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Developing the Skill of Associating Mathematics with Real Life Through Realistic Mathematics Education: An Action Research *

Gerçekçi Matematik Eğitimi Yoluyla Matematiği Gerçek Yaşamla İlişkilendirme Becerisinin Geliştirilmesi: Bir Eylem Araştırması

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ABSTRACT: The purpose of this study is to investigate how to improve middle school 6th-grade students' skill of associating mathematics with real life through Realistic Mathematics Education, which was reinforced with educational games, to determine the problems possible to be encountered in practice and how to solve these problems in details. This study, designed as action research, was carried out in mathematics lessons with 25 sixth-grade students studying in the first and second semesters of the 2018-2019 academic year. The qualitative data of the research were collected through semi-structured interviews, camera recordings related to the application process, a structured student diary, a researcher diary, and reflective assessment forms. The quantitative data of the study were collected with worksheets, educational games, performance projects, and the Diagnostic Form for Students' Skill of Associating Mathematics with Real Life developed by the researchers and performed twice before and after the application. According to the results, Realistic Mathematics Education reinforced with educational games was efficient in increasing the skill of associating mathematics with real life.

Keywords: Educational games, skill of associating mathematics with real life, action research.

ÖZ: Bu araştırmanın amacı, ortaokul 6.sınıf öğrencilerinin matematik derslerinde eğitsel oyunlarla pekiştirilmiş Gerçekçi Matematik Eğitimi yoluyla matematiği gerçek yaşamla ilişkilendirme becerisinin nasıl geliştirilebileceği, uygulamada karşılaşılacak sorunların neler olabileceği ve nasıl giderilebileceğinin ayrıntılı olarak incelenmesidir. Eylem araştırması olarak tasarlanan bu çalışma 2018-2019 eğitim-öğretim yılı birinci ve ikinci döneminde matematik derslerinde toplam 25 altıncı sınıf öğrencisi ile yürütülmüştür. Araştırmanın nitel verileri; yarı yapılandırılmış görüşmeler, uygulama sürecine yönelik kamera kayıtları, yapılandırılmış öğrenci günlüğü, araştırmacı günlüğü ve yansıtıcı değerlendirme formları aracılığıyla toplanmıştır. Araştırmanın nicel verileri ise, araştırmacılar tarafından geliştirilen ve uygulama öncesi ve sonrası iki defa uygulanan Matematiği Gerçek Yaşamla İlişkilendirme Becerisi Tanılayıcı Form, çalışma yaprakları, eğitsel oyunlar ve performans görevi aracılığıyla toplanmıştır. Elde edilen sonuçlara göre, eğitsel oyunlarla pekiştirilmiş Gerçekçi Matematik Eğitimi'nin matematiği gerçek yaşamla ilişkilendirme becerisini artırmada etkili olduğu tespit edilmiştir.

Anahtar kelimeler: Eğitsel oyun, matematiği gerçek yaşamla ilişkilendirme becerisi, eylem araştırması.

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One leading issue that today's societies regard is to reach accurate information, understand the information obtained, produce new information from it, and use the produced information for decision-making processes and problem-solvingIn this sense, educators have noticed that today's education systems aim to teach students how to reach information, make sense of the information obtained, and create new information rather than simply transferring existing information. Making sense of information brings about information processing skills. Because after graduation, they are expected to be individuals who not only make sense of the information they have acquired but also produce new ones and solve their problems by using this information (Doğanay, 2017). Undoubtedly, one of the most efficient ways to make sense of information is to associate it with real-life situations. The reflection of acquired knowledge in real life facilitates learners' internalization of the information and helps them adapt to new situations.

A deep understanding of mathematics is more relevant to mathematical learning than students' current knowledge of mathematics and correct problem-solving (Dolapçıoğlu & Doğanay, 2020). The source of mathematical knowledge is real-life problems, and inferences and applications made from mathematical knowledge are also intertwined with real life. Due to this structure, mathematics includes skills and methods used in every field, starting from the preschool period until the end of life. In the renewed 2018 primary education mathematics curriculum of the Ministry of National Education (2018), it has been emphasized that mathematics education is one of the basic skills and competencies and contributes to a happy and successful life. Related to the field of proficiency, the importance of mathematical thinking, being able to formulate events mathematically, and using mathematical knowledge in inferences about events, facts, and situations have been emphasized as mathematical literacy skills in the 2018 primary education mathematics curriculum of the Ministry of National Education (MEB, 2018). The first of the points that make mathematics important is that the individual wants to live in a better quality after guaranteeing his life process. The second is that existing natural entities and events have a stable structure and that their stability can only be explained by means of mathematics. The third is that mathematics develops the thinking, reasoning, and argumentation abilities of people. Therefore, knowing how mathematics is learned by the individual is an important way to improve mathematics education (Skemp, 1987).

According to Altun (2016), everything in nature behaves decisively, this determination constitutes a suitable basis for mathematics, and mathematical correlations are obtained as a result of researching this stability. Therefore, the knowledge of mathematics produced through inspiration and applications that the human mind gets from nature is not disconnected from real life. Due to this importance, mathematics-related behaviors take place at every level and in every field from the first years of primary education to higher education (Üzel, 2007). Mathematics education includes all activities in the process of learning and teaching mathematics, and all activities in this process depend on the acquisition of mental and high-level skills (Işık et al., 2005). Well-designed, purposeful activity environments are needed for children to create knowledge through their experiences (Olkun & Toluk Uçar, 2006). On the other hand, students experience difficulties with where and how to use the information they have learned in the classroom environment in their daily lives (Doruk & Umay, 2011).

It is possible to say that mathematics education has a decisive effect on high-level mental skills and cannot be disconnected from other disciplines and real life. However, most people avoid mathematics in their education life; they are afraid, and as this fear leads them to failure, the severity of the fear increases (Keklikci & Yılmazer, 2013).

According to Akyüz (2001), one of the reasons for rote learning is that there is no real connection between life and what is learned in textbooks. The fact that memorized information is forgotten more quickly and can result in failure makes it difficult to retain information. In contrast, students can learn useful behaviors more easily (Sönmez, 1999). Baki (1996) stated that correlating the activities of the mathematics curriculum with daily life could encourage students to learn mathematics, keeping them away from the fear of mathematics. In this sense, it is possible to say that one of the approaches that can be used in mathematics education is Realistic Mathematics Education (RME). RME approach (Olkun & Toluk Uçar, 2006), which is similar to the basic principles of the constructivist learning approach, has been introduced for improving and developing mathematics education; mathematics learning is considered as a process of interpretation in this approach (Nelissen & Tomic, 1998).

According to Boehm (1967), while applied mathematicians once successfully and curiously tackled the problems of the world, pure mathematicians seemed to have almost lost touch with the real world. It was possible to talk about the sharp boundaries between applied and pure mathematics. On the other hand, studies conducted in recent years have highlighted the role of mathematics in daily life. There are researches on what the mathematics learned at school will do in real life (Moschkovich, 2002; Van den Heuvel-Panhuizen, 2003). Since it will be easier to make sense of real life by using mathematical knowledge and skills, it is possible to process mathematics lessons in the context of real life and thus increase students' ability to relate mathematics to real life.

RME is the learning and teaching approach in mathematics teaching, which was first developed and introduced at the Freudenthal Institute in the Netherlands by Hans Freudenthal and his colleagues in the 1970s. This reform movement was first triggered by the Wiskobas project developed by Wijdeveld and Goffree in 1968, and then RME has now been shaped mostly around Freudenthal's views on mathematics (Van den Heuvel-Panhuizen, 1998). The RME approach has been used outside the Netherlands; many countries such as England, Germany, Spain, Brazil, Portugal, South Africa, Vietnam, Indonesia, Malaysia, Japan, and the United States have used it in their education systems (Gravemeijer & Terwel, 2000; Yağcı & Arseven, 2010). Freudenthal (1973) mentioned that mathematics teaching should take the form of seeking solutions for real-life problems and phenomena, which means doing mathematics. RME is based on the stimulation of an environmental event to do mathematics and emphasizes that theoretical knowledge should not be acquired separately from practice. The role of students in the preparation of learning activities in RME is remarkable, and it is essential to start learning mathematics from an event that will require mathematics (Altun, 2010, p.35). This makes concretizing mathematics teaching possible in realistic mathematics education. With the RME method, students are able to think about daily life problems, develop solutions and discuss these solutions, and, thus, do well in mathematics. In this process, students are expected to reinforce the knowledge and skills they have acquired with different practices and to use this knowledge and skills in new situations. According to Boehm (1967), while applied mathematicians once successfully

and curiously tackled the problems of the world, pure mathematicians seemed to have almost lost touch with the real world. It was possible to talk about the sharp boundaries between applied and pure mathematics. On the other hand, recent studies have highlighted the role of mathematics in daily life. Research is being conducted on what mathematics learned at school will do in real life (Moschkovich, 2002; Van Den Heuvel Panhuizen, 2003). Since it will be easier to make sense of real life by using mathematical knowledge and skills, it is possible to process mathematics lessons in the context of real life and thus increase students' ability to relate mathematics to real life. RME, an approach that examines the role of real-life associations in school mathematics, is a leading approach in this regard and emphasizes that mathematics should start with reality and continue. According to this, this research can serve as an example to determine how students' mathematical estimation skills will develop in learning environments that will be organized in accordance with the principles of Realistic Mathematics Education and how they will use mathematics in situations they will encounter in real life.

For this reason, the results of the research are important in terms of determining the ways to be followed for students to do mathematics in the development of different thinking skills. In addition, since this research has been carried out by a researcher who is a mathematics teacher, it is thought that the research will contribute to understanding the problems originating from the teacher and presenting a solution to these problems. Because the research process is "the most effective opportunity for people to make progress in knowledge, to know the environment and to make the best use of it, to reach their goals and to solve some scientific problems" (Üstdal & Gülbahar, 1997, p. 82). And the examples of activities, educational games, and performance tasks that have been used in this research can guide instructors in developing targeted skills.

Another important point here is the necessity of considering the age characteristics of student groups in reinforcement activities to be performed. Young children acquire concepts by discovering them as a result of their active interaction with their environment (Aktaş-Arnas, 2004). According to this, games are the activities students enjoy, especially in small classes, and are mostly used for the reinforcement of what has been learned (Altun, 2016). The most acceptable game is the game that does not require mathematical activities explicitly but requires these mathematical activities to be performed for winning the game" (Altun, 2016, p.38). In this sense, it can be useful to reinforce the knowledge and skills acquired with games possible to be used at different levels after RME-based activities in order to increase the permanence of the learned. Çakır (2013) stated that mathematization means more mathematical. Mathematization can be examined in two stages horizontal and vertical mathematization.

a) Horizontal mathematization: Mathematization is the process of formulating or visualizing a problem in different ways, discovering relationships, and transferring a real-life problem to a mathematical problem (Üzel, 2007). In other words, horizontal mathematization refers to the transition from an environmental event to symbols (Altun, 2010). The process starts with horizontal mathematization.
b) Vertical mathematization: Vertical mathematization is reaching higher-level mathematical concepts and formulas by working with symbols and establishing

relationships between existing mathematical concepts (Van den Heuvel-Panhuizen, 1998).

Treffers (1987, 1991) classified mathematics education under four headings, considering horizontal and vertical mathematization.

Traditional or mechanical approach: This approach, by its nature, tends to teach by saying to apply rules and regulations; in other words, it is algorithmic (Akyüz, 2010). A person is like a computer or a machine. In this approach, both horizontal and vertical mathematization is less or even not used (Treffers, 1991).

Experimental approach: In this approach, students work with materials from their own environment. Horizontal mathematization is used to move students from real models to mathematical knowledge, but vertical mathematization is not used as students are not encouraged to symbolize this informal situation.

Constructivist approach: This approach uses vertical mathematization. This is done with artificial materials prepared by the students beforehand. However, in light of the information gained in the lessons, unless the students are taught how to use certain rules, how the applications will be made, and adaptations to new situations cannot be revealed. Therefore, only vertical mathematization can be used in this approach (Cansız, 2015).

Realistic approach: The starting point for learning in the realistic approach is a real-world situation or a real-life problem. Learning starts with horizontal mathematical activities, and students organize problems, try to determine the mathematical aspects of the problem, explore rules and relationships, and develop their own mathematical concepts using vertical mathematization (Cihan, 2017).

When the foreign literature on mathematics education was reviewed, it was noticed that different studies were carried out on RME (Barnes, 2004; Fauzan, 2002; Papadakis et al., 2016, 2021; Rasmussen & King, 2000; Searle & Barmby, 2012; Van Der Kooij, 2001). However, it was observed that these studies were mostly carried out on RME within the scope of academic achievement. In addition, when the literature was reviewed, it was noticed that studies on WME were mostly planned experimentally (Akyüz, 2010; Bıldırcın, 2012; Can, 2012; Çakır, 2013; Çilingir, 2015; Gelibolu, 2008; Verschaffel & de Corte, 1997). In the studies, the realistic mathematics education approach and the traditional approach were compared.

According to Ekiz (2009), active participation in action research meant that practitioners had the opportunity of changing and developing their own activities participating into the research process. This enabled the practice to be understood and developed systematically. For this reason, there has been a need for a more qualitative, in-depth problem-solving research approach, such as gaining basic knowledge and skills in mathematics education. In secondary school mathematics curriculum, it was observed that daily life experiences and real-life problems were regarded in accordance with the RME approach. However, the studies designed as action research were found to be missing among the research reviewed to develop the skill of associating mathematics with real life. However, in-depth research should be conducted on thinking skills in learning-teaching processes and on the use of what is learned in daily life because acquiring these skills is an effort that requires time and effort in the process. According to Arıkan (2013), action research has three purposes:

a) Ensuring that social and educational activities are reasonable and fair,
b) Understanding these activities and developing related concepts,
c) Developing the environment in which these activities are carried out" (Arıkan, 2013, p.70).

This study will contribute to the field of curriculum development because it can both facilitate the meaning of the learned, associating it with daily life, and support the development of similar skills in different disciplines. It is also important that this research provides alternative ways of teaching thinking skills and contributes to in-service training studies.

In light of the obtained information, this study aims to examine how to improve middle school 6th-grade students' skill of associating mathematics with real life through Realistic Mathematics Education reinforced with educational games in mathematics lessons in detail, analyze the possible problems to be encountered in practice, and how to solve these problems. In accordance with this main purpose, answers to the following questions were sought:

- When reinforced with educational games, does Realistic Mathematics Education in secondary school sixth-grade mathematics lessons contribute to the development of students' skills in associating mathematics with real life? And if yes, how?
- What are the problems encountered in secondary school sixth-grade mathematics lessons in the process of developing students' skills of associating mathematics with real life, and the ways to be followed in solving these problems?
- What are the pre-application and post-application views of the students about Realistic Mathematics Education administered to improve students' skills of associating mathematics with real life in secondary school sixth-grade mathematics lessons?
- What are the parents' opinions before and after the research regarding the education process of developing students' skills in associating mathematics with real life?

Within this context, it is aimed to evaluate in detail how the implementation process can be organized and implemented and how the problems that may be encountered in practice can be resolved.

Limitations of the Research

- It is limited to the data to be collected for the purposes of measuring the development of the ability to relate mathematics to real life from middle school sixth-grade students through RME.
- Information on the development of students' ability to associate mathematics with real life during the research process, the problems to be encountered in the process, and the solution to these problems are limited to the analysis of the qualitative and quantitative data to be obtained during the application process.
- In the 6th grade of a State Secondary School, the three-stage, 20-week, 30-lesson hours are limited to the mathematics course time.

Method

Research Model

In this study, action research, which is one of the qualitative research designs, was performed. "Action research used in education emerged in the 1960s in England in the case of school-based program development" (Ekiz, 2009, p.181). Fraenkel et al. (2012) define action research as research conducted by one or more individuals or groups to solve a problem or gather information about local practice. The action research approach in the qualitative research is a research approach that includes systematic data collection and analysis to reveal problems related to the application process or to understand and solve existing problems either directly by the practitioner or a researcher (Yıldırım & Şimşek, 2013). Similarly, Mills (2003) defined action research as a process carried out by teachers and administrators to define "what has happened" to their students in schools and classrooms and to understand the effects of educational interventions. Unlike real scientific research, action research is a more impressionistic and subjective approach to solving classroom problems and includes self-assessment, continuous assessment of changes, and development of practices to achieve goals (Cohen & Manion, 1994). When we look at the literature, it is seen that action research is classified in different ways in terms of genre (Yıldırım & Şimşek, 2013). Combining these different classifications, Berg (2001) classifies action research under three headings: technical/scientific/collaborative action research, practice/mutual collaboration/discussion-oriented action research, and liberating/developing/critical action research.

Mills (2003) and McNiff and Whitehead (2002) list the steps of the action research process as follows (Balcı, 2013, p. 54):

- Planning the action,
- Application,
- Observation,
- Evaluation,
- Replanning.

In this study, the process was carried out with a group of students who lacked the skills to associate mathematics with real life. For the solution to this problem, the researcher carried out studies to identify the problems and solve them within the process. Throughout the research, an approach that included planning, application (act and observe), and reflection was regarded as the basis. In order to improve the skills determined in the application process, learning experiences were continuously planned and evaluated, and moving to a new stage or developing and administering a new action plan was decided to solve the problem according to the results of the analysis of the problems experienced.

Participants

The participants of the action research were determined with the criterion sampling method as one of the purposeful sampling methods. The study group included 25 6th-grade students studying at a branch out of 11 classes in a secondary school in the central district of Turkey. Of the 25 sixth-grade students, who were the participants in

the study, 13 were females, and 12 were males. Within the scope of assessment studies, a preliminary interview was done with the mathematics teachers working at the school where the application was administered in order to both confirm the existence of the problem situation and decide on the practitioner teacher. Within the scope of assessment studies for the determined branch, observation studies were carried out through the camera during a predetermined unit, and the students' skill of associating mathematics with real life was examined in order to reveal the problem situation more clearly. Subsequently, interviews were made with the students selected with a purposeful sampling method and six students' parents, these students' skills of associating mathematics with real life were evaluated with a level identification form, and the data obtained were analyzed. Within the scope of the research, some information about the students and their families was collected, and more detailed information was obtained about the characteristics of the study group. Moreover, the information obtained from the e-school information system about students' mathematics achievements was used to describe the study group. Before the application, information about the students' pre-test scores for their skills in associating mathematics with real life was presented in Table 1.

Table 1

Results of Pre-test Scores Related to the Diagnostic Form for Students' Skill of Associating Mathematics with Real Life

Number of Participants	Arithmetic Average	Standard Deviation	Mode	Median	Min Score	Max Score	Possible Max Score	Skewness	Kurtosis
25	9.52	6.44	8	8	1	24	40	.958	.127

According to Huck (2012), the skewness and kurtosis values varying between -1 and +1 indicated that the data had a normal distribution. According to Table 1, it was revealed that the total scores obtained from the Diagnostic Form for Students' Skill of Associating Mathematics with Real Life met the normality condition (skewness = .958; kurtosis = .127). As presented in Table 1, the arithmetic average of the pre-test scores of the participants in the Diagnostic Form for Students' Skill of Associating Mathematics with Real Life was 9.52 before the application. Since the highest score that was possible to be obtained from the Diagnostic Form for Students' Skill of Associating Mathematics with Real Life was 40, it could be mentioned that the participants' level of associating mathematics with real life was low according to the pre-test results.

In addition, the class in which the action research was conducted was determined by the criterion sampling method, one of the purposive sampling methods. The following criteria were taken into account in determining the study group of the research:

Criteria for teachers, school administrators, and physical conditions:

- Volunteering of the mathematics teacher, who is teaching in the classroom that constitutes the study group, to participate in the action research,
- The mathematics teacher is having problems with the determined problem situation,
- Having at least 5 years of experience in the profession of mathematics teacher,

- Allowing the use of video cameras and audio recording devices in the research,
- The school administration's willingness to support the work and fulfill its duties in this process,
- The physical equipment required for the implementation to be available at the school.

The criteria taken into account in determining the students who make up the study group:

- They are studying at the 6th grade level of secondary school,
- Lack of ability to relate mathematics to real life and to predict.

Role of the Researcher

Action research is possible to be carried out by the practitioner himself or by an outside researcher (Yıldırım & Şimşek, 2013, p.333). In this study, the researcher took the role of the researcher teacher due to providing the conditions of being a practice teacher. The researcher made observations through the camera and administered the action plans before and during the application stage. During the extracurricular times, the researcher conducted interviews with the students and parents and recorded them.

Data Collection Tools

The data obtained to answer the research problem were collected in order to monitor the development of students' skills of associating mathematics with real life with Realistic Mathematics Education reinforced with educational games in 30 lesson hours in the 2018-2019 academic year. Data collection techniques in action research could vary depending on the research questions, the status of the research, and the researcher's individual competencies (Balcı, 2013, p.54). The data of this study were obtained by means of qualitative and quantitative data collection methods. The data relating to the research were collected with unstructured observations based on camera recordings, in-depth semi-structured interviews, student-researcher diaries, worksheets, educational games, and student products before, after, and during the process. In addition, the Diagnostic Form for Students' Skill of Associating Mathematics with Real Life was performed in order to determine students' skill of associating mathematics with real-life before and after the application in the study. During the application process of the research, activities were used within the scope of Realistic Mathematics Education to improve the skills of associating mathematics with real life. The information obtained with the activities was assessed using worksheets, and an educational game application was included at the end of each action cycle in order to reinforce the learned. The information related to the Diagnostic Form for Students' Skill of Associating Mathematics with Real Life was presented below.

In the research, first of all, the Diagnostic Form of Associating Mathematics with Real Life was applied in order to determine the ability of students to associate mathematics with real life. In the implementation process of the research, activities within the scope of Realistic Mathematics Education to be carried out to improve the skills of associating mathematics with real life were used. The information obtained through the activities was evaluated using worksheets, and an educational game application was included at the end of each action cycle in order to reinforce what was

learned. In addition, data organization charts were used to prevent data loss during the research process and to assist the researcher in collecting and organizing data. Student work products, on the other hand, are written or visual data sources created by students that emerge during or at the end of the teaching-learning process. Samples can be collected at different time intervals to make sense of students' performances and changes over time (Johnson, 2014). After the activities were carried out within the scope of Realistic Mathematics Education, educational game applications aimed at reinforcing the determined skills and worksheets were included to evaluate what was learned. Student game scores and worksheet performances obtained from these educational games were used as data collection tools. Educational games are applications that develop high-level mental skills such as problem-solving, creativity, and critical thinking (Yıldız et al., 2017). In this respect, educational games are a technique that provides reinforcement and repetition of what has been learned (Hazar & Altun, 2018).

Diagnostic Form for Students' Skill of Associating Mathematics with Real Life

The Diagnostic Form for Students' Skill of Associating Mathematics with Real Life used before and after the application was developed by the researcher, and a validity study was carried out to make it ready for use. Tekin (2009) defined content validity as the degree to which the scale and each item in the scale served the purpose. For the validity study, two field experts were consulted in terms of content and language validity. The validity study was carried out with the support of two experts, an associate professor at the Department of Primary Education at Çukurova University and an assistant professor carrying on studies in the Department of Instructional Programs and Teaching. Furthermore, a faculty member carrying on studies as an associate professor in the Primary Education Department was consulted in terms of the suitability of the age of the students to whom the measurement tools would be applied and the language development level of the questions. In accordance with the interviews and feedback, the Diagnostic Form for Students' Skill of Associating Mathematics with Real Life was prepared for pilot application. The Diagnostic Form for Students' Skill of Associating Mathematics with Real Life had two parts, including questions about how to use mathematics in 10 different places and how to associate ten mathematical concepts with real life.

Rubric (Graded scoring key)

The criteria for scoring the success and skill levels in the rubrics used in the action research process were determined. In order to ensure content validity, the relevant rubrics were revised in accordance with the opinions of experts who have carried out studies in the field of mathematics education. Opinions regarding the clarity and comprehensibility of the rubric items and their status of reflecting the specified criterion, and their suitability for the purpose were obtained from each expert. The rubrics were finalized in accordance with the views. The diagnostic Form for the Skill of Associating Mathematics with Real Life had four criteria, including determining the area of use, associating with real life, using accurate knowledge and skills, and using mathematical thinking processes in the rubric. For each criterion, scoring was specified as Sufficient (5 points), Partially Sufficient (3 points), Insufficient (1 point), and Empty

(0 point). The highest score possible to be obtained from the rubric was calculated to be 40. The rubric was also used to evaluate the performance task given for students' skills in using mathematics outside the school during the application process. This rubric included 5 criteria and 4 levels of achievement for each criterion. Performance statements were created for each success level, and multiplying the obtained scores by 5.

Data Analysis and Validity-Reliability Studies

The data analysis used for answering the research questions was the process of revealing the meaning of the data obtained (Merriam, 2013). In data analysis, quantitative and qualitative data analysis techniques were used depending on the data type. Quantitative data analysis could be defined as the process of deriving scientifically valid results from data using appropriate statistical techniques (Büyüköztürk, 2014, p.7). An inductive and comparative approach was adopted in the analysis of all qualitative data obtained from this action research, which was carried out to develop the skill of associating mathematics with real life. Lincoln and Guba (1985) defined inductive data analysis as a process that involved dividing data into units and creating categories in order to reveal embedded information and make it visible. While collecting the data of the research, the obtained data were analyzed for the next process to be administered. Apart from micro analyzes, all data obtained after the research was completed were analyzed at macro level. In the analyzes made at the macro level, all data were analyzed collectively, and the findings were reached, revealing the categories and themes and the relationships between them.

The validity committee established to carry out the research systematically and gain an objective perspective on the study assumed the role of supervising and examining the researcher's study. Totally seven meetings were held with the validity committee on different dates. In addition to validity studies, the way to determine whether the method used was effective or not was to assess its reliability (Jackson, 2008, p. 67). According to Lincoln and Guba (1985), expert control was the most important method in ensuring the reliability of the studies (cited in Creswell & Miller, 2000). In this sense, the researcher gave the texts obtained from student and parent interviews conducted to collect data before and after the application to a mathematics teacher who completed his master's degree in Statistics and determined the consistency between the analyzes of two coders. For the agreement rate between the two coders, the reliability formula of Miles and Huberman (1994,64) as "P (Percentage of Agreement%) = [Na (Agreement)/Na (Agreement) + Nd (Disagreement)] x 100" was used for calculations. Four interview texts, two of which belonged to parents and two to students, were given to an expert, and the consistency of the two coders in the analysiswas calculated in terms of coder reliability. These rates were [9/9+2x100] = 81% and [8/8+2x100] = 80% in terms of the interview texts belonging to the parents, [20/20 + 6X100] = 76%, and [13/13]. + 4X100] = 76% in terms of the interview texts belonging to the students. Miles and Huberman stated that the consensus between coders being at least .70 indicated that the coding was reliable (Akay & Ültanır, 2010). The researcher and the expert reached an agreement about the codes of disagreement studying together.

Ethical Precautions

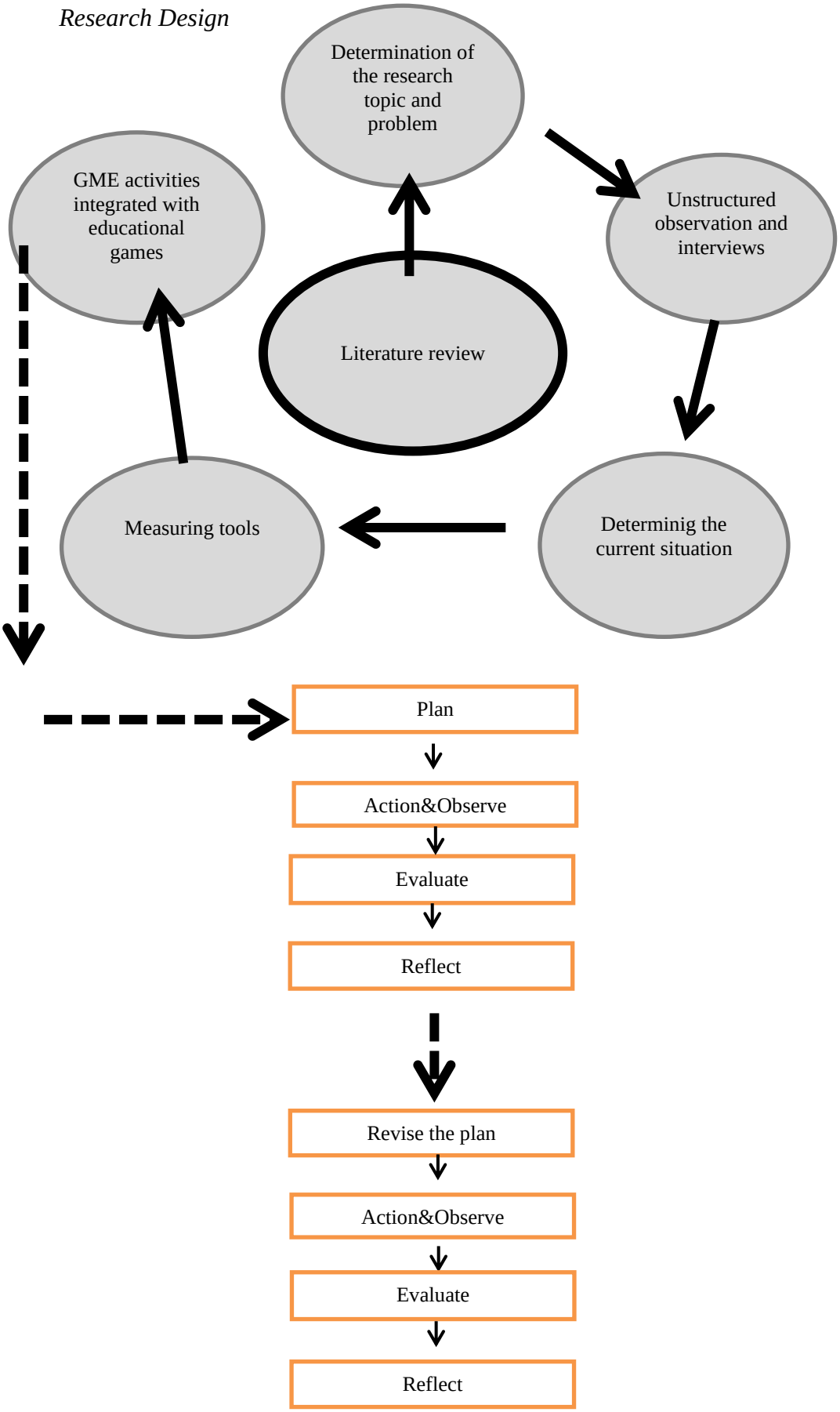
Since human has generally been the subject of educational research, the ethical and legal responsibilities of conducting such research should be known and applied (McMillan & Schumacher, 1984, p.135). According to Graziano and Raulin (2007), many experts argued that research participants should be protected from deception, dangerous procedures, and invasion of privacy. In this study, the researcher took some ethical precautions. The research was initiated with the official permission of the Adana Provincial Directorate of National Education. At the beginning of the study, all participants were informed about the purpose of the study, the implementation process, and the data collection methods.The parents of the students in the classroom where this study was carried out were also informed about the process, and the camera recording in the classroom and a confirmation letter that the study would be carried out were submitted for their signature. Name codes were used to keep the identity information of the participants in the research confidential. It was stated that all sounds and images obtained would not be used outsideof the research.

Action Research Process

The first stage of the research process was the literature review. The research topic and research problem were determined using the information obtained. In order to confirm whether the determined research problem was a problem encountered in practice or not, a pre-interview was made with the mathematics teachers at the school where the research was conducted. In these preliminary interviews, mathematics teachers were asked whether they noticed a deficiency in students in terms of their skill of associating mathematics with real life. After confirming the existence of the problem situation with preliminary interviews, the literature review was maintained, and information about the problem situation. After this stage, measurement tools were developed using this information. After determining the participants, an interview form and a diagnostic form were prepared in consultation with field experts to determine the current level of students' ability to associate mathematics with real-life situations.Information was collected by combining these data with in-class observation data. Subsequently, the research problem was reviewed, and action research questions were determined. These studies were presented to field experts, and a validity study was carried out. In line with these studies, implementations were carried out by preparing action plans.

Figure 1

Research Design



Results

The answer to the first sub-question of the study is "When reinforced with educational games, does Realistic Mathematics Education in secondary school sixth-grade mathematics lessons contribute to the development of students' skills of associating mathematics with real life? How?" was sought using the Diagnostic Form for Students' Skill of Associating Mathematics with Real Life. Whether there was a significant difference between the pre-test and post-test mean scores of the students was analyzed in order to determine the efficiency of Realistic Mathematics Education. The analysis results are presented in Table 2.

Table 2

Pre-test and Post-test Paired Groups T-Test Results Related to Students' Associating Mathematics with Real-Life Skills

Measurement	Number of Participants (*N*)	Arithmetic Average (X)	Standard Deviation (S)	Degree of Freedom (*Sd*)	T Value	Level of Significance (*p*)
Pre-test	25	9.48	6.55	24	-12.182	.000*
Post-test	25	27.76	8.59			

*$p<.001$

As can be seen in Table 2, there was a significant difference between the pre-test and post-test scores of the students. This difference was in favor of the post-test scores. Based on this finding, it was possible to mention that students' skill of associating mathematics with real-life increased significantly as a result of the applications based on Realistic Mathematics Education. The second sub-question of the study was: "What are the problems encountered in secondary school sixth-grade mathematics lessons in the process of developing students' skills of associating mathematics with real life and the ways to be followed in solving these problems?? " The answer was sought by analyzing the problems that occurred in each action cycle and developing solutions to reflect them in the next cycle.The solution suggestions were developed for the problems encountered in each cycle during the action research process. The process progressed, reflecting the developed solution suggestions for the next action cycle. The data obtained from the interviews regarding the third sub-question of the study, which was stated as, "What are the pre-application and post-application views of the students about Realistic Mathematics Education administered to improve students' skill of associating mathematics with real life in secondary school sixth-grade mathematics lesson?", were analyzed with NVIVO program. The findings related to the student views were presented as pre-application and post-application.

Table 3

Pre-Application Views of Students to Associate Mathematics with Real Life

Definitions to associate mathematics with real life	Not knowing how to associate mathematics with real-life *f:3*
	Making operations in daily life *f:1*
	Encountering mathematical operations in daily life *f:1*
	Using mathematics in daily life *f:14*
	Using mathematics knowledge in daily talks *f:1*

As could be seen in Table 3, three out of 20 students could not make a definition for associating mathematics with real life because they had not heard it before. When definitions of the other students were analyzed, it was seen that fourteen students responded as using mathematics in daily life but did not include any information about which aspect of mathematics was used in their definitions. In addition, it was determined that one student each made a definition of making mathematical operations in daily life, encountering mathematical concepts in their daily lives and using mathematical knowledge in their daily conversations. While S19 said "For example, using mathematics when talking to our friends", S14 said "I can't think of anything" in reference to the words associating mathematics with real life. When these definitions were regarded, it was possible to state that the students did not have sufficient skills in associating mathematics with real life. When all these definitions were analyzed, it was noticed that the students used a certain aspect of mathematics in real life before the application, and they could not make a comprehensive definition to associate mathematics with real life. And it was determined that some students could not make a definition because they had not heard of it before. When asked how they used the knowledge they acquired in mathematics lessons in their real lives, the answers given by the students were presented in Table 4.

Table 4

Students' Views on Using Mathematical Knowledge in Real Life

Use of mathematical knowledge in daily life	*Areas of using*	For money calculations in shopping *f:12*
		while giving directions *f:1*
		in time calculations *f:1*
		while helping friends with subjects they don't understand *f:1*
		while studying *f:1*
		while sharing *f:1*
		while making mental calculations *f:1*
	Partly using	For money calculations in shopping *f:5*
		while doing homework *f:1*

		While taking a test *f:1*
	Not using	not associating mathematics with real-life *f:1*

As can be seen in Table 4, the students stated that they mostly used the knowledge and skills they gained in mathematics lessons while making money calculations during shopping. One student stated that mathematics was not a course related to real life and therefore did not use mathematics knowledge and skills in real life. Aiming to use mathematical knowledge and skills during shopping, S3 said, "I use something when summing or subtracting something in the market." Related to be used when describing directions, S4 said, "For example, when someone asks a question and asks for directions, I say 'go straight, then turn right, walk this far.'" Benefiting from mathematics knowledge and skills while describing directions, calculating time, and sharing could be given as examples of using mathematics in different real-life situations as these were the activities in daily life. In this context, students were asked about their opinions on whether mathematics should be a lesson intertwined with real life or not. The given student answers are presented in Table 5.

Nineteen of the students said that mathematics was a lesson that was intertwined with real life in at least one aspect, and one student said that the rules of mathematics were not valid in real life. Ten students justified their opinions as to the use of mathematics in daily life, and four students said they needed mathematics in daily life. In addition, two students expressed that four operations made their lives easier, while one student said that he had numbers in his life. Accordingly, whereas S6 said, "Let me give an example, we need to calculate at home before going to the cashier in the grocery store, we need to calculate money accordingly, and this makes our life easier," S10 said, "It is a good lesson, that can be useful." T19 mentioned that "We definitely use numbers when talking to our friends, cousins , and neighbors." It was possible to mention that the students' views on this question were limited, and they associated with only one aspect of real life.

Table 5

Students' Views about Mathematics' Being A Lesson Intertwined with Real Life

Mathematics' being a lesson intertwined with real life	*Positive thoughts*	Having numbers in our lives f:1
		being a beneficial lesson f:1
		needing mathematics f:4
		having reflections in real life f:1
		Four 'operations' making our lives easier f:2
		using in daily life f:10
	Negative thoughts	Mathematics rules' not being real in real life f:1

Table 6

Pre-Implementation Students' Views on Lecturing Mathematics through Associating with Real Life

Reasons for not associating with real life in mathematics classes	*Reasons related to real life*	real life's being more important than exams *f:1*
		needing in real life *f:2*
		being a part of real-life *f:1*
		making life easier *f:7*
		making life more enjoyable *f:1*
	Reasons for not associating with real life	not using in real life *f:1*
		its being related to exams *f:4*
	Reasons related to academic achievement	providing to be successful in exams *f:1*

Most of the students expressed reasons related to real life, such as being a part of real life, needing in real life, making life easier, and real life's being more important than exams. One student stated reasons related to academic achievement such as providing to be successful in exams while another student stated reasons for not associating with real life, such as not using in real life. When the students' views were analyzed, it was noticed that all students considered that mathematics lessons should be taught, associating with real life, depending on the different reasons presented. Then, the students were asked for suggestions on how to ensure that mathematics lessons are connected to real-life situations. When all students' suggestions were examined, it was seen that most of the suggestions were based on not getting bored in mathematics lessons and increasing academic success. It was possible to mention that the suggestions made for teaching lessons without disconnecting mathematics from real life were insufficient and superficial. In the interviews made after the application, students were asked their opinions about the teaching process. The findings for this question are presented in Table 7.

As shown in Table 7, students' views on the post-application teaching process were centered around two themes: the positive and negative aspects of education. It was possible to specify that the students' views on the teaching process were generally positive. In addition to the development of their skill of associating mathematics with real life, their positive impact on different subjects could be accepted as a result of the fact that mathematics lessons are taught through Realistic Mathematics Education. It was liked by students and provided them with benefits within the scope of mathematics lessons.

At the end of this training, the students were asked whether there were any changes in their use of mathematics in real life. Four of the students stated that there was no change, and the other students stated that there was a change. The students who said that there were changes in their use of mathematics in real life were asked what kind of changes occurred. Students' answers given to this question were gathered under

two themes as using mathematics in daily life and associating it with real life in mathematics lessons. Students' answers led to the conclusion that the applications for the skill of associating mathematics with real life through Realistic Mathematics Education positively affected students' association between mathematics and real life when reinforced with educational games.

Table 7

Post-Implementation Students' Views On The Teaching Process

The opinions related to the educational process	*Positive sides of education*	reminding forgotten subjects *f:2*
		acquiring a regular study habit *f:1*
		making contributions to decreasing discipline problems *f:1*
		making learning easier *f:5*
		causing mathematics lesson to be loved *f:4*
		providing to learn subjects in depth *f:4*
		providing to make predictions closer to real results *f:5*
		strengthening student-teacher relationship *f:1*
		providing to use mathematics knowledge in real life *f:2*
		increasing mathematics achievement *f:1*
		providing to overcome the fear of mathematics *f:1*
	Negative sides of education	not eliminating missing learning completely *f:1*
		solving few questions in lessons *f:1*
		some educational games' being difficult *f:1*
		not regarding the lesson enjoyable *f:1*

At the end of the application, semi-structured interviews were conducted with 6 parents of the students, who were interviewed before the application related to the fourth sub-question of the study. This sub-question was expressed as "What are the parents' opinions before and after the research regarding the education process of developing students' skills of associating mathematics with real life for their parents?" The findings obtained from the interviews revealed that the students' parents of the students were generally satisfied with the education. Parents stated that thanks to this training, they observed positive changes in students' behaviors towards their skill of associating mathematics with real life and their use of mathematics in environments outside school.

Table 8

Changes Appeared in Using Mathematics in Real Life

Changes experienced in associating mathematics with real life	*Using mathematics in real life*	perceiving mathematics knowledge used in daily life *f:1*
		increase mathematical awareness in real life *f:2*
		solving problems using mathematics knowledge in real life *f:2*
		using mathematical concepts in daily talks *f:2*
		Using mathematics to make sense of real-life events and facts *f:1*
	Establishing a relationship with real life in mathematics lesson	giving examples of situations when numbers are rounded in daily life *f:4*
		noticing the counterpart of decimal presentations in real life *f:3*
		noticing the counterpart of rate calculations in real life *f:3*

The Current State of the Ability to Relate Mathematics to Real Life

- Before the application, it was determined that the students' ability to associate mathematics with real life was low according to the scores they got from the Descriptive Form of Associating Mathematics with Real Life.
- Before the application, it was determined that the students used a certain aspect of mathematics in real life, and they could not make a comprehensive definition for associating mathematics in real life.
- Before the application, it was determined that the students benefited from the knowledge and skills they acquired in mathematics lessons the most during shopping outside of school.
- Before the application, it was determined that some students did not use their mathematical knowledge and skills in real life.
- Before the application, it was determined that the students did not see mathematics as a discipline that is intertwined with real life and that they associated mathematics with one aspect of real life at most.
- Before the application, it was determined that all students, for different reasons, thought that mathematics lessons should be taught in connection with real life.
- Before the application, it was determined that the students offered a limited number of suggestions in order not to be disconnected from real life in mathematics lessons and in order not to get bored in mathematics lessons / to increase academic success.
- Before the application, it was determined that the parents of the students had the opinion that the mathematics education given at school was not related to real life and that the students had difficulty using their mathematical knowledge and skills in real life or that they did not use them at all.

- According to the findings obtained from the Diagnostic Form of Associating Mathematics with Real Life and interviews with students and students' parents, it was concluded that students' skills in associating mathematics with real life should be developed before the application.
- The results obtained regarding the development of students' skills in associating mathematics with real life through Realistic Mathematics Education were as follows:
- When the pre-test and post-test scores of the students obtained from the Diagnostic Form for Students' Skill of Associating Mathematics with Real Life were compared, it was determined that there was a significant difference in favor of the post-test scores. Accordingly, it was found that after the application, students' skills in associating mathematics with real-life increased significantly.
- It was determined that the students who were determined to use mathematics in limited areas in real life before the application started to use mathematics knowledge and skills in different situations in the form of using mathematics in daily life and connecting with real life in mathematics lessons.
- It was determined that before the application, the parents of the students had the opinion that their children had difficulty with using their mathematical knowledge and skills in real life or that they did not use it at all, and after the application, the education had a positive effect on the use of mathematics in real life.
- According to the findings obtained from the Diagnostic Form for Students' Skill of Associating Mathematics with Real Life and the findings obtained from the interviews with the students and their parents, it was concluded that the students' skill of associating mathematics with real-life improved positively after the application when compared to the pre-application process.

Discussion and Conclusion

According to the results of the analysis obtained from the quantitative data on the development of the skill of associating mathematics with real life, it was determined that the students' ability to associate mathematics with real life before the application was lower than the scores they got from the Descriptive Form of Associating Mathematics with Real Life. It was determined that there was a significant difference in favor of the post-test scores related to the Diagnostic Form for Students' Skill of Associating Mathematics with Real Life between the pre-test and post-test scores of the participant students in the study. Accordingly, it could be concluded that the students' skills in associating mathematics with real-life improved significantly as a result of the application. It was possible to mention that some studies analyzing the effect of Realistic Mathematics Education on mathematics achievement also supported this result, and studies conducted with activities based on Realistic Mathematics Education achieved successful results in increasing mathematics achievement (Akkaya, 2019; Bintaş et al., 2003; Gelibolu, 2008; İnce, 2019; Klein et al., 1998; Özdemir & Üzel, 2011; Özdemir, 2020; Özkan et al., 2023; Widjaja & Heck, 2003).

When the students' opinions before and after the application were compared, it was determined that the students understood the importance of mathematics lessons better in associating mathematics with real life as a result of the application, and this revealed the idea that Realistic Mathematics Education was efficient in associating

mathematics with real life. This situation may have resulted from the fact that students were given the opportunity of finding their own solutions and discussing in Realistic Mathematics Education, and thus the students produced shortcuts suitable for their level and gained experience. Bulut et al. (2016) stated in their study that they structured it according to document analysis that in the evaluation of a subject they dealt with in the 7th-grade mathematics textbooks, especially real-life associations were included. The activities in the textbooks should be organized in accordance with the curriculum and of high quality in terms of gaining knowledge and skills. In this direction, there are studies showing that the textbooks examined in different years are oriented towards associating the subjects with daily life (Arslan & Özpınar, 2009; Dinç-Artut & Ildırı, 2013; Küçüközer & Bostan, 2007). However, on the contrary, there are studies that show that the textbooks are not arranged in a way that students can use in their daily lives and that examples selected from real life are not included in the textbooks (Şahin & Turanlı, 2005; Taşdemir, 2011). This situation suggests that alternative approaches, such as Realistic Mathematics Education, can be used, which will enable students to integrate the knowledge and skills in the textbooks with daily life in order to associate mathematics with real life.

It can be said that Realistic Mathematics Education positively affects students' making the connection between mathematics and real life and enables them to start using mathematical knowledge in many different areas of real life. In addition, considering that mathematics develops as a result of solutions to real-life problems, it is possible to say that mathematics can be produced with in-class applications. In the study carried out by Doruk and Umay (2011), the effect of mathematical modeling activities on transferring mathematics to daily life was examined. It was concluded that these modeling activities, similar to the principles of Realistic Mathematics Education, increased the level of students' skill in transferring mathematics to daily life. It can be said that this result is consistent with the research findings. Moreover, the obtained result was coherent with the results of similar research results, which concluded that mathematical modeling using real-life activities was efficient in increasing the relationship of mathematics with real life (Deniz & Akgün, 2014; Sağırlı et al., 2010). In the study carried out by Karakoç and Alacacı (2012), expert opinions suggest that the use of real-life connections in the course increased students' interest in mathematics and improved their mathematical process skills. When this opinion was compared with the results of the research, it was possible to mention that the suggestions of the students, such as teaching lessons based on student problems and bringing real-life examples to the classroom, were acceptable to increase their skill of associating mathematics with real life. The student recommendations for the application were coherent with the findings of the research carried out by Cankoy (2002) that provided data for the development of the Mathematics and Daily Life course program that was used in the Turkish Republic of Northern Cyprus.

It was noticed that the students made associations with mathematics, focusing on only one aspect of real life before the application. After the application, emphasizing the activities based on the principles of Realistic Mathematics Education, they stated that these activities enabled them to use their mathematical knowledge in real life. It could be said that the students who said that achieving the result without making any actions in activities and applications had a facilitating effect on real life, saw after the

application that mathematics was a lesson intertwined with real life in different aspects. In the research conducted by Fauzan et al. (2002), it was concluded that students were satisfied with Realistic Mathematics Education in terms of thinking in class, and being more active and creative. The parents of the students, who offered positive opinions about Realistic Mathematics Education, suggested that this kind of education and practices should continue, and similar practices should be applied in different lessons. Accordingly, it could be said that the parents of the students considered that the structure of Realistic Mathematics Education, which progressed in the form of determining the mathematical aspect of real-life problems and the way of evaluating the students' 'knowledge, contributes to the development of students' skill of using mathematics in real life.

Implications

The results of the research revealed that Realistic Mathematics Education reinforced with educational games improved secondary school sixth-grade students' skills in associating mathematics with real life. Accordingly, mathematic lessons could be lectured with problem situations selected from real life, educational games related to the subject taught in mathematics lessons could be included, and activities could be organized in accordance with the principles of Realistic Mathematics Education. According to the research results, considering that associating mathematics with real-life improved learning, cooperation could be made with students' parents, and informative training could be organized for them on the importance of this situation in order to create an environment and provide more opportunities for students to use their mathematics knowledge and skills in out-of-school environments. Considering the principles of Realistic Mathematics Education, it could be ensured that Realistic Mathematics Education applications were included in pre-service and in-service training of teachers in order to improve their teaching skills. In order to ensure that students learn mathematics by associating it with real life, action research based on students' considering mathematics in real life should be conducted. In this study, the diagnostic form developed by the researcher was used to develop the skill of associating mathematics with real life. Different measurement tools for this skill could be developed and used in future studies. This study was carried out in a school with middle and lower socioeconomic level students. More comprehensive results can be obtained by conducting studies in schools where students from upper socioeconomic levels are included.

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Statement of Responsibility

All stages such as conceptualization, methodology, software, validation, formal analysis, investigation, resources, data curation, writing-original draft, visualization, supervision, project administration, and funding acquisition of this research were carried out by Pelin UREDI under the supervision of Prof. Dr. Ahmet DOGANAY.

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