Research Article

Journal of Innovative Research in Teacher Education, *4*(2), 336-357,
ISSN: 2757-6116
http://www.jirte.org
DOI: 10.29329/jirte.2023.572.10
Received: 07/04/2023
Revised: 13/09/2023
Accepted: 19/09/2023

Discovering mathematics beyond the classroom: an investigation of secondary-school students' experiences of mathematics in outdoor learning environments*[1]

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Abstract

This study investigates how 7th-grade students engaged in mathematics education in outdoor learning environments and how these experiences influenced their perception of mathematics. The research employed a qualitative approach with a case study design and involved 21 students in the 7th-grade middle school. Structured interview forms, student diaries, and unstructured observation notes were used as data collection tools. The data collected was analyzed using content analysis, resulting in the identification of themes and codes. The study examined the students' expectations for the activities to be carried out in outdoor learning environments. They expressed the highest positive expectations about learning problem-solving techniques and study methods for mathematics. Additionally, the students expressed a desire to learn mathematics enjoyably, overcome their prejudices against mathematics, and understand its logic. Before the research, the students knew that mathematics is used in real-life situations, primarily in calculations and transactions. However, after the study, it was observed that students not only had their expectations met but also gained awareness of the more diverse applications of mathematics in real-life contexts. Additionally, a positive change was observed in their attitudes toward mathematics, and they gained the awareness that mathematics goes beyond being just a subject learned in school and has many real-life applications. Consequently, it was concluded that outdoor learning environments can contribute to mathematics education and positively influence students' perception of mathematics. These findings provide an important perspective for evaluating different learning environments and experiences in mathematics education.

Keywords: Outdoor learning, math education, real life.

Cite: Altuntaş, M., & Çetin, İ. (2023). Discovering mathematics beyond the classroom: An investigation of secondary-school students' mathematics experiences in outdoor learning environments. *Journal of Innovative Research in Teacher Education, 4*(2), 336-357. https://doi.org/10.29329/jirte.2023.572.10

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* This research was carried out after being approved by the decision of the Ethics Commission of Necmettin Erbakan University at session No. 163 held on December 12, 2020.

[1] This research is an extension of a study presented at the International Symposium on Contemporary Education and Social Sciences (ISCESS 2018).

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INTRODUCTION

Mathematics, as a universal language, has been used in many areas throughout the history of humanity and is an indispensable part of various fields. Mathematics offers practical solutions to many problems we encounter in our daily lives (Ang, 2010; Spandaw & Zwaneveld, 2009). Mathematical concepts in fields such as construction, finance, health, sports, travel, and many others make our lives easier and help regulate and order them. Although for many people, the term "mathematics" may remind them of a series of formulas and equations learned at school (Yenilmez, 2011), mathematics is fundamentally a tool used to solve problems encountered in daily life (Işık, Çiltaş & Bekdemir, 2008). Therefore, a better understanding of the role of mathematics in real life can help us see mathematics as a part of our lives rather than just an irrelevant subject of study.

To develop students' mathematical skills, creating environments in which mathematics has a concrete and meaningful place is crucial. Classroom and school environments are where students spend most of their time engaged in learning activities. There is, however, a growing interest in how students develop their mathematical thinking in informal learning environments, particularly how their experiences outdoors can support their learning in the classroom (Saraç, 2017). If students are provided with opportunities to continue learning (Edelmann & Wittmann, 2012) and given an environment they can explore, mathematics education can occur in any setting without the need for a classroom. Because developments influence learning environments in factors such as technology, pedagogical approaches, and physical and virtual environments, it has been observed that the use of alternative education and training tools has increased, and it is no longer regarded as sufficient to confine learning solely to school and classroom environments (Eshach, 2007). In recent years, an approach named "outdoor mathematics," which connects mathematics with real-life situations and asserts that mathematics education can be conducted in learning environments outside the classroom, has gained prominence (Gurjanow, Jablonski, Ludwig & Zender, 2019).

Teaching mathematics should not be limited to well-known classroom settings and the use of textbooks (Taranto et al., 2021). The facts that students perceive textbooks as the main source of what they are learning, which has arisen as a result of an exam-centered education approach, and that textbooks are ultimately insufficient in delineating the relationship between mathematics and real life (Korkmaz, Tutak & İlhan, 2020), has prompted the consideration of alternative learning environments that may be able to establish that relationship better. Mathematics is inherently an abstract discipline (Alakoç, 2003), and if its relationship with real life cannot be established, it tends to be perceived as a subject consisting of rules to be memorized solely for academic purposes (Derin & Aydın, 2020). When mathematics is associated with real life, students can learn it more easily (Carpenter & Lehrer, 1999). The applications of mathematics in daily life are abundant and diverse. Using mathematics in such contexts helps students better understand mathematical concepts and develop positive attitudes toward mathematics (Stylianides & Stylianides, 2008). Moving mathematics away from merely an academic subject and providing students with a perspective that helps them solve actual problems they encounter strengthens the link between real life and mathematics (Singletary, 2012). For this reason, schools should foster mathematical thinking in students because it plays a significant role in understanding and solving problems encountered in real life (Stacey, 2014). However, most people do not use mathematics in real life. Therefore, it is important to develop mathematical thinking skills and understand how to apply mathematics in real-life situations to make mathematics education lasting and meaningful (Ikeda, 2015). Developing mathematical thinking skills and knowing how to use mathematics in real life are extremely important for meaningful mathematics teaching.

Recently, the fact that routine problems are more common in learning environments has led mathematics educators to search for problem-solving alternatives (Kertil, 2008). Approaches such as mathematical modeling and STEM, which are based on non-routine problems and associate mathematics with real-life (Kertil & Gürel, 2016), have contributed to a change in approach to mathematics. Specifically, it has been argued that comparing students' experiences of real-life problems using mathematical modeling and "realistic" mathematics education can provide a foundation for meaningful mathematics learning (Derin, 2017). One component of the skill of "association" in the mathematics curriculum is connecting mathematics to real life (Bingölbali & Coşkun, 2016). However, although many mathematics problems introduced in the classroom may be based on real-life situations, they often lack a strong connection to real life and do not provide a meaningful context. In other words, these questions are often simply context-based questions with only superficial connections (Çepni, 2019). While mathematics did not initially have a strong emphasis on real-life applications, engaging with problems in nature and seeking solutions to them to discover the role of mathematics in real life can greatly enhance the connection between mathematics and our lived experience. If we expect students to perceive school mathematics as useful in solving problems encountered outside the classroom, they must engage with tasks that closely resemble real-life problems (Galbraith, 2007). Mathematics is the fundamental human endeavor to understand nature and everyday life and solve problems (Gül, 2021), and it becomes more meaningful when it can produce solutions to these problems. In other words, education in a real-world setting and can be associated with real-life issues is easier and more meaningful for students and leads to more permanent learning (Ülger, Ar & Sarıoğlu, 2022). Mathematics education connected to real life also helps reduce students' anxiety about mathematics (Demir, 2017). The use of outdoor learning environments to alleviate this kind of anxiety (Grothérus & Fägerstam, 2017; Kurtuluş, 2015) has become popular in recent years because it also increases interest in learning and fosters positive attitudes (Sample-Mckeeking, Weinberg, Boyd & Balgopal, 2016).

International student assessment programs, such as Trends in International Mathematics and Science Study (TIMSS) and the Program for International Student Assessment (PISA), include questions based on real-life situations that students may encounter. This approach aims to determine the level of mathematical literacy by measuring how students apply mathematical knowledge in real-life situations rather than simply assessing the acquisition of mathematical knowledge (Organization for Economic Co-Operation and Development [OECD], 2019). An important aspect to note is that some recent questions in the PISA require students to run simulations to answer them. To this end, these problems collect data related to real-life events and draw mathematical conclusions based on these data. Students are expected to collect the data from the simulation and make associations rather than being provided with ready-made data for the problem. This process involves the students' prior understanding of real-life situations, using data from those situations, and the ability to draw meaningful mathematical conclusions. It will enable this approach, which is gaining popularity in mathematics education, to find a place in learning environments.

Outdoor Learning

Outdoor learning is generally defined as teaching and learning in educational, outdoor, and non-school environments (Becker, Lauterbach, Spengler, Dettweiler & Mess, 2017). The teaching and learning content can vary, and the activities may differ based on the overall purpose of the program, the target group, and the learning environment. Specifically, these learning environments can include places such as museums/science centers, interactive exhibitions, planetariums, zoos, aquariums, botanical gardens, national parks, and industrial establishments, which can be visited periodically and have institutional characteristics, as well as natural environments which can be visited on field trips (Eshach, 2007). Activities in outdoor learning environments encompass all the activities that can occur outside the four walls of the classroom (Şen, 2019). The approach that emphasizes the use of these environments argues that traditional education systems still rely on a teacher-centered learning approach. Although educational systems may allow for the implementation of different teaching methods, some teachers still argue that they are not able to give up the teacher-centered approach to learning (Fägerstam 2014; Waite, 2011) or move outside the traditional classroom environment (Boaler, 1999; 2002).

Literature Review

Many countries have explicitly incorporated outdoor learning activities into their curricula and have recommended regular implementation of such approaches. Particularly in the last decade, there have been significant initiatives for outdoor learning environments in the Scandinavian countries (Becker et al., 2017). For instance, as of 2016, outdoor learning activities had been implemented in approximately one-fifth of private and public schools in Denmark (Barfod, Ejbye-Ernst, Mygind, & Bentsen, 2016), and they were included in the "2016 National Core Curriculum" in Finland (Finnish National Board of Education [FNBE], 2016). Outdoor learning activities are carried out in several countries, particularly within the context of "forest schools," they are implemented at different grade levels and in different subjects. "Forest schools" can be defined as centers offering activities in a forest or wooded area, using active participatory learning methods, where students spend 2-3 hours engaging in tasks that promote self-confidence and self-esteem (Kanat, 2020). In recent years, there have been numerous studies on forest-based activities in Scandinavian countries like Denmark, Sweden (Isgren Karlsson, Alatalo, Nyberg & Backman, 2023), and England (Cont, Rowley, Knowles & Bowe, 2023; Friedman, Gibson, Jones & Hughes, 2022). Additionally, many studies have been conducted on outdoor learning activities in countries such as Spain (Corres Gallardo & Ruiz-Mallén, 2023; Larrea, Muela & Imaz, 2022), Portugal (Motta & Ferreira, 2022), Poland (Janik, 2022), England (Prince & Diggory, 2023), and Iran (Ashjae, Fattahi, & Derakhshanian, 2022). These studies have concluded that outdoor learning activities provide students rich learning opportunities, foster positive social relationships, and contribute to mental well-being and vitality (Becker et al., 2017).

Research on outdoor learning environments has been conducted at various educational levels, ranging from preschool to university, and for different purposes. However, preschool education has seen a greater emphasis on research related to outdoor learning environments. Internationally, nature and science activities have been prominent in preschool studies (Motta & Ferreira, 2022; Saleh, Latip, & Rahim, 2018), as well as in Türkiye (Dere & Çifçi, 2022; Özer & Yıldırım-Polat, 2019). In Türkiye, content analysis of outdoor learning areas has shown that more studies have focused on science and social sciences due to the connections between science-related outdoor learning environments and daily life, as well as the opportunities for teaching in historical museums in the field of social sciences (Saraç, 2017). Studies on outdoor learning activities in science education have generally explored museums (Güler, 2011), science centers (Bozdoğan, 2007; Öztürk & Başbay, 2017), and nature camps (Yardımcı, 2009). Concerning the social studies curriculum, there have been studies on museum visits (Kartal & Şeyhoğlu, 2020), virtual museum tours (Avcı & Gümüş, 2020), out-of-class activities related to specific subject areas (Altınbay & Gümüş, 2020), and teachers' perspectives (Galip, 2015).

In the revised mathematics curricula in Türkiye in 2016, it was emphasized that importance should be placed on activities in extracurricular learning environments, considering the knowledge, skills, and values they provide to students (Ministry of National Education [MoNE], 2019). An Outdoor Learning Environments Guidebook was prepared for each province as part of the Outdoor Learning Environments project by the Provincial Directorates of National Education. These books were made available as e-books in PDF form on the website and distributed to educators. However, while most of these PDFs focused on mapping learning outcomes to outdoor learning environments, they lacked information on planning activities and presenting and evaluating the content effectively.

The research shows that learning environments that place students at the center and provide more learning opportunities can enhance students' academic achievement and indirectly improve their performance in mathematics (Brooks, 2010; Zimmerman, 2000). Examining the studies in the literature on mathematics education, it is evident that only a limited number of studies have been conducted on this topic due to the challenges of the process and the lack of sufficient experience regarding such learning environments (Bahadır & Hırdıç, 2018; Baya'a & Daher, 2009; Çağlar, Ünal, Çalışkan, Gürel &

Durmaz, 2018; Kurtuluş, 2015; Sözer, 2013; Ürey, Çepni, Köğce & Yıldız, 2013; Yıldız & Göl, 2014). These studies were conducted in school gardens and indoor spaces with primary- and high-school students. In recent years, studies have emerged that use digital applications in mathematics activities in outdoor learning environments. These studies include mathematical modeling-based activities conducted with digital applications (Isgren et al., 2022), the use of mobile city maps (Çetinkaya & Çolakoğlu, 2017), the use of MOOCs (Taranto et al., 2021), and programs supported by MathCityMap (Ariosto, Ferrarello, Mammana & Taranto, 2021; Ludvig & Jesberg, 2015; Rosanti & Hararap, 2022). However, it is evident that studies specifically focusing on the use of informal environments as learning environments in mathematics education are limited (Çağlar et al., 2018; Yıldız & Göl, 2014). Furthermore, outdoor activities are rarely encountered in current educational practices, primarily due to the emphasis on exam preparation based on multiple-choice questions (Anlı, 2015). Creating educational materials and establishing direct connections to the curriculum in such environments poses challenges. Moreover, teachers' lack of knowledge and experience in actively conducting extracurricular activities (Yıldız & Göl, 2014) demonstrates the need for more research in this field.

The aim of this study was thus to examine the experiences of 7th-grade middle school students who participated in "The Colorful World of Mathematics" project conducted within the scope of the Scientific and Technological Research Council of Türkiye's [Türkiye Bilimsel ve Teknolojik Araştırma Kurumu [TUBITAK] 4004 Nature Education and Science Schools Support Program. The study aimed to explore the activities carried out in outdoor learning environments, their impact on the students' use of mathematics in daily life, and their perspectives on mathematics. Furthermore, the research provides practical suggestions for improving teaching in outdoor learning environments and highlights important considerations for the educational setting. It aimed to address the question, "How do the activities carried out in outdoor learning environments affect students' views about mathematics?" The following sub-problems were identified:

1. What do the students aspire to learn through the activities conducted in outdoor learning environments?
2. Do the activities carried out in outdoor learning environments satisfy the students' expectations?
3. How do the activities conducted in outdoor learning environments influence the students' beliefs about the practical use of mathematics in daily life?

METHOD

Research Design

This research aimed to evaluate the activities carried out during the project's outdoor learning environments using a case study approach. A case study is a qualitative research method where the researcher examines one or more specific situations within a limited timeframe using various data collection tools, such as observations, interviews, documents, and reports, to understand the situation and identify relevant themes (Creswell, 2007). In this study, the students' opinions regarding the activities conducted in the outdoor learning environments were collected as part of the case study. The students were observed during the activities, and detailed notes were taken. The study also used the "Know, Want, Learned" (KWL) technique, which was developed by Ogle (1986). The KWL technique is a constructivist strategy that enables learners to assess their prior knowledge, identify what they want to learn and reflect on what they have learned through research. In this context, the participating students were provided with "knowledge-want-learning" documents titled "What do I know?", "What do I want to learn?" and "What have I learned?". They were asked to write about their thoughts on mathematics before the activity, their understanding of the use of mathematics in daily life, their expectations from the activities in the outdoor learning environments, and what they had learned after the activities. The research used the case study approach and the KWL technique to gain insights into the students' perspectives, prior knowledge, and learning outcomes regarding outdoor outdoor learning environments.

Participants

The TUBITAK 4004 Nature Education and Science Schools Support Program aims to bring science and society together by promoting knowledge and science in an accessible and interactive manner (TUBITAK, 2019). This program disseminates knowledge widely and provides interactive applications to visualize it. In this study, a group of 21 7th-grade secondary-school students (10 girls, 11 boys) from a disadvantaged region within a metropolitan city in Central Anatolia participated in a specific TUBITAK 4004 project called "The Colorful World of Mathematics." The fact that the curriculum is intensive and suitable for the content developed was an important factor in selecting children in the 7th grade as the study participants. In addition, the facts that 8th-grade students are preparing for a national exam and that the content did not adequately match the 5th- and 6th-grade levels were also considered. Care was taken to select students with high academic achievement through verbal and written interviews conducted with their teachers at the school. An electronic application form was prepared and shared through the Provincial Directorate for National Education [Milli Eğitim Müdürlüğü (MEM)] and the project's web page. The selection of students who had not previously visited the specific outdoor learning environments (such as the Science Centre or shopping mall) mentioned in the project application form was used to invite them to participate. Including students from a less privileged socio-economic background in the TUBITAK 4004 project aimed to provide them with opportunities, they may not otherwise have to engage in mathematics in outdoor learning environments and bridge the gap between science education and their everyday lives.

Data Collection Tools and Process

This study employed multiple data collection tools, including a structured interview form, unstructured observation notes, and student diaries. The structured interview consisted of two questions, one to be administered before and the other after the research activities. In formulating the interview questions, the research problems were considered, and input was received from two experts in the field of mathematics education. To assess the comprehensibility and clarity of the questions, the opinions of a Turkish teacher and a 7th-grade student were also sought, following which the interview form was finalized. The relevant ethics committee obtained the necessary permissions to use the structured interview form as a data collection tool. Each student was given 15 minutes to complete the interview form.

The interview questions used in the research were as follows:

Before the research:

1. What do you want to learn in the outdoor learning activities?
2. What are your expectations of these activities?

After the research:

1. What did you learn from the activities carried out in the outdoor learning environments?
2. Did these events satisfy your expectations?

Diaries were used to examine the changes in students' thoughts about the project and mathematics after participating in the activities carried out in the outdoor learning environments. The students were asked to fill out these diaries daily after each activity and at the end of each day. Furthermore, the researchers on the project utilized unstructured observation forms to record conversations between the students and other participants, including teachers, during the project to capture the students' thoughts about the project and mathematics. The data for the study were collected before, during, and after the activities, which lasted for six days. The students completed the structured interview questions before and after the research and filled out the diaries daily. A matrix showing the problem statements and data collection tools based on the KWL technique is shown in Table 1.

Table 1. Problem Statements and Data Collection Tools Before and After Activity

		Before Activity	After Activity
	K	**W**	**L**
K-W-L Technique	What do I know? (Know)	What do I want to learn? What are my expectations? (What)	What have I learned? Were my expectations satisfied? (Learn)
Problem Sentences	What are students' perceptions of mathematics?	What are students' expectations about the use of mathematics in daily life?	To what extent were the students' expectations regarding the use of mathematics in daily life satisfied?
		What do students want to learn about mathematics through the activities?	What did the students learn about mathematics through the activities?
Data Collection Time	Pre-research	*During the research Before and after the research	*During the research Before and after the research

Attention was paid to ensuring that the activities carried out within the scope of the research were those in which students could learn mathematics in a natural environment and make connections with daily life. Various permissions were obtained for the activities to be carried out before the research, which were carried out with safety measures in place. The activities were carried out in the Ashrafoglu and Alaaddin Mosque, the Konya Science Center, the School Garden, Butterfly Valley, and the Selçuklu Cognitive Games Laboratory. They included geometric pattern workshops, calculating geometric objects' length, area, and volume, and several games.

Data Analysis

The data obtained in this study were analyzed using the content analysis method. The qualitative data collected were imported into MAXQDA 2020 qualitative data analysis software by the researchers. Similar data were grouped together based on specific codes and themes and organized to facilitate understanding for the reader. In quoting from the data, each student's statements are identified with codes ranging from T1 to T21, and the data sources are indicated as follows: unstructured observation (UO), interview form (IF), and student diary (SD). For example, at the end of a quotation from a student coded as S15 based on the interview questions, the source is indicated as (S15, IF).

Validity and Reliability

To ensure the reliability of the research, the researchers, using the MAXQDA 2020 software, independently analyzed the data. Any coding disagreements between the researchers were resolved by consulting a third researcher with expertise in mathematics education. The codes and themes obtained in the study were visualized using MAXMaps, and the frequency of each code and theme was displayed visually. After the analysis, two MAXQDA files were merged into a single project, and the percentage of agreement between the codes was calculated. The final agreement percentage was 96% using the formula Agreement/(Agreement+Disagreement) for all coding. Miles and Huberman (1994) recommend an agreement rate of 80% or higher to ensure consensus among all coders.

Ethical Consideration

The approval of the Ethics Committee for Social Sciences and Humanities Research of Necmettin Erbakan University was obtained for the study.

RESULTS

This section analyzes the data collected from structured interviews, student diaries, and observation notes using codes and themes. The findings are then visualized and presented, including frequency counts and direct and indirect quotations. The data analysis involved identifying common codes and themes from the information collected. These codes and themes helped categorize and organize the data, allowing a deeper understanding of the participants' experiences and perspectives. Frequency counts were conducted to determine the prevalence of certain codes and themes within the data. This provided insights into the frequency with which the participants expressed certain ideas, thoughts, or experiences. Direct and indirect quotations were also used to support and illustrate the findings. These quotations were selected from the data and presented in the analysis, providing concrete examples of the participants' responses and reflections. Overall, the data analysis involved a comprehensive examination of the information gathered, identifying key codes and themes, frequency counts, and including relevant quotations to support the findings.

Participants' Expectations Regarding Activities Organized in Outdoor Learning Environments

The first sub-problem of the research examined the students' expectations of the activities carried out in the outdoor learning environments, as well as their perceptions of whether these expectations were met. The students' responses were analyzed and categorized into different codes related to their expectations and fulfillment. In terms of their initial expectations, six different codes emerged, with a total frequency of 62. These codes represent the various expectations that the students had. On the other hand, seven different codes emerged regarding the fulfilment of their expectations, with a total frequency of 119. These codes represent the students' views on whether their expectations were met. The codes related to the participants' expectations and fulfillment of these during the project are shown in Figure 1. This illustrates both themes: the students' expectations, shown in red, and the fulfillment of these expectations, shown in blue. The yellow codes shown in the middle were encountered in each theme. The frequency of occurrence of each code is also stated as a number between the code and the theme.

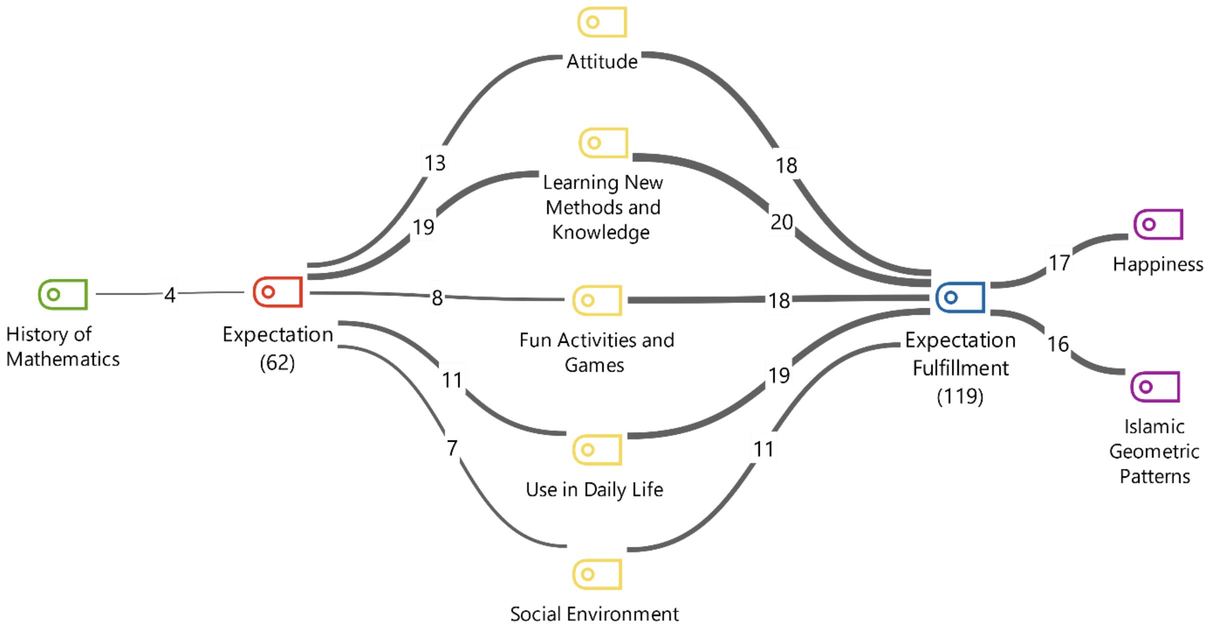

Figure 1. Participants' Expectations of the Project and Codes Related to Meeting Their Expectations

In the research, the students were asked about their expectations regarding the activities carried out in the outdoor learning environments and what they wanted to learn about mathematics through these activities. The students expressed their desire to learn how to solve questions better in mathematics, study effectively, and acquire short and practical methods for problem-solving. These expectations were categorized under the code "learning new methods and knowledge" with a frequency of 19. It is worth noting that, as 7th-grade students, their expectations were influenced by the exam-oriented nature of their curriculum. They saw the outdoor learning activities as an opportunity to prepare for exams and improve their performance. This emphasis on exam preparation and practical learning methods was observed in the discussions between the students and researchers. The students' expectations aligned with their desire to learn mathematics more effectively and efficiently. They recognized the importance of developing problem-solving skills and acquiring new methods and information to improve their academic performance. These findings demonstrate the students' motivation to enhance their mathematics abilities through the activities conducted in outdoor learning environments. The opinion of one student (S1) was as follows: *"I want to learn short and practical methods in math and to learn the basics of some higher-level subjects."* (S1, IF). Analyzing the students' opinions regarding their expectations of the activities, it became evident that they wanted to learn mathematics fun and engagingly. They expressed their desire to learn through "fun activities and games " with a frequency of 8. One student who wanted to have fun while learning mathematics (S13) expressed this situation as follows:

> I want to learn what kind of ways I can use to learn mathematics in a fun way and what kind of things I can do I should adopt to prove to my friends that mathematics is actually a very fun lesson. (S13, IF)

Furthermore, the students hoped to overcome their prejudices toward mathematics and develop a positive attitude toward it. One student (S2) who had preconceived notions about mathematics expressed their belief that these activities would help them overcome their one-sided view and enjoy better insights into the subject. Another student's (S8) response highlighted the importance of fostering a positive attitude toward mathematics. These findings emphasize the students' desire to experience mathematics positively and enjoyably, challenging their preconceived notions and discovering the logical and fun aspects of the subject. Activities conducted in outdoor learning environments allow students to engage with mathematics differently and more enjoyably, helping them develop a positive attitude toward the subject.

The students stated that they expected to "learn new methods and knowledge" (f=19) about the practical applications of mathematics in daily life. They expressed their desire to use mathematics daily and not just confine it to classroom lessons. One student (S6) mentioned the importance of learning new information about the use of mathematics in daily life, not only for themselves but also for their friends who participated in these activities. Another student (S7) expressed curiosity about the relationship between mathematics and daily life, particularly in architecture and social areas. The student's expectation regarding these ideas was as follows: *"With these activities, I want to learn how mathematics is used in architecture and social fields, what exactly it does, and in what situations it saves lives."* (S7, IF). They wanted to learn how mathematics is applied in architecture and social contexts, understanding its significance and the situations in which it plays a life-saving role.

Another code that emerged from the students' responses was "history of mathematics" (f=4). The students expressed their interest in learning about the origins of mathematics and how it developed over time. They were curious about the historical aspects of mathematics, including its emergence and the methods used by early mathematicians. One student (S11) specifically mentioned their desire to explore the mathematics behind buildings and how it was applied in different contexts. They expressed their interest in understanding the historical significance of mathematics to architectural and structural designs. In expressing their curiosity about the history of mathematics, the students demonstrated a desire to gain a deeper understanding of the subject beyond its practical applications. Exploring the historical development of mathematics can provide valuable insights into its evolution and contributions to various fields of study.

> I want to learn how and with which methods mathematics was used in the past through the activities that we're going to carry out. Because, at least for me, the pyramids of Egypt and the dome method used to build mosques in the past and many other things are still a mystery, I came to this camp hoping to answer some of my biggest questions. (S11, IF)

As can be seen, the students were curious about where mathematics is used in daily life, and they expected to develop more positive attitudes toward mathematics through the activities.

Satisfying Participants' Expectations Regarding the Activities Organized in the Outdoor Learning Environments

In the second sub-problem of the research, eight codes (f=119) were formed within the scope of the students' answers to whether their previously stated expectations had been met through the activities. Five of these codes were related to fulfilling the expectations regarding the activities carried out in outdoor learning environments, while "happiness" and "Islamic geometric patterns" were newly emergent codes. The fact that the codes formed about the expectations before the activities carried out in outdoor learning environments could also be used after the activities can be interpreted as showing that the activities did meet the students' expectations.

The students participating in the research stated that they wanted to "learn new methods and knowledge" before (f=19) and after (f=20) the activities in the outdoor learning environments. This code, present before and after the research, was the most frequently encountered code. One student (S3) who stated that they had learned different types of calculations during activities wrote the following in their student diary:

> Dividing the line segment into two and three with a ruler without measurements seemed strange. Especially from drawing a square or a pentagon with circles. It is better to draw polygons using circles according to the rules rather than just drawing them haphazardly with a pencil. (S3, SD)

Forming a positive attitude toward mathematics before the activity was expressed by the students both before the research (f=13) and afterwards (f=18) and was thus a common code for which the expectation was met. The students stated that they had previously seen mathematics as boring, a lesson learned only in the classroom, and thought that mathematics consisted of numbers. After the activities, they felt that mathematics was not a lesson to be frightened of, and they stated that they liked mathematics more. The student coded S2, who had considered mathematics boring beforehand, explained this situation in the interview as follows:

> Before I came here, I would not say I liked mathematics very much, but I learned that the games we played here and the places we visited are related to mathematics, and now I do not think that mathematics is a scary subject. (S2, ID)

Another common code that met the expectations of the students was the "use of mathematics in daily life." After the activities, the students discussed the use of mathematics in daily life more (f=19) than before the activity (f=11). In other words, the activities increased the students' awareness of different uses of mathematics in daily life. The students tended to perceive mathematics as a course consisting of numbers, problems, and operations and thought it was only used in shopping and professions requiring calculations. However, they said that although mathematics is used in different parts of daily life, they were unaware of it. One student (S11) said: "In fact, there is mathematics in many places in our lives, but we were not aware of it." He wanted to express his view that the students' awareness of the use of mathematics in daily life had increased due to the activities in the outdoor learning environments.

Before the activities, the students stated that they wanted to learn about the history of mathematics and how mathematics was done. After the activities, this code was replaced by the "Islamic geometric patterns" code. One of the participants (S1) stated that mathematics was born from human needs in the past as follows: *"I realized that mathematics emerged from everyday needs and that people use mathematics to solve their problems."* (S1, ID). Apart from developing positive attitudes toward mathematics, another affective change experienced by the students was that they felt "happy" after the activities (f=17). Perhaps one of the study's most important findings is that those students who were bored by the mathematics activities carried out in the classroom were happy after the activities carried out in the outdoor learning environments. The researchers' observation notes also support the finding that the students were happy during the project. In particular, the female students told the researchers they were happy while participating in the project. The statement of one student (S11) who expressed this was as follows:

> I was usually unhappy after the math lesson in the classroom, especially if the topic was difficult. Although many activities we did here were difficult, I was very happy to do these things for the first time. Being in this environment made me feel really good. (S11, SD)

Findings Related to the Status of Participants' Thoughts on the Use of Mathematics in Daily Life Before and After the Activities in Outdoor Learning Environments

In the third sub-problem of the study, the students were asked about where mathematics is used in daily life both before and after the activities to determine the change in their thoughts about this. Five codes (f=33) were formed from the answers given by the students before the activities, and five codes (f=54) were also formed after the activities, three of which were common codes and two of which were new. The codes created from the answers given by the students for this research question are given in Figure 2. This shows two themes: before the project, shown in blue, and after the project, shown in purple. The yellow codes in the middle were common for both themes. The frequency of each code is also stated as a number between the code and the theme.

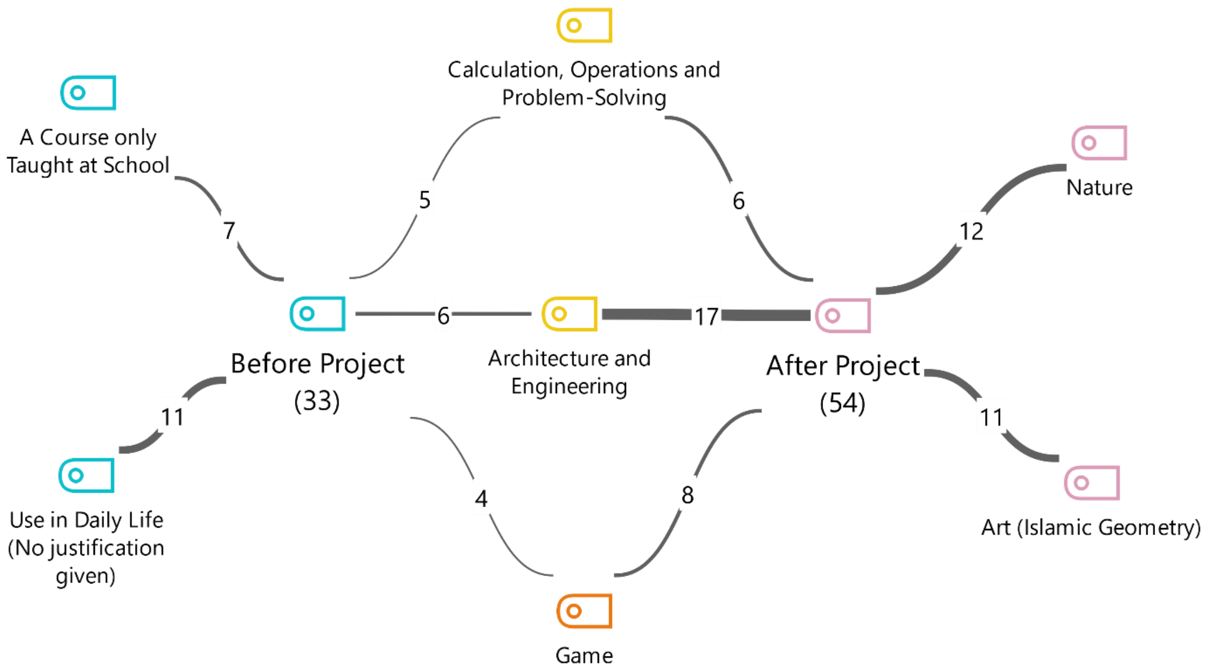

Figure 2. Participants' Views on the Use of Mathematics in Daily Life

Before the activities were carried out in the outdoor learning environments, the codes "use in daily life," "a course only taught at school," "architecture and engineering," "calculation, operations and problem-solving," and "game" were obtained from the answers given by the students to the question about where mathematics is used in daily life. It was determined that students gave limited answers on this subject.

The statements of the students who stated that mathematics is used in daily life without giving a justification were coded as "use in daily life (no justification given)" (f=11). The students knew the use of mathematics in daily life, but they had no specific, conscious idea about the areas in which it is used. The student-coded S6 used the following statements about the development of intelligence of people who use mathematics in daily life:

> I think mathematics is with us at every moment of our lives. We can liken it to a book. Just as the more we read a book, the more we want to read it, and the more we read it, the more we learn mathematics, and the more we use it in daily life, the more we want to use it, and each use improves our intelligence. (S6, ID)

Another code generated from the answers given by the students was that they thought that mathematics is "a course that is taught only at school" (f=7). It was determined that the students did not know that mathematic activities could be carried out in outdoor learning environments. The student coded S3 stated that mathematics is a course that can be taught in the classroom due to its abstract structure as follows: *"Mathematics is a lesson that is learned and taught in the classroom. It is done by thinking abstractly. Therefore, it is difficult. Maybe it is used or exists somewhere, but we cannot see it."* (S3, SD) The fact that the students were receiving an education with an understanding of mathematics disconnected from daily life may have led to this kind of thinking.

Another code created from the students' answers about using mathematics in daily life was using mathematics in "architecture and engineering" (f=6). Students know that mathematics is used in architecture and engineering, but their knowledge of where it is used is limited. The observation notes of the researchers also support this finding. In discussion with the student coded S13, the student stated: *"I know that it is used in architecture, but I want to learn exactly how mathematics is used in architecture and what exactly is being done in the activities here."* (S13, SD) The students, they expressed their views on the use of math in architecture and engineering according to their current degree of understanding of this topic. However, their answers did not fully reflect how mathematics is used in engineering and architecture.

The second code for using mathematics daily was "calculation, operations, and problem-solving" (f=5). The statement of one student who associated mathematics mostly with making transactions and problem-solving and who said that mathematics is mostly used in professions that require calculation, such as banking or retail, was as follows:

> Mathematics is encountered in many areas of daily life. For example, we encounter mathematics in numbers even when buying bread from a basic grocery store. For this reason, everyone should have some knowledge in mathematics. I go to the supermarket from time to time. I should be able to do the math well and correctly. (S2, SD).

The last code related to using mathematics in real life before the activities were the "game" code (f=4). Student coded S5 stated that mathematics is used in computer games, other games, and sports: *"In computer games, we mostly use mathematics to buy fields or weapons. However, we use mathematics in card games and many games played with the ball."* (S5, UO) After the activities related to the use of mathematics in daily life, the codes such as "architecture and engineering," "calculation, operations and problem-solving" and "game" were developed to understand better the answers given by the students. The codes for "art" and "nature" are new codes that emerged after the research. The "nature" code (f=12) had the highest frequency among the codes formed from the data obtained from the answers given by the students after the activities. Students carried out activities at outdoor learning environments such as Beyşehir Lake, Butterfly Valley, and Science Center and saw the applications of mathematics in the natural world. The students expressed that there are mathematical structures in many places in nature and their lives as follows: "*When we went to the butterfly valley, we saw the symmetry on the butterfly's wing. Geometry is exactly in nature.*" (S14, IF).

Another code obtained because of the research was "art (Islamic geometry)" (f=11). The students observed geometric patterns in many buildings in the center of Konya, especially in Alaaddin and Ashrafoglu Mosques, and their awareness of these patterns increased. The observation notes of the researchers support this finding. The students constantly pointed out the geometric patterns they saw in the buildings to their friends and researchers during their trips to the city. The students tried to replicate such patterns using geometric structures during geometric pattern drawing workshops held in the specified places. The student coded S19 wrote this situation in the student diary as follows: "*In today's activity, we tried to create the motifs we saw in mosques ourselves and very pretty things came out of this. We had much fun coloring in the motifs we had created on the page.*" (S19, SD)

Another student (S14), referring to the applications of reflection, symmetry, and translation, which are the subjects of transformation geometry regarding patterns, said, "*Really nice patterns emerged by applying reflection and translation to different shapes. Many parts of the mosque contained octagons, hexagons, pentagons, and quadrilaterals. I was very interested in this place."* (S14, IF). It can be said that students' awareness of the use of mathematics in the fields of "*architecture and engineering*" (f=17) increased after the activities. An increase was observed in the frequency of the" code of "architecture and engineering" after the activity (f=6). This result may have come about due to architectural structures in the outdoor learning environments visited. One student wrote the following on the interview form regarding this finding: "*Now, when I go to an old building, I pay more attention to the architecture of that building.*" (S9, IF). This statement can be said to show that students' awareness of the use of mathematics in architecture had increased after the activities.

DISCUSSION, CONCLUSION AND RECOMMENDATIONS

After participating in the activities in the outdoor learning environments, the students reported positive changes in their views and attitudes toward mathematics. The themes that emerged from their experiences included learning new methods, learning new information about mathematics, engaging in fun activities and games to learn mathematics, using mathematics in daily life, and socializing with their peers. The increased frequency of these themes in the students' views after the activities indicated that their expectations were met and that the activities positively impacted their perceptions of mathematics. This finding is consistent with the study conducted by Duatepe-Paksu, Kazak, and Çontay (2022), where students expressed satisfaction with outdoor mathematics learning activities and believed that mathematics could be effectively learned in such environments. Furthermore, the students' increased general positivity and heightened awareness of Islamic geometric patterns, which they were curious about, further support the notion that the activities fulfilled their expectations.

During the activities in the outdoor learning environments, the students reported learning about the background of mathematical concepts and various measurement techniques. They discussed the skills they had acquired, such as constructing polygons according to rules using circles, dividing line segments into equal parts using different methods, and making estimations for measuring objects in the environment. These findings align with the research by Evcan, Adilov, Eken, Barut, Kemali, & Tınaztepe (2020), who observed that projects conducted in outdoor settings enabled students to apply different measurement approaches that are applicable in both daily life and educational contexts. The cognitive development achieved through these activities was also transferred to the kinesthetic domain, providing students with a practical understanding of mathematical concepts. In addition, informal learning environments, such as outdoor settings, offer students new perspectives, alternative teaching methods, and the opportunity to acquire previously unknown information (Adıgüzel, 2006; Ho, 2008).

The study revealed that the students developed positive attitudes toward mathematics through the activities conducted in the outdoor learning environments. This finding is consistent with previous research that has shown the positive impact of outdoor learning environments on students' attitudes toward mathematics (Adams, 2007; Fägerstam & Blom, 2013; Falk, Dierking, & Storksdieck, 2007; Siew-

Eng, Kim-Leong, & Siew-Ching, 2010). Additionally, the activities led to a decrease in anxiety and fear about mathematics among the students. The student coded S2 stated that he no longer saw mathematics as a "scary" lesson. Studies have reported statistically significant reductions in "math anxiety" scores following activities in outdoor learning environments (Saltık-Ayhanöz, Kahraman, & Akmeşe, 2022). Long-term regular outdoor mathematics learning has also been found to reduce mathematics-related stress and anxiety (Grothérus & Fägerstam, 2017). The fact that teaching in outdoor learning environments is more closely related to daily life and its content is associated with real-life situations contributes to increased student motivation (Bostan-Sarıoğlan & Küçüközer, 2017). Outdoor learning environments create rich educational contexts for mathematics education, fostering changes in students' attitudes and opinions (Kelton, 2015).

Furthermore, the activities in the outdoor learning environments led to positive changes in the students' perceptions of the use of mathematics in daily life. Before the activities, the students acknowledged that mathematics was used daily but struggled to justify its applications. Their understanding of the uses of mathematics was limited to basic scenarios such as shopping or calculating change. Additionally, some students perceived mathematics as a course focused solely on operations and calculations rather than recognizing that its multidimensional nature involves logic, problem-solving, analytical thinking, abstraction, and generalization skills. This limited perspective hindered their understanding of mathematics and its application to real-world problems. However, after participating in the activities, students realized that mathematics is employed in various contexts, such as nature and architecture, and its use extends beyond mere calculations. This finding supports the idea that outdoor learning environments enable students to connect classroom lessons with real-life situations (Marulcu, Saylan, & Güven, 2014). Activities that highlight the applications of mathematics in different fields have also been found to significantly enhance students' views on using mathematics in social life (Çağlar et al., 2018). Learning in nature has been identified as useful in establishing a relationship between life and mathematics (Sözer, 2013).

Within the scope of the research, the students visited buildings that featured an abundance of geometric designs and patterns of architecture (Beyşehir Ashrafoglu and Alaaddin Mosques) and examined the geometric decorations in these buildings. The expectation of learning about the history of mathematics before the activities was replaced by learning about Islamic geometric patterns when they saw such patterns being used in historic buildings. In addition, in the applied drawing workshops in these locations, the students increased their awareness of this topic by learning how to divide a line segment into three equal parts and construct polygons with circles, which they were curious about even though it was not part of the curriculum. Tzanakis et al. (2000) state that out-of-class mathematics activities include identifying forms and designs in nature, architecture, and art. It has been stated that thanks to mathematics education in informal learning environments, it is easier for students to see mathematics in real life, and their interest in mathematics increases as a result (Bahadır & Hırdıç, 2018) and their views on using mathematics in daily life change (Çağlar et al., 2018).

Considering that factors such as seeing mathematics as an abstract concept, having difficulty understanding mathematics, lack of motivation, and being afraid and anxious about mathematics may prevent students from employing it in daily life, different approaches can be used to encourage students in this regard. In addition, the effect of outdoor learning environments on mathematics learning could be investigated through different variables. Mathematics topics that correlate with students' interests could help students develop a more positive attitude toward using mathematics in real life. This would allow the effects of these environments on students' affective variables, such as mathematics anxiety, self-efficacy, attitude, and motivation, to be investigated.

If the real-life examples of concepts are not adequately explained in mathematics lessons, students may think they cannot use mathematics in real life. Therefore, demonstrating practical applications in mathematics lessons may help students to be inspired to use mathematics in real life. For students to have enough motivation to use mathematics, examples of how it is used in daily life can help them see its practical applications and become more motivated. Mathematics applications in outdoor learning environments can be used as a tool.

It was observed that before the study, the students saw mathematics lessons as more calculation- and operation-orientated, but after the outdoor education, their ideas had changed. Mathematics education should enable students to see mathematics not simply as a tool for calculation but as one that they can use to solve real-world problems and develop their analytical thinking skills. To this end, mathematics education should include examples and applications that enable students to connect abstract mathematical concepts to concrete situations. For example, interactive learning methods that focus on the practical applications of mathematics and examples that focus topics used in daily life will help students use their mathematical skills in daily life.

The students perceived mathematics as a subject that was only taught using textbooks and in the classroom before the research, and even if examples of the use of mathematics in daily life were given, the abstractness of these examples prevented students from associating mathematics with concrete reality. Therefore, to prevent the perception that mathematics as an abstract subject, teachers should design learning environments to help students apply mathematical concepts to real life, using virtual or concrete examples and materials.

Within the scope of the study, the sample was limited to 7th-grade students and students with a poor socioeconomic status who wanted to be more academically successful in mathematics. Studies could be conducted with students with different grade levels and negative attitudes toward the subject. In addition, qualitative data collection tools were used in this study. In similar studies, quantitative studies could also be conducted using scales to determine attitudes toward outdoor learning environments. In addition, since the research was conducted within the scope of one project, it only covered six days in total. By extending the process over a wider period, it will be possible to determine any change in students' attitudes more clearly.

Statement of Researchers

Researchers' contribution rate statement: The authors equally contributed to the article.
Conflict statement: There is no conflict of interest between the authors.
Support and thanks: This research were funded by the Scientific and Technological Research Council of Turkey (TUBITAK) 4004 Nature Education and Science Schools 2017-2018 (Project No:118B544)

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