an important technology for primary and secondary education in the next five years (Johnson et al., 2010). Therefore, it is very important to conduct research on how this new technology can be used for education and how effective it is.

AR is one of the potential technologies to eliminate and correct common misconceptions in science education (Yoon, et al., 2017). Yoon et al. (2017) have shown that AR is effective in reducing misunderstandings about physics and understanding difficult scientific concepts. For example, a common misconception about Bernoulli's Principle is that there is a direct relationship between air velocity and air pressure. In reality, however, there is an inverse relationship between these two variables; as the air velocity increases, the air pressure decreases. Yoon et al. (2017) provided museum visitors with an AR experience where they could see the velocity and pressure of two airflows in real time. In this way, the participants were able to observe how the inverse relationship between air velocity and air pressure in the room keeps a ball floating in a fast-moving air stream in the real world.

Yoon et al. (2012) investigated the use of Augmented Reality (AR) in a science museum. In this study, it was found that students in the AG condition better understood the inversely proportional relationship between air velocity and pressure and eliminated their misconceptions. Yoon et al. (2017) argued that AR is effective in this regard as it visualizes invisible mechanisms and allows students to question their intuitive misconceptions. However, not all scientific misconceptions are that easy. In the case of Natural Selection, for example, there are cognitive barriers to understanding evolution and natural selection. These misconceptions include a purposeful view of the subject, the assumption that the entities participating in the process act with intent, the belief that the characteristics acquired throughout the life of the individual are passed on to the next generation, and defining evolution as a process or balance, not an event. These misconceptions are not inconsistent and related (Gregory, 2009). Although these misconceptions are different from a simple inverse relationship, it is possible that AR can challenge these misconceptions by creating an interactive environment where it visualizes invisible mechanisms and shifts students' attention from the real world to the virtual.

Use of Augmented Reality in Educational Activities

It is known that technology provides many benefits to educational environments. In this context, it is inevitable that augmented reality technologies, which have been constantly developing in recent years and used in various sectors, are also applied in the field of education (Kul, 2019). Augmented reality is a technology that builds a bridge between the real world and the virtual world, enabling students to interact with virtual objects in the real environment (Azuma, 1997). Many researchers have stated that the use of augmented reality in education contributes greatly to the teaching and learning processes. Considering the different learning levels, styles and needs of students, the importance of AR usage increases even more (Bingöl, 2018). The increase in students' interest in the lessons in education and training will also increase their motivation for the lesson. Using augmented reality by integrating it into education according to the classical lecture method will allow the student to be more active in the lesson (Keleş, 2022). Augmented reality facilitates the teaching of lessons by activating more than one sense, especially on subjects where they do not have the opportunity to make direct observations in real life. Augmented reality provides students with opportunities to embody abstract concepts, experiment, solve problems, explore and develop creativity (Wu et al., 2013). Therefore, the use of augmented reality technology in education can positively affect students' academic achievement and attitudes (Chen & Tsai, 2012).

It has been shown in many studies that the use of AR in education increases the attention, interest and motivation of students. In studies examining the contributions of augmented reality use in the field of education in Turkey, it has been found that teaching using AR in mathematics and physics lessons has a positive effect on students' academic achievement and attitudes towards the lessons. For this reason, the use of AR has been suggested in various branches, especially in difficult subjects (Keleş, 2022). Augmented reality increases the student's course performance by contributing to the student-centered classroom environment (Bujak et al., 2013). AR also helps students develop positive attitudes towards technology (Giasiranis & Sofos, 2016). Augmented reality applications used in education are suitable for a multi-learning environment. The increase in the interest in the lesson also accelerates the learning. Augmented reality is successful both in terms of saving time and arousing interest by presenting virtual objects simultaneously with real-world images (Akkiren, 2019). AR, which is widely used in countries around the world, has given the opportunity to observe extinct dinosaurs in three dimensions through augmented reality applications in order to provide a more educational and creative experience to its visitors, especially in science museums (Somyürek, 2014).

Delello (2014) stated in a study that 30 pre-service teachers participated using the aurasma platform, that the use of AR applications in the classroom had positive effects. It has been observed that AR applications increase students' interest and motivation in the course. Perez-Lopez et al. (2013) emphasized that AR technologies provide convenience in terms of applicability in the learning and teaching process in their work on eliminating misconceptions with third-year students including AR applications (Kul, 2019). It is seen that it is possible to create a more productive educational environment with the widespread use of augmented reality in education life. It is estimated that the possible negative aspects of augmented reality will be understood more clearly in the future.

Augmented reality technology is applied in many different fields of education, in addition to these, it is also used in different learning levels such as preschool, primary school, secondary school and high school (Sırakaya & Alsancak Sırakaya, 2018). One of the other levels where augmented reality technology is widely used is higher education institutions.

Augmented Reality in Science Education

Since science education is a field full of abstract concepts, there may be situations where students have difficulty in understanding. At this point, augmented reality (AR) technology makes lessons simpler and more visual by embodying abstract concepts and difficult topics. AR applications increase the interest and motivation of students today, as they are easily accessible with

various electronic devices, save time in science lessons, and offer rich visuals by integrating virtual objects with the real world. In a study by Santos et al. (2014), it was stated that the use of AR applications in education positively affects the academic success of individuals (Sivri, 2021).

In science education, the learning process supported by applied and visual shapes is very important. As students have limited opportunities to relate to the real world in science subjects such as DNA, the world and the universe, and the atom, these subjects may remain superficial. Therefore, the use of AR technology in teaching these subjects is of great importance in terms of intelligibility. For example, three-dimensional visualizations are provided by using AR applications in the teaching of human anatomy, which is one of the science subjects, and students are allowed to examine in interaction with the physical environment (Sarıyıldız, 2020). In addition, misconceptions may occur in some subjects in science education and these misconceptions can be eliminated by using AR technology.

As a result of the literature research on the subject of studies on augmented reality in science education, it has been seen that the number of domestic and foreign studies in this field has increased rapidly after 2015. Augmented reality studies in science education have been carried out to support students' learning processes in various science subjects. In the literature review, augmented reality studies in science education, augmented and virtual reality and periodic table teaching (Avcı and Taşdemir, 2019), the use of virtual reality programs in teaching astronomy subjects (Buluş Kırıkkaya and Şentürk, 2018), the effect of augmented reality simulation system application in a chemistry lesson (Ayyıldız and Karabulut, 2022), it has been seen that augmented reality is used in different science fields such as the use of earth sciences and the use of augmented reality in biology lessons.

Çelik (2022) aimed to improve the academic success and mental models of 6th grade students in the solar system unit with science teaching supported by mobile augmented reality (MAG) application. The study was carried out with a quasi-experimental design with pretest-posttest control group. The study is designed as a course activity that lasts 4 weeks. The experimental group used the MAG supported 5E teaching model, while the control group only used the 5E teaching model. The data of the study were collected with the solar system achievement test and mental model drawings. Analysis of the data showed that both teaching models significantly improved students' academic achievement and mental models, but the MAG supported 5E teaching model was more effective.

Atay (2022) aimed to determine the views of secondary school science teachers on the use of augmented reality (AR) applications in classroom

environments. The study was carried out as a qualitative research with 30 science teachers from Mersin. The data of the study were taken with a semi-structured teacher opinion form. Analysis of the data revealed that AR applications are useful in concretizing abstract subjects in science lessons, increasing students' interest and motivation, and enriching the learning process. In addition, it was stated that teachers adapted to AR applications and that the technological infrastructure should be developed.

Anıl and Batdi (2022) aim to examine the effectiveness of augmented reality (AR) applications in science education with a multiple complementary approach (McA) in their research. In the study, which is a mixed method research, there are three stages as pre-complementary, post-complementary and complementary. In the pre-complementary stage, AR applications in the literature related to science lessons were evaluated with meta-analysis and meta-thematic analysis. In the final complementary stage, an experimental design with pretest-posttest control group was applied by using AR applications on "refraction, lenses and prisms" in science education. In the complementary stage, a more comprehensive and broad perspective on the effectiveness of AR in science education was obtained by combining the results of the first two stages. As a result of the study, it was emphasized that AR has positive and significant effects on various variables that support academic achievement and science teaching, and that teacher training is necessary for the dissemination of this technology in science education.

Kayalar and Baran (2021) aimed to evaluate the researches in the literature on the use of augmented reality technology in science education and to identify research gaps and deficiencies in this field. In the study conducted with the document review method, 30 academic articles with augmented reality were examined using an evaluation rubric in terms of content, method, data collection tool, data analysis method, findings and results. The obtained data were subjected to descriptive analysis. As a result of the study, it has been determined that there are important problems in the evaluation processes and content compatibility in researches related to augmented reality. In addition, it has been emphasized that augmented reality technology is effective in improving students' motivation, conceptual understanding, inquiry skills and academic performance in science education.

Sarıoğlu (2021) aims to examine the effect of augmented reality technology education for science teachers in his study. In the study conducted with a quasi-experimental design, 21 science teachers in Bursa were selected as pretest-posttest control group. Teachers' attitudes towards augmented reality applications were measured with the Attitude Scale towards Augmented Reality Applications and semi-structured interviews were conducted with

three teachers. As a result of the analysis of the data, it was determined that there was a significant increase in the attitude scores of the trained teachers and that augmented reality applications would improve the teaching of abstract concepts in science education, the motivation of students, their inquiry skills and their academic performance. As a result of the study, the importance of teacher training was emphasized in order to disseminate the use of augmented reality technology in science education.

Sivri (2021) examined the effects of models and materials designed with AR technology on the academic achievement, motivation and interest levels of students on the support and movement system in the 6th grade science course. The study was conducted with 66 students in a state secondary school in Istanbul with a quasi-experimental design. In the study, the 5E teaching model using the material designed with AR technology to the experimental group; On the other hand, the 5E teaching model was applied to the control group using only models. The data of the study were collected with the support and movement system achievement test, the motivation and interest scale for the science course. Analysis of the data showed that both AR technology and modeling technique significantly increased students' academic achievement, motivation and interest levels, but AR technology was more effective.

Sarıyıldız (2020) investigated the effect of using AR technology in the pure substance and mixtures unit in the 7th grade science course on the academic achievement and motivation of the students. The study was carried out with 76 7th grade students in a semi-experimental design. In the study, 5E teaching model using AR technology; On the other hand, only the 5E teaching model was applied to the control group. The data of the study were collected through the mixtures unit achievement test, the motivation scale for the science lesson, and the semi-structured interview. Analysis of the data showed that the use of AR technology significantly increased students' academic achievement and motivation towards the course. In addition, it was determined that students reported positive opinions about the use of AR technology.

Yıldırım (2020) aims to examine the effect of using augmented reality (AR) based teaching materials (science cards) in science education. In the study, which is a mixed method research, 63 students studying in the 7th grade of a secondary school in Antalya were selected as the study group. In the research, two groups were formed as the control group and the experimental group, and the experimental group was taught using science cards and AR applications. Students' academic achievements were measured with pre-test and post-test, and their views on AR applications were obtained through interviews and observations. As a result of the analysis of the data, it was determined that AR applications increased students' success, meaningful learning of abstract

subjects, and their interest and motivation towards science lessons. As a result of the study, it was emphasized that AR applications are an effective teaching tool in science education and the necessity of teacher training for the dissemination of this technology.

Akkiren (2019) investigated how augmented reality (AR) applications affect 6th grade students' achievement, attitude and understanding of the circulatory system compared to teaching with models. The study was carried out with 38 students studying in Hatay. In the study, data collection tools such as circulatory system achievement test, attitude scale towards science lesson, diary, heart structure drawings and semi-structured interview were used. The results of the study showed that AR applications significantly increased students' achievement, attitude and understanding levels compared to teaching with models. In addition, it has been confirmed by the opinions of teachers that AR applications support students' active participation in the learning process, self-management skills and positive attitudes.

Kara (2018) examined the current situation of augmented reality technology in education in the literature, the technologies used and its potential for education. The study evaluated 145 educational augmented reality studies indexed in Web of Science and ERIC databases using content analysis method. The findings of the study showed that augmented reality technology is used in different fields in education, especially in the fields of Science and Engineering, it increases the motivation, interest and success of the students, enriches the learning process and provides realistic experiences. As a result of the study, it was emphasized that the necessary infrastructure, hardware and software support should be provided for the augmented reality technology to be used more widely in education. The study is a comprehensive and up-to-date resource that reveals the importance and benefits of augmented reality technology in education.

Fidan (2018) used problem-based learning method supported by augmented reality (AR) applications to increase secondary school students' academic success, permanence, attitude and self-efficacy beliefs about science course. The study was designed as an 11-week course activity covering the unit "Force and Energy". 91 seventh grade students participated in the study. The experimental group used the problem-based learning method supported by AR, while the control group only used the problem-based learning method. The data of the study were collected with the academic achievement test, the attitude scale and the self-efficacy belief scale. Analysis of the data showed that the experimental group got significantly higher scores in all variables than the control group. These results revealed that AR applications increase the effectiveness of the problem-based learning method and develop positive attitudes and self-efficacy beliefs towards science lesson.

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METAVERSE AND ITS USE IN MATHEMATICS EDUCATION

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Abstract

This study aims to examine Metaverse technology with a literature review in mathematics and geometry education and to emphasize the use of Metaverse in mathematics and geometry education. The study focuses on the development of internet technologies, the definition of Metaverse and how this technology can be combined with education. In addition, augmented, virtual, and mixed reality subjects are also mentioned to understand the Metaverse technology fully. The effects of reality technologies on mathematics and geometry education and studies in this field were also included in the content of the study by examining the literature. As a result of this review, it has been determined that the use of Metaverse in mathematics and geometry education is still new in educational sciences. However, augmented reality and virtual reality studies have begun to be included in the educational content.

Keywords: *Metaverse, Virtual Reality, Mixed Reality, Mathematics Education*

Introduction

Technology has become an important tool in facilitating human life in recent years. Technology and computer concepts are among the most critical elements in daily life, business life and education for modern societies and education systems (Tutak, İlhan and İç, 2018). Internet technologies have gained popularity, especially in the last 20 years (Doğan and Şen, 2022). The development of the Internet is examined in three stages. The first stage is the period called Web 1.0 and known as the portal age. In this period, the Internet is associated with personal computers. The second period is known as Web 2.0 and is defined as the search and socialization period. The spread of mobile

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Internet was also observed in this period. The third period is called Web 3.0 and includes features such as virtual reality glasses, wearable technologies and intelligent Internet. Metaverse, conversely, can be considered a product of the Web 3.0 era (Ge, 2022).

The Metaverse concept consists of combining the words "Meta" and "Universe." Since there is no exact equivalent word in Turkish, the term "other universe" is accepted as a suitable translation (Çelik, 2022). It is known that the term metaverse was first used in 1992 in sources such as the science fiction novel Snow Crash (Parasite) (Stephenson, 1992). Many experts describe Metaverse as the next phase of the Internet. Facebook's change of name to Meta can be shown as an essential example of this situation (Doko, 2021). Metaverse refers to a digital platform where the user interacts and engages with avatars in the virtual world (Suh & Ahn, 2022). Metaverse is a virtual universe that offers an experience similar to real-world activities (Lee & Hwang, 2022). According to Hugges (2012), Metaverse is an environment where digital avatars represent people, and users can connect simultaneously. Metaverse is a continuous post-reality universe that combines physical reality and digital virtuality platforms.

Metaverse is based on technologies such as virtual platforms, digital objects, virtual reality and augmented reality so that people can interact multiple times (Mystakidis, 2022). Metaverse is a world that can be in different periods and cultural structures through human and machine interactions, offers users the opportunity to solve problems, redefines the past and shapes the future (Zackery, Shariatpanahi, Zolfagharzadeh & Pourezzat, 2016).

When a shared meaning is taken from the above definitions, Metaverse can be explained as "an impressive virtual platform, which is an enhanced and expanded version of the real world, where people can introduce themselves, socialize, interact with different people and objects with their avatars over a network" (Doğan and Şen, 2022). Metaverse aims to establish an ecological system that is an extension of the physical world, not a virtual world separate from the real world (Ning, Wang, Lin, Wang, Dhelim, Farha, & Daneshmand, 2021). Metaverse brings real-world events to a virtual world through virtual and augmented reality devices. Figure 1 below can be examined for the Metaverse platform.

Figure 1. Metaverse Platform

Although the concept of metaverse was generally understood as virtual reality when the first observations were made, it is a platform consisting of a combination of augmented reality, internet and web technologies (Lee & et al., 2021). To fully understand the metaverse concept, it is essential to know augmented reality environments. Augmented reality is a term for environments where the real and virtual worlds are combined and consist of a combination of augmented reality, virtual reality and mixed reality technologies (URL 1).

Aim

This study aims to examine Metaverse technology in light of the literature on mathematics and geometry education and highlight the studies in which Metaverse is used in mathematics and geometry education.

Method

This study has been prepared to examine Metaverse technology in light of the literature on mathematics and geometry education and to present studies in which Metaverse is used in mathematics and geometry education. A literature review was conducted to determine these methods. In this study, the data in the literature were defined and evaluated in detail.

Augmented Reality and Its Applications in Mathematics Education

The term augmented reality was used by Thomas Caudell and David Mizell in 1992 (Raja & Calvo, 2017). Although augmented reality is generally thought of as an extension of virtual reality, in order for an environment to be called an augmented reality environment, it must provide three essential features. These features are:

- The meeting and merging of real and virtual objects in the real world,
- These objects interact in real-time,
- Three-dimensional recording of these objects (Azuma, 1997).

These items are the key elements that define the augmented reality experience.

With the constant changes in the world, the importance of education is increasing, and societies have realized that educated individuals have a fundamental impact on the development of society by making education compulsory with this awareness (Nayıroğlu, Tutak, & Tutak, 2021). In mathematics, augmented reality has been most applied to geometry because the technology can visualize three-dimensional geometric objects (Cai, Liu, Yang & Liang, 2019). Augmented reality in geometry education and training allows students to interact between concrete and abstract concepts by actively participating in the learning process. When studies on the use of augmented reality in mathematics teaching are examined, it is seen that it is often used in geometry subjects and especially in the teaching of geometric objects (Korkmaz & Morali, 2022). As a result of the evaluation of these studies, augmented reality in geometry teaching has been observed that the use of this method improves students' spatial skills and inquiry skills (İbili, Çat, Resnyansky, Şahin, & Billinghurst, 2020; Lin, Chen, & Chang,2015; Özçakır & Çakıroğlu, 2022).

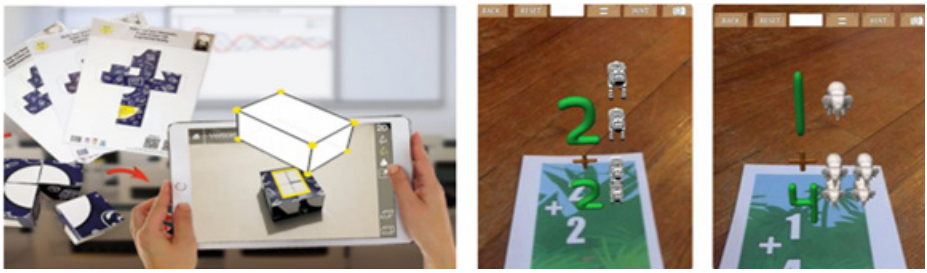

Figure 2. Use of Augmented Reality Applications in Mathematics Education

Özdemir and Özçakır (2019) used augmented reality-supported materials while explaining the subject of fractions. In the study, created with the participation of 5th-grade students, they examined their interest in mathematics and their academic success. As a result of the research, they stated that the use of augmented reality technologies in lectures positively affects students' attitudes toward the course and course success.

Figure 3. Teaching Practice of Fractions with AR Technology (Özdemir and Özçakır, 2019).

By integrating the possibilities of augmented reality with origami, Budinsi and Lavicza (2019) organized classroom activities that could show new options for teaching mathematical concepts and subjects; they had students make masu boxes using origami methods and techniques. Afterward, they asked them to calculate the box's volume, and finally, they made models using the Geogebra application, one of the augmented reality applications. These models are shown in Figure 4 below.

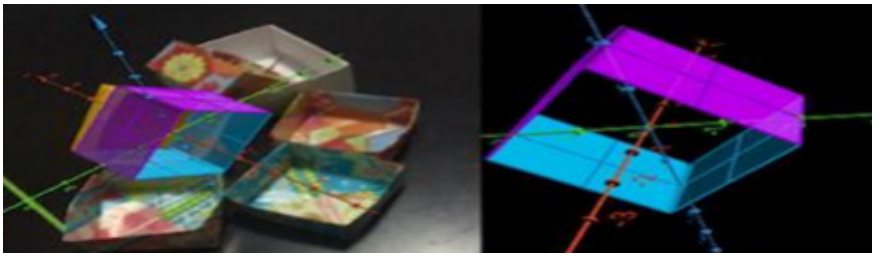

Figure 4. Modeling the Masu Box Using the GeoGebra Application

Virtual Reality and Its Applications in Mathematics Education

The combination of intelligent devices with the internet has contributed to the creation of virtual platforms, and the formation of these virtual platforms has accelerated the emergence of virtual reality technology that has made a splash in the 21st century. Virtual reality provides people with the experience of being there in three-dimensional environments through computers (Kaleci, Tepe & Tüzün, 2017). It offers a digital-based artificial environment separate from the physical world. Jaron Lanier first used virtual reality technology; It is defined as the sequence of images and sounds produced by computer to simulate objects and people belonging to the past, present or future" (Akaslan Ernst, Sarıışık & Erdoğan, 2018).

Virtual reality technology; is actively used in fields such as architecture, health sciences and the military, especially in education (Bayraktar and Kaleli, 2007). In order to provide a learning experience in which the learner is active, virtual reality can improve learning outcomes as it allows one to visualize complex concepts and observe the interactions between them (Yeh, Tseng & Heng, 2020). Virtual reality offers many advantages, such as providing live simulation examples of situations that cannot be done in the real world, embodying abstract concepts and increasing participation in learning activities. One of the most critical of these advantages is that it provides an impressive experience to the user. This impressive and immersive experience includes various sensory experiences, such as smelling, hearing and touching, apart from primitive applications consisting of only sound and visual combinations (Riva & Serino, 2020). Thanks to these facilities, users can interact both mentally and physically.

Figure 5. Use of Virtual Reality Environments in Mathematics Education

Dancsházy and Hampel (2014) stated that virtual reality allows students to acquire the ability to "conquer" information themselves and that learning information in virtual learning environments can benefit learning activities. With the development of technology, virtual learning environments are constantly changing and developing. For example, Construct3D; is a three-dimensional geometric structure designed for mathematical and geometric education in pedagogy, psychology and augmented reality (Kaufmann & Schmalstieg, 2003). Again, another virtual reality application is SketchUp, which uses augmented reality to present 3D models that can be uploaded directly to the web and stored directly in the database within the same program (González 2015). VRMath2 is one of the examples to be shown as a virtual learning environment. This application is an educational platform that allows students to understand and make sense of most subjects of mathematics, especially algebra, probability and geometry, using augmented and virtual reality technologies. The VRMath2 application uses the application to create mathematical micro-worlds and provides the opportunity to define mathematical subjects and concepts with codes and measure and evaluate the results (Yeh, 2017). Another of these applications, HandWaver software, is an environment where students move in geometric shapes using their hands and mathematics is reconstructed. Students can create new geometric objects by using their hands to change the size of mathematical objects. For example, a point can transform into a line segment, while a straight segment can transform into a planar shape and a planar shape into a solid. HandWaver aims to provide experiences where users present in virtual environments use their hands to create or manipulate mathematical objects (Dimmel & Bock, 2017).

Figure 6. VRMath Application

Mixed Reality and Its Applications in Mathematics Education

Mixed reality or mixed reality is a technology that covers different forms of reality from the real to the virtual environment. While this technology includes AR technologies initially, it combines all realities with virtual reality in the final stage (Tamura, 1999). While AR and AR technologies have been used in education for a long time, the use of mixed reality applications in education has been increasing recently (Doğan and Şen, 2022). Mixed reality technologies are still in development but provide the opportunity to incorporate the benefits of digital tools through applications embodied with mathematical and geometric content. This makes manipulating objects possible and significantly reduces the mental load (Doğan and Şen, 2022). For this reason, related studies are on using mixed reality applications for teaching mathematics.

Figure 7. Use of Mixed Reality Technology in Geogebra Application

Aiming at constructivist teaching in the real world, Khan, Trujano, Choudhury, and Maes (2018) developed the "Mathland" application as a mixed reality that enriches the physical world with interactive mathematical concepts and annotations. Similarly, Iza, Sofiane and Sébastien (2021) produced "Magic Cauldron" (Magic Cauldron) as a mixed reality application to support fraction teaching. This application, designed in a collaborative design cycle, helped children conceive fractions as rational numbers by seeing them on the number line and simultaneously as parts of an object through a game scenario (Iza, Sofiane & Sébastien, 2021). In summary, besides AR and AR applications, mixed reality technology offers many benefits for convenience in teaching

mathematics. However, creating mixed reality materials is challenging and complex for students and teachers.

Metaverse and its Applications in Mathematics Education

Metaverse is a technology that helps to perform real-world actions in a virtual world with SG (Virtual Reality) and AG (Augmented Reality) devices (Lee & et al., 2021). This technology is a platform that brings together the internet, augmented reality and web technologies. In education, the Metaverse platform can also be used to create interactive learning experiences. In particular, Second Life is one of the most well-known educational virtual platforms and offers its users a virtual environment experience through avatars (Doğan and Şen, 2022). In addition, platforms such as Fortnite, Minecraft, Zepeto, Roblox, and Gather Town also provide virtual world experiences using 3D graphics (Park & Kim, 2022). These virtual environments allow users to offer experiences they cannot experience in real life.

A metaverse environment can potentially convey students' learning in a motivating, entertaining, interactive and immersive way (Doğan & Şen, 2022). Students can experience learning in an environment where they can communicate more and increase their motivation through avatars (Estudante & Dietrich, 2020). Metaverse technology is predicted to trigger the emergence of new studies and applications in education (Collins, 2008). The education offered in a metaverse environment where the players can move freely will attract the students' attention. The metaverse, specially designed for problem-solving-focused topics, allows students to learn actively (Barry, Kanematsu, Fukumura, Ogawa, Okuda, Taguchi & Nagai, 2009). There is an intense interest in using the metaverse environment supported by Augmented Reality, Virtual Reality and Mixed Reality technologies in education. However, development in this area is still in its infancy (Narin, 2021).

Since virtual learning environments enrich students' learning experiences, schools and universities have started to create virtual campuses (Doğan and Şen, 2022). Universities such as Middle East Technical University, Istanbul University and Atatürk University in our country have started to work on creating their virtual campuses. In the example of Istanbul University, an event environment was prepared by Erbay, Şimşek and Kirişçi (2019), and Second Life infrastructure, one of the virtual reality applications, was used in this event. Images of this event are in Figure 8.

Figure 8. Information boards used in the event environment, direction keys and the screen where it reaches the final line

Result and Suggestions

It was revealed in the literature review that studies on Metaverse were examined in various fields, but Metaverse studies focused on mathematics and geometry education, in general, were limited. In Turkish sources, it has been observed that there is a focus on the sub-dimensions or tools of the Metaverse, especially Second Life, Virtual Reality and Augmented Reality. However, Facebook's updating its name as Meta, the popularity of cryptocurrencies and the publication of a peer-reviewed journal called "Journal of Metaverse" in Turkey in 2021 show that societies' interest and academic interest in Metaverse has increased. The examination results show that countries investing in Metaverse technologies and schools that integrate education and technology can contribute significantly to the well-equipped education of new generations. For this reason, the importance of Metaverse and reality technologies in education cannot be ignored and should be included more in the Turkish Education System. In order to provide quality learning and teaching to future generations, educators must pay attention to the potential of Metaverse technologies to create impressive experiences, and even this awareness should be maintained despite possible negativities (Ata, 2022).

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ARTIFICIAL INTELLIGENCE APPROACH AND APPLICATIONS IN MATHEMATICS EDUCATION

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Abstract

The rapid development of technology has affected all fields and education. The use of computers in schools, especially in education, and the widespread Internet use in schools indicate this. The development of technology and its use in education, the fact that students are more interested in technological tools, has made its use in education and training widespread. Artificial intelligence, which has become increasingly widespread in recent years, has begun to be used in all fields of science. One of them is mathematics education. Artificial intelligence in mathematics education has been very effective, especially in teaching lessons. It is seen that students prefer contemporary teaching methods rather than traditional teaching methods. This study aims to search the literature about artificial intelligence's use and application areas in my mathematics education and to reveal information about other application areas where artificial intelligence is used. For this purpose, a literature review was conducted. In line with the examinations, it aims to present an important data source to researchers in new studies to be made with artificial intelligence applications.

Keywords: *Mathematics Education, Artificial Intelligence, Artificial Intelligence Applications*

Introduction

Developments in technology have also manifested themselves in educational sciences, especially in the last century, and have allowed educators to carry out development and research studies in this field. Technology and computer concepts are essential in daily life, business life and education for modern societies and education systems (Tutak, İlhan, & İç, 2018). Technology education

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affects technology, and an understanding that is not used in the educational environment and remains away from technology negatively affects success, so using computers and technology in education has become mandatory (Tatar, Kağızmanlı, & Akkaya, 2013). In addition to the necessity of using technology in education in general, mathematics education, in particular, is a suitable area for using technological resources (Öksüz & Ak, 2010).

With the constant changes in the world, the importance of education is increasing, and societies have realized that educated individuals have a fundamental impact on the development of society by making education compulsory with this awareness (Nayıroğlu, Tutak, & Tutak, 2021). Technological resources in mathematics education suggest new ways to overcome applied traditional content. The application of technology increases the experimental and concrete approach to mathematical subjects and provides students with success in later periods that include a more abstract and symbolic approach (Tatar, Kağızmanlı, & Akkaya, 2013). One of the technologies used in mathematics education is artificial intelligence. Artificial intelligence is one of the most critical technologies in today's world. Today, the use of artificial intelligence has begun to be effective not only in health but also in almost every field, such as mining, industry, agriculture, voice assistants, driver improvements, online chat, software and communication. Considering this area of influence of artificial intelligence, it is inevitable that it will also affect the field of education (Arslan, 2020). The development of systems based on artificial intelligence has not only changed the human profile that is likely to be raised in education systems but has also changed the educational structure and functioning. With the help of today's artificial intelligence applications and the use of significant data sources, processes such as individual performance monitoring, personalized training programs, determining the teaching model, and preparing course content have increased the quality of education (Karaca and Telli, 2019).

Artificial intelligence systems used in education can be divided into intelligent instructional, expert, and dialog-based systems. Although the artificial intelligence systems used in education are studied inseparably under the sub-title, new sub-fields have emerged since artificial intelligence's development has occurred very quickly. The most widely known ones are computer vision, artificial neural networks, genetics, robotic algorithms, chaotic modeling, and annealing simulation (Çoşkun and Gülleroğlu, 2021).

Artificial intelligence applications have been used a lot in education in recent years. It has been used primarily in mathematics lessons. One of these applications is the 'Mathigon Application.' Mathigon Application; It is an

interactive learning platform for mathematics. Mathigon is a website and an application that helps effective learning.

This study discusses the use of artificial intelligence applications in mathematics education and the methods of application areas in the existing literature. In addition, the positive and negative aspects of artificial intelligence in education were also examined.

Aim

The study aims to search the literature about the use and application areas of artificial intelligence in mathematics education and to reveal information about other application areas where artificial intelligence is used.

Method

This study has been prepared to review the literature about the use and application areas of artificial intelligence in my mathematics education and to provide information about other application areas where artificial intelligence is used. For this purpose, a literature review was conducted. In line with the examinations, it aims to present an important data source to researchers in new studies to be made with artificial intelligence applications.

Definition of Artificial Intelligence and Its Importance for Mathematics Education

Artificial intelligence is a research area that aims to examine and formulate mental functions in individuals with the help of computer models and to apply them to unnatural systems. Another broad definition is artificial intelligence; They are computers equipped with human intelligence capabilities such as perception, obtaining information, thinking, seeing and making decisions (Bozbuyuk etc., 2005). With the development of technology, artificial intelligence has begun to be used in all areas of our lives. One of these areas is the field of education.

When artificial intelligence studies in today's education are examined, different applications can be seen in almost every field, not only knowledge-based but also data and logic-based artificial intelligence and artificial intelligence applications. These include exploratory education or personalized education, article analysis of students, intelligent agents, data mining in education, child-robot interaction, chatbots, education for children with special needs, automatic test creation systems, and artificial intelligence-based assessment systems (Arslan, 2020).

Mathematics is an essential resource in artificial intelligence, as it is the basis and source of all sciences. In each of the artificial intelligence techniques, the aim is to produce solutions to problems by modeling the human brain. These

problems are; decision-making, classification, etc. All these techniques show that artificial intelligence can model through mathematical formulas (Yılmaz, 2022).

Although the issue of how artificial intelligence applications will be integrated with education is still discussed, many predictions and thoughts are emphasized. Some of these thoughts and predictions focused only on the subject of artificial intelligence applications, which is one of the duties of teachers in the classroom. Although it is still discussed on this subject, there are a few applications where artificial intelligence technologies are currently used in education. Although these applications are not used continuously, and in detail, they allow students to learn at their own pace and reach the information they are looking for effectively (İşler, 2021).

History of Artificial Intelligence

Artificial intelligence originated in the 1950s by British computer scientist Alan Turing, who asked, "Can machines think?" According to another thought, the emergence of artificial intelligence dates back to 1950, when McCarthy, a professor of mathematics at Dartmouth College in the USA, organized a two-month workshop. McCarthy used the concept of artificial intelligence for the first time in 1956 (Taşçı and Çelebi, 2020).

Although the origin of artificial intelligence shows the work done by Alan Mathison Turing (1912-1954) during World War II and after, it shows that people's desire and efforts to make machines date back to ancient times. Some of the works of Ebul Iz El Cezeri in the Artuqid palace in the 13th century; are machines that work with mechanical and water parts (clock with an elephant, automatic birds, musicians, automatic floating boat, two sheiks offering sherbet to each other, two-section jug, the automatic system with two floats with four outlets, automatic ablution and water flow, drying machine and catering also a bucket mechanism, water closet, engine-compressor mechanism, robots and a combination key, 2015).

After the first use of the term artificial intelligence, many scientists have worked on this subject. Thanks to developing technologies, artificial intelligence technologies have become a part of our lives. When we examine the effects of artificial intelligence chronologically, we can see the development stages more clearly. Especially after 1950, we can see essential developments in artificial intelligence. We can see the development of artificial intelligence after 1950 in Table 1 below (İşler and Kılıç, 2021).

Table 1. Development of artificial intelligence after 1950

Years	Experienced Developments
1952	Written the first program to play chess with artificial intelligence
1961	The first commercial robot named Unimate was built by General Motors
1968	Terry Winogard's thesis showed that computers can understand English sentences.
1986	Started a secret project by Honda to develop a humanoid robot
1997	Deep Blue chess computer beat world chess champion Kasporov
2000	Honda designed ASIMO, an intelligent human robot
2009	Google starts developing self-driving cars
2017	Deep Mind researchers succeeded in adding memory to artificial intelligence

When Table 1 given above is examined, it is seen that programs were written and developed in artificial intelligence between 1950 and 1986. Since 1986, robot development studies have come to the fore. By 2000, an intelligent human-robot was developed. By 2009, driverless cars were developed. Especially after 2010, much faster developments have been made, and it has continued until today.

Benefits of Artificial Intelligence Applications

İşler (2021) listed the benefits of artificial intelligence as follows:

- Offers the opportunity for individualized teaching. In other words, it contributes to the adjustment of learning according to the student's individual needs.
- Studies have shown that the effect of artificial intelligence also increases academic success.
- AI can provide intelligent support for collaborative learning.
- It can save time for teachers.
- Provides feedback and continuous evaluation.

Teachers can have their lessons reviewed according to the situation and the situation of the students.

- Private lesson applications can be provided with online education.
- New ways of interacting with information enable effective learning.
- Educational feedback is provided.
- Various books can be recommended according to the interests and needs of individuals on artificial intelligence applications.
- Voice communication can be provided between students and academic content.
- Personalized homework appropriate for students' academic skills and learning levels.

They can.

- Provides virtual reality and immersive environments.
- Creates broader societal consequences.
- It can predict the risk of students dropping out of school.
- Better classroom management can be achieved.
- More effective administrative management can be achieved. News, student absences, etc., information can be handled quickly and efficiently and evaluations can be made.

It can provide accessible collection and storage of student data.

- Effective teaching can be realized by utilizing artificial intelligence in educating students with special needs.

Harms of Artificial Intelligence

Systems connected to artificial intelligence are being developed and transformed into higher systems due to their interactions with humans. However, it is also possible to transform these systems, which are of great benefit to humanity, and these applications made by human hands, into systems that are hostile to humans. A social experiment was organized on Twitter with the chat robot named "Tay", an artificial intelligence application developed by Microsoft. However, the experiment was forced to stop after sixteen hours due to the racist, bigoted, immoral and hateful remarks made by the artificial intelligence application named Tay. Therefore, it is in the hands of people to use it as beneficial and harmful for humanity in all technological developments and artificial intelligence systems (Çoşkun and Gülleroğlu, 2021). However, some concerns have arisen. Some of those;

The first emphasis on these concerns is that artificial intelligence may have risen above human intelligence.

- The second concern is the emphasis that artificial intelligence will gradually replace humans in some environments, especially with the development of technology, and that artificial intelligence will become uncontrollable.
- The third concern with artificial intelligence is the singularity. Academics are concerned that artificial intelligence technology will increase singularity in the future.
- The fourth criticism made with artificial intelligence is that it will not be possible to adapt it according to the existing curriculum or teaching roles.
- Finally, the fifth concern is about the validity, comprehensiveness, confidentiality and limitation of the data (Taşçı and Çelebi, 2020).

Artificial Intelligence Application Areas

In the 21st century, artificial intelligence has become an important research topic in many fields. Artificial intelligence techniques are applied in the main areas listed below:

a. Intrusion Detection Systems (IDS) and Artificial Intelligence: Different artificial intelligence methods protect communication and computer systems against intrusions.

b. Application of Artificial Intelligence Techniques in Medicine: Artificial intelligence is used in many fields, such as medical image classification, improvement of hospital care, analysis of endoscopic images, diagnostic science and MR brain tumor interpretation.

c. Application of Artificial Intelligence in Accounting Databases: Artificial intelligence is used to solve and alleviate the problems of accounting databases.

D. Application of Artificial Intelligence Techniques in Computer Games: Artificial intelligence is used in computer games when modeling character behaviors and artificial intelligence-controlled enemies.

to. Application of Artificial Intelligence in the Military: Artificial intelligence is used in many fields, such as signal analysis in the military, radar, defense industry, logistics, education, intelligence analysis, situation detection, reconnaissance, smart missiles, and flight trajectory determination.

f. Use of Artificial Intelligence in the Business World: In the business world, artificial intelligence is used in areas such as forecasting oil and geological structure changes, defining social trends, creating databases, airlines and price regulation, and handwriting recognition.

g. Use of Artificial Intelligence in Finance: In the finance sector, artificial intelligence is used in areas such as counterfeit money and document recognition, credit risk assessment, investment trends, handwritten form evaluation and portfolio analysis.

h. Artificial Intelligence in Production: Artificial intelligence in production processes is used in areas such as automation of control and robot systems, quality control, production process control and part selection.

I. Artificial Intelligence in Automotive: Artificial intelligence technologies in the automotive industry are used in many areas, such as ABS braking systems, electronic stability programs, intelligent airbags, vehicle tracking systems, lane change warning systems, smart mirrors, bright headlights, and parking pilot systems.

j. Communication and Artificial Intelligence: Artificial intelligence is used in communication fields such as text-based dialogue systems and virtual assistants.

k. Journalism and Artificial Intelligence: In journalism, artificial intelligence is used in data journalism and content production.

These examples show that artificial intelligence is used in a wide range. However, since research and applications in artificial intelligence are developing rapidly, many other fields also show the effects of artificial intelligence. Some studies on artificial intelligence are given in Table 2 below.

Table 2. Some studies on artificial intelligence

Name of the Study	Purpose of the Study	Application Field of the Study	Results of the Study
Taşçı ve Çelebi (2020) A New Paradigm in Education: "Artificial Intelligence in Higher Education"	She argues that artificial intelligence can strengthen universities when used correctly in higher education.	Field of Application in Higher Education	Field of Application in Higher Education
Gürbüzer (2008) Game development with Artificial Intelligence Methods	By programming two different games, it has been tried to reveal what kind of features the artificial intelligence programmed in a game today or maybe tomorrow should show.	Field of Application in computer games	As a result of this study, it has been shown that by programming two different games, calculating all possible moves, the move that maximizes the computer's gain or minimizes its loss is revealed.
Çoşkun ve Gülleroğlu (2021) The Development of Artificial Intelligence in History and Its Use in Education	The aim is to discuss the point reached by artificial intelligence, whether it poses a threat or superiority to humanity, and its possible effects on education, based on the relationship between artificial intelligence and human intelligence, by considering the development of artificial intelligence from past to present, although it is a field that can be considered a new field, which is rapidly developing and affects almost all disciplines.	Field of Application in Education	The use of artificial intelligence in the field of education will provide practicality in many areas and will bring important contributions. The effects of artificial intelligence systems on all fields of science and society can only be adapted to the education system. On the other hand, the education system also makes use of artificial intelligence systems while preparing individuals for the change created by artificial intelligence.
Arslan (2020) Artificial Intelligence in Education and Its Applications	This study focused on three questions; What is artificial intelligence actually, how will artificial intelligence contribute to education, what are the applications of artificial intelligence in education?	Artificial Intelligence Applications in Education	Any explanation or information about artificial intelligence in education will definitely be incomplete, because new educational applications based on artificial intelligence will appear with new techniques tomorrow as they do today.

Gür, Ayden ve Yücel (2019) Advances in Artificial Intelligence Impact on Human Resources Management	The main purpose of the study is to examine the role of artificial intelligence in human resource management.	Human Resources Application Areas of Artificial Intelligence	AI-based HR applications have a strong potential to increase employee productivity and help HR professionals become knowledgeable consultants that improve employee performance. HR applications empowered by AI are capable of analyzing, predicting, diagnosing and finding more powerful and capable resources.
Kuşçu (2015) Artificial Intelligence Applications in Translation	The aim of the study is to take advantage of translation in artificial intelligence to eliminate the borders in information and communication technologies between nations.	Artificial Intelligence Usage Area in Translation	As a result, we see that the studies on artificial intelligence are increasing day by day and very positive results are obtained.

Result

In recent years, when artificial intelligence has developed rapidly, it has shown its effect in many areas. The field of education is one of these affected areas. Mathematics education, in particular, can be challenging and abstract for students. For this reason, it is tried to make the learning process more effective by developing new methods and applications. With web-based applications in education, artificial intelligence also has new application areas. Mathigon application can be given as an example in this field. Mathigon is a website with many activities related to mathematics. This resource site, which contains many activities, from tangram activities to mathematical shapes, offers students an interactive and fun mathematics experience.

The history of artificial intelligence dates back to ancient times. Although its first appearance dates back to the end of World War II, studies of artificial intelligence date back to the 13th century. The desire and attempts of people to make automatic machines date back to ancient times. Many scientists have worked on artificial intelligence studies. It is seen that artificial intelligence is constantly developing with technology, and its use is becoming more and more widespread. Its use is increasing in many fields, including the military, trade, medicine, construction, communication, tourism, production, automotive, economy and education. This shows that artificial intelligence is a valuable technology for humanity. However, artificial intelligence also has some potential disadvantages. These include concerns such as the development of robots, cyber-attacks, and isolating people. Artificial intelligence will continue to develop, its usage area will expand and progress in parallel with technology. However, it should not be forgotten that artificial intelligence is a valuable application used for humanity's benefit and can lead to negative consequences when used to its detriment.

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MATHEMATICS EDUCATION WITH INTELLIGENCE GAMES LESSON

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Abstract

This study aims to examine intelligence games with a literature review in mathematics education and to emphasize the use of intelligence games in mathematics education. As a result of the changes in the education system, intelligence games have been included in the curriculum since 2012. In the curriculum of this course, it is emphasized that intelligence games can be used as an effective tool in developing problem-solving, communication and reasoning skills that enable unusual and original thinking and have alternative answers and solutions (Ministry of National Education [MEB], 2013). These objectives are also similar to the objectives of the mathematics course. This study investigated how commonly used intelligence games affect students' mathematical process skills in light of the literature. Since the number of studies (Alkaş Ulusoy, Saygı, & Umay, 2017; Demirel, 2015; Erdoğan, Eryılmaz-Çevirgen, & Atasay, 2017; Şanlıdağ, 2020; Yondemli, 2018) which relates intelligence games to mathematics lesson is limited, this study is expected to contribute to the literature. In addition, no experimental study has aimed at improving mathematics achievement and some high-level skills by enriching the content of mathematics lessons with intelligence games. For this reason, this study is expected to make significant contributions to the literature in terms of content and method.

Keywords: *Mathematics, Intelligence Games, Mathematics Education*

Introduction

Games offer children the opportunity to maximize their attention span, learn to get along with their friends, develop their creativity, support the development of emotional intelligence, and gain academic skills that form the basis of further

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learning (Singer, Golinkoff, & Hirsh-Pasek, 2006). With the constant changes in the world, the importance of education is increasing, and societies have realized that educated individuals have a fundamental impact on the development of society by making education compulsory with this awareness (Nayıroğlu, Tutak, & Tutak, 2021). The intelligence games course can realize the use of the game in education.

In our country, studies have been carried out on preparing an elective course program with the thought that intelligence games will play an essential role in developing students' mental skills and increasing their reasoning abilities based on learning by fun. Secondary School and Imam Hatip Secondary School Intelligence Games Lesson studies started in 2012 and were gradually implemented starting from the 5th and 6th grades in the 2013-2014 academic year (Alkaş et al., 2017).

The general purpose of the Intelligence Games training is to enable students to recognize and develop their intelligence potential, to develop different and original strategies in the face of problems, to make fast and correct decisions, to develop a systematic mindset, to develop skills to work individually, as a team and in a competitive environment within the scope of intelligence games. Moreover, they are developing a positive attitude towards problem-solving" (MEB, 2013).

It reveals that intelligence games played in schools improve students' various skills and academic success (Melero & Hernández-Leo, 2014). These skills help individuals develop their abilities in different areas, such as socialization, positive competitiveness, and cognitive abilities (Kirriemur & McFarlane, 2004).

The intelligence games course aims to enable students to recognize and develop their intelligence potential, to develop different and original strategies against problems, to make quick and correct decisions, to develop a systematic mindset, to develop skills to work individually, as a team and in a competitive environment within the scope of intelligence games, and to develop positive problem-solving skills. It is to develop an attitude (MEB, 2013). When the objectives of the mind games lesson are examined, it can be seen that there are many similarities with the objectives of the Mathematics lesson (Razon, 1985).

Aim

The aim of this study is to examine and investigate the contribution of the intelligence games course to the mathematics learning process in the light of the literature. The limited number of studies in this area reveals the importance of this issue.

Method

This study has been prepared to examine the contribution of the intelligence games course to the mathematics learning process in light of the literature and to present these studies. Therefore, in this study, a literature review was conducted. In this study, the data in the literature were defined and evaluated in detail.

Intelligence games

Educational games can reduce the stress caused by traditional teaching methods, which are frequently used in education, and make teaching fun and permanent. In recent years, education with games has gained importance as an education method in many countries, especially at preschool and primary education levels. Educational games can be organized, planned, and accepted as practical learning tools frequently used in educational environments (Er & Karadeniz, 2021). Educational games make education exciting and fun, motivate learners positively and encourage active participation (Sadıkoğlu, 2017; Demirel, 2015).

According to the results of the research, intelligence games are the games that contribute the most to the mental development of the individual. These games expose the brain to intense intelligence exercises (Demirel, 2015). Mental training with intelligence games can contribute to the individual's high-level life skills, such as problem-solving, correct and quick decision-making, and creative thinking. It can provide the individual's mental maturation at an earlier period. In addition, it is emphasized that intelligence games contribute to the individual's abstract thinking and imagination skills, rehabilitate the mental problems children experience at a young age, and protect the mind against problems related to mental development (Turkey Intelligence Foundation, 2017).

Intelligence games consist of 3 steps:

Level 1 - Beginner Level: This level includes learning the rules of the games, acquiring essential knowledge and skills, playing beginner-level games and solving puzzles.

Level 2 - Intermediate: Intermediate level includes making logical inferences, starting from the right place in puzzles, applying basic strategies in strategy games, playing intermediate games and solving puzzles.

Level 3 - Advanced Level: Advanced level includes high-level knowledge and skills such as creative thinking, analysis, developing original strategies, evaluation, and generalization. At this level, advanced games are played, puzzles are solved, and the experiences of others are used (MEB, 2013).

The intelligence games course curriculum was designed by considering the game categories while creating the learning areas. These categories are divided into six units: Verbal Games, Reasoning and Operational Games, Geometric-Mechanical Games, Memory Games, Strategy Games and Intelligence Questions.

We can list them as follows (TTKB, 2013):

1. Verbal Games: These games are games in which the players use general culture or vocabulary and their logical inferences. For example, games such as anagrams, password games, Scrabble (puzzle), word search (word hunt), word grouping, and word placement can be given.

2. Reasoning and Operational Games: These are usually single-player puzzle games in which conclusions are drawn based on clues and only logical inferences. This category includes games such as Sudoku, Battleship Admiral, Minesweeper, Yin-Yang, Fence, Logic Square, Fuze, Scratchcard, Kendoku, Kakuro, and Operation Square.

3. Geometric - Mechanical Games: These games are games in which players benefit from mental thinking skills, geometric thinking methods, motor skills or hand-eye coordination. For example, games such as Tangram, Counting Cubes, Mazes, Rubik's Cube, Knot Games, Mechanical Sorting Riddles, Jenga, Puzzles, and Mikado are included in this category.

4. Memory Games: These are games in which long-term or short-term memory is used. For example, games such as matching, remembering pictures, wayfinding games, and recognizing objects with close-up photos can be examples of this category.

5. Strategy Games: These games are types of games played with two or more players, where there are winners and losers. Examples of classic strategy games are Go and Chess.

6. Intelligence Questions: These games are questions that the player does not know the solution method at the beginning and finally reaches a clear conclusion by evaluating the clues. One person usually plays it, and the person who prepared the question is expected to find the result they are looking for. For example, questions such as "How do you turn on three light bulbs in a closed room?", "Passing the wolf, lamb and grass across the river" and "measuring a different volume exactly" can be examples of this category.

Mathematics

Mathematics is a subject of universal competitions such as international competitions, the Olympics and games. When the weekly course schedules are examined, it is seen that the mathematics course is at the forefront of the courses devoted to the most hours in schools. This situation shows that the importance

given to mathematics by countries and the efforts made for mathematics teaching has increased. Mathematics is one of the most essential skills that individuals today should have. All countries of the world are constantly working to eliminate the fear of mathematics and negative attitudes (Işık, Çiltaş, & Bekdemir, 2008). Studies have been carried out in Turkey to eliminate the fear of mathematics. When these studies are examined, it is seen that games are essential in embodying the abstract discipline of mathematics, understanding it more straightforwardly and making sense of it (Uğurel & Moralı, 2008). This study examined the effect of teaching mathematics lessons through intelligence games on academic achievement in mathematics.

Brain games and Mathematics

Creative thinking, problem-solving skills, reasoning and psycho-motor skills development are at the core of the Intelligence Games course curriculum. Considering the connection between the Mathematics lesson and the Intelligence Games lesson, it may be appropriate to give the Intelligence Games lesson to mathematics teachers. However, in some schools, science teachers or teachers from other branches may attend these courses due to the need for more intensity of teachers. For this reason, it is stated that the opinions of teachers are precious in order to organize the curriculum of the newly introduced Intelligence Games course, to provide the necessary training for the teachers who will teach this course and to eliminate their deficiencies (Ulusoy, Saygı & Umay, 2017).

There is a widespread belief that there is a strong correlation between the performance of intelligence games and math achievement or ability. The basis of this belief can be sought in the observations that intelligence games involve strategic, flexible and versatile thinking and that most people who engage in intelligence games are successful in mathematics. Another critical dimension of the relationship between mind games and mathematics is that they lie in their foundations. Many intelligence games are based on an adaptation of mathematical objects, facts, problems and concepts (Pinter, 2010; Silva, 2011). Likewise, there are many areas where mathematics is fed by intelligence games, such as Blaise Pascal's development of probability theory based on games of chance.

In the context of teaching mathematics, Offenholley (2012) divides games that can be used in mathematics lessons into two groups intrinsic and extrinsic. Internal games are games where the concept is embedded in the game and forms the basis of the game. Such games help to understand and apply mathematical concepts. For example, activities such as solving mathematical problems or discovering mathematical relationships can be examples of internal games.

On the other hand, external games can be used for different concepts and topics. Such games increase students' motivation while supporting the

application of mathematical concepts. For example, mathematical card games or math-themed quizzes are examples of external games.

Using games in teaching mathematics can help students improve their mathematical skills and reduce their negative attitudes toward mathematics. Using internal and external games can make mathematics lessons more effective, fun and motivational. For this reason, games must be chosen carefully and used by the teaching objectives in mathematics teaching.

Result and Suggestions

Gamification motivates users in education by making them willing to work (Munteon, 2011). O'Donovan (2012) states that the traditional education system includes some gamification elements. Elements such as exams, transcripts, certificates of appreciation, assignments, honors, striving for success, individual effort and cooperation are all part of gamification. The Intelligence Games course is a tool that can contribute positively to the mathematics learning process. The Brain Games course, which aims to develop skills similar to the mathematics course objectives, can help students develop their creative thinking, problem-solving, reasoning and psychomotor skills. Brain teasers are closely related to mathematics as they involve adaptations of mathematical concepts and problems. In addition, individuals who engage in intelligence games also tend to be successful in mathematics. The curriculum arrangement and the teaching of the course by the mathematics teachers can ensure that the Intelligence Games course is taught effectively. However, teachers from other branches can attend these courses due to the lack of teachers or their intensity. In this case, it is vital to meet teachers' training needs and give the course following its purpose.

As a result, the Intelligence Games course positively affects the mathematics learning process and can be an essential tool in developing mathematics skills. More research and curriculum development in this area can help increase students' achievement in mathematics and reduce their negative attitudes toward mathematics.

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