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PRE-SERVICE MATHEMATICS TEACHERS' PERSPECTIVES ON TEACHING MATHEMATICS IN OUT-OF-SCHOOL LEARNING ENVIRONMENTS

MATEMATİK ÖĞRETMEN ADAYLARININ OKUL DIŞI ÖĞRENME ORTAMLARINDA MATEMATİK ÖĞRETİMİNE YÖNELİK BAKIŞ AÇILARI

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ÖZ

Bu araştırmada, ortaokul matematik öğretmen adaylarının okul dışı öğrenme ortamlarında matematik öğretimine yönelik bakış açıları araştırılmıştır. Bu araştırma kapsamında okul dışı öğrenme ortamlarında matematik eğitimine yönelik çevrim içi ders tasarlanmış olup, öğretmen adaylarının bu derse katılmadan önceki ve sonraki bakış açıları nitel yöntemlerle incelenmiştir. Araştırmanın katılımcılarını 2. ve 3. Sınıfta öğrenim görmekte olan 36 öğretmen adayı oluşturmaktadır. Araştırmada nitel araştırma yöntemlerinden fenomenoloji yöntemi kullanılmıştır. Araştırmanın veri toplama kaynağını katılımcıların ders öncesi ve ders sonrasında verilen açık uçlu sorulardan oluşan ankete verdikleri cevaplar oluşturmaktadır. Veri analizi açık kodlama tekniği ile yürütülmüştür. Analiz dört temel boyutta gerçekleştirilmiştir: (1) Okul dışı matematik eğitimine yönelik ortamların belirlenmesi (2) Okul dışı öğrenme ortamlarında matematik öğretimine yönelik bağlamlar, (3) Okul dışı öğrenme ortamlarında matematiği öğretme amaçları ve (4) Okul dışı matematik öğretimine yer verme sıklığı ve sebepleri. Araştırmanın bulguları katılımcıların dersi aldıktan sonra okul dışında matematik öğretimine yönelik bakış açılarında önemli değişikliklere işaret etmektedir. Araştırmanın bulgularının, okul dışı matematik öğretimine yönelik öğretmen eğitimi araştırmalarına ışık tutacağı ön görülmektedir.

ABSTRACT

This study explored pre-service middle school mathematics teachers' perspectives on teaching mathematics in out-of-school learning environments. The current study designed an online course on out-of-school mathematics education and investigated participants' perspectives before and after the class. The phenomenology method, one of the qualitative methods, was employed. Participants of the study were 36 second- and third-year pre-service middle school teachers who enrolled in the course. The data sources of the study were participants' open-ended responses to questionnaires. Open coding was used to analyze the data. The data analysis was carried out under four dimensions: (1) Identification of out-of-school mathematics education environments, (2) teaching contexts for teaching mathematics in out-of-school learning environments, (3) teaching purposes for teaching mathematics in out-of-school learning environments, and (4) frequency for using out-of-school education and their reasons. The findings of the study pointed to important changes in the participants' perspectives on teaching mathematics in out-of- school learning environments after taking the course. The findings of the study would shed light on studies on teacher education in the emerging field of out-of-school mathematics education.

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Introduction

The importance of out-of-school learning has been highlighted by numerous researchers, particularly in the field of science education (Dierking et al., 2003; Eshach, 2007; Kisiel, 2013). Out-of-school learning is described as self-motivated learning that provides free-choice opportunities and is mediated by sociocultural aspects (Rennie et al., 2003). Compared to the field of science education, out-of-school mathematics education, interchangeably used with informal mathematics education, is an emerging and growing field (Nemirovsky et al., 2017).

Informal mathematics education, which differs from everyday mathematics and refers to designed learning environments, offers new images of mathematics and opportunities for everyone to engage with mathematics in new ways with a variety of experiences (Nemirovsky et al., 2017). Although it offers new ways of mathematical thinking and learning, researchers in mathematics education have paid less attention to how students and adults learn mathematics outside the school in everyday life and in designed learning environments such as mathematics exhibits, museums, and science centers (Pattison, Rubin, & Wright, 2017). The number of mathematics museums and mathematics-themed interactive exhibits in Turkey and all around the world is increasing (Duatepe-Paksu, 2019). For example, MoMath, located in New York, is one of the prominent examples of mathematics museums that enable visitors to interact with materials and give hands-on experience with mathematics (Henebry, 2012). In Turkey, mathematics museums located in Aydın and Ankara, and mathematics-themed exhibits in Rahmi M. Koç Museums were designed to experience mathematics and engage in enjoyable learning of mathematics. Such developments in out-of-school mathematics education highlight the need for professional training of museum educators, staff, and teachers.

In the field of mathematics education, Nemirovsky et al. (2017) argued that there is no professional training for informal mathematics educators in the United States and suggested professional training for educators to better understand the nature of informal mathematics education. In Turkey, although Higher Education Council (HEC, 2018) included an elective course of "Mathematics Education in Out-of-School Learning Environments" (Matematik Öğretiminde Okul Dışı Öğrenme Ortamları)" into the curriculum for mathematics education in universities, it is unclear how to design this course to support the professional training of teachers. Furthermore, drawing on the studies in science education, Kisiel (2013) drew attention to the role of pre-service teachers in out-of-school education and argued that teachers are often unaware of their roles during field trips. Kisiel suggests that there is a need for training, especially among novice or pre-service science teachers. Pre-service teachers' training can be supported by the universities by offering courses that help them to learn about and experience teaching in out-of-school environments (Anderson et al., 2006; Olson et al. 2001). Such professional training might help pre-service teachers gain early exposure to out-of-school settings such as museums and parks, and help them to broaden their perceptions regarding learning in such environments (Kisiel, 2013).

In this regard, this study aimed to design a course to support pre-service mathematics teachers' professional training in out-of-school mathematics education by taking into consideration of studies in science and mathematics education, and, in particular, exploring their perspectives toward teaching mathematics in out-of-school learning environments after taking this course.

Literature Review

Theoretical Background in Out-of-School Learning

The majority of studies on out-of-school education have been conducted in the field of science education. Out-of-school mathematics is an emerging and developing field (Nemirovsky et al., 2017). Even though the number of studies on out-of-school mathematics education is limited and there is no a consensus on defining out-of-school learning and environments, theoretical studies on science and mathematics education guided the current study to conceptualize out-of-school education, identify out-of-school environments, and explore teachers' perspectives and motivations to visit such environments.

In the field of science education, Eshach (2007) examined ways of connect in-school and out-of-school learning in the science education context by clarifying the meanings of formal, informal, and non-formal education. Eshach (2007) described out-of-school learning within the scope of informal and non-formal education without making a sharp distinction between these categories, acknowledging the difficulty in defining out-of-school learning. The difference between these categories lies not only in the physical locations where learning takes place but also in factors such as students' motivations, the nature of assessment, and the social context. While learning in non-formal environments such as zoos and museums is planned and adaptable, informal learning is described as spontaneous learning that occurs particularly in our daily lives, such as at home, on the streets, and in parks. In this way, Eshach conceptualized out-of-school learning into two categories: non-formal (e.g., industry, scientific centers, botanical gardens, interactive exhibits) and informal learning (e.g., streets, homes, playgrounds).

The importance of out-of-school learning has been emphasized by numerous researchers, particularly in the field of science education (Dierking et al., 2003; Eshach, 2007; Kisiel, 2013). Out-of-school learning is described as self-motivated learning that provides opportunities for free-choice and is mediated by sociocultural factors (Rennie et al., 2003). Compared to the field of science education, out-of-school mathematics education, which is interchangeably used with informal mathematics education, is an emerging and growing field (Nemirovsky et al., 2017).

In the context of mathematics education, Pattison et al. (2017) used different terminology. They termed out-of-school mathematics education as informal mathematics education and categorized it under two topics: (1) everyday mathematics and (2) designed informal mathematics environments such as museums, science centers, and children's museums. In their categorizations, they reviewed studies on everyday mathematics involving the informal and spontaneous use of mathematics in daily life settings. Designed informal mathematics environments, which correspond to the non-formal learning environment in Eshach's (2007) categorization, involve mathematics- themed exhibits in science museums such as MathMoves, Geometry Playground (Danctep et al., 2015), Handling Calculus (Gyllenhaal, 2006) or mathematics museums such as MoMath (Henebry, 2012), or libraries. Unlike the categorizations of Pattison et al. (2007) and Eshach (2007), Nemirovsky et al. (2017) describe informal mathematics education as excluding everyday mathematics that involves spontaneous and unplanned ways of mathematics learning. They regarded museums as informal mathematics learning settings that were intentionally designed due to their schedules, having educators, and providing technologies and tools to support the learning of mathematics. They identified museums, summer camps, clubs, and after-school programs as informal learning settings where students learn mathematics.

Researchers have not only attempted to describe out-of-school education; but also, identified crucial factors that might affect out-of-school learning. Dierking and Falk (1992) described a model, named the Interactive Experience Model, to explain visitors' museum experiences as an interactive experience. They identified three contexts that interact with each other in museum visits: (a) Personal context (e.g., visitors' prior experience, knowledge, motivation), (b) Physical context (e.g., objects in the exhibits, ambiance), (c) Social context (e.g., interactions with staff, other visitors, families). They suggested it as a framework to understand visitors' museum experiences. In a further study, Eshach (2007) also organized factors that might affect out-of-school learning, particularly non-formal learning, considering previous studies. Eshach identified four major factors: personal (e.g., students' prior knowledge), physical (e.g., design of the exhibits), social (e.g., interactions between students), and instructional (teacher's approach). Each factor has affective (attitude, motivation) and cognitive dimensions (students' knowledge, understanding of a concept). For example, the physical nature of the environment would affect both affective and cognitive domains. To be more precise, the color of the exhibits might motivate students, and its interactivity level and presentation of scientific ideas also affect students' understanding of a concept. The author also addresses that the teachers or instructors also have a crucial role in preparing students for field trips emotionally and helping them understand scientific ideas in the exhibitions. Situating within these theoretical studies, the current study designed a course to support pre-service mathematics teachers' professional training in out-of-school mathematics education by exploring their perspectives regarding teaching mathematics in out-of-school learning environments.

Out-of-School Mathematics Education and Teacher Education

Out-of-school mathematics education, informal mathematics education, and outdoor mathematics education are often used interchangeably. Studies on out-of-school mathematics education have focused on a variety of topics such as describing informal learning in mathematics education (Nemirovsky et al., 2017; Pattison et al., 2017), discussing the potential strengths and limitations of informal mathematics education (Pattison et al., 2017), connecting ways of in and out-of-school learning (Kelton, 2021), examining the educator's role in supporting mathematics learning (Pattison et al., 2017), exploring visitor experiences (Cooper; 2011; Gyllenhaal, 2006), the nature of mathematical thinking and learning in certain contexts of out-of-school education (Kus & Cakiroglu, 2022; Nemirovsky et al., 2013; Nemirovsky, 2018), political and aesthetic dimensions of mathematics museums (Kelton & Nemirovsky, 2022); the ways of using materials in museums (Pattison, Ewing, & Frey, 2012), embodied interactions to make sense of a mathematical exhibition (Kelton & Ma, 2020). In the Turkish education context, most studies have been conducted in the field of science education (e.g., Çiğdemoğlu et al., 2019; Ertaş-Kılıç & Şen, 2014; Şen et al., 2021). There are very few studies in the field of mathematics education. Duatepe-Paksu et al. (2022) carried out a project, called "Mathematics Everywhere" to help seventh-grade students realize mathematics in out-of-school environments and increase their curiosity and exploration during mathematics learning. They observed positive changes in students' attitudes and beliefs toward mathematics after they engaged in out-of-school activities.

Research on teacher education in the context of out-of-school mathematics education is rare (e.g., Kelton, 2021). Nemirovsky et al. (2017) discussed this issue in their comprehensive paper and suggested the need for further studies and professional development in this emerging field. They argued that there is no a professional training for informal mathematics educators in the United States. Such training is needed to create a career path and professional identities in this field, to preserve and acknowledge the difference between formal and informal education, and to avoid reproducing prevalent educational practices in schools by crossing boundaries between different disciplines ranging from mathematics, arts, and history to philosophy. However, there are no expectations to facilitate the training of informal mathematics educators.

Although there are very few studies on out-of-school mathematics education, particularly on teacher education is very few, there have been some studies in the field of science education. Kisiel (2005) identified eight major motivations of teachers for visiting science centers. These are (1) providing opportunities to learn science concepts that are new or already learned; (2) having novel experiences that students may not have in school settings; (3) having memorable experiences, (4) supporting students' interest and motivation, (5) changing the routine of the classroom settings and activities, (6) showing students that they can learn throughout their lives outside of school, in other settings, (7) engaging students in enjoyable activities, (8) meeting the demands of the school. Kisiel (2005) also identified six ways to connect field trips to curriculum. These are (1) curriculum-related experience (gaining hands-on-experience regarding curriculum), (2) curriculum-related learning (learning a content in the curriculum), (3) connection to language skills (developing language skills in a new learning setting), (4) point-by-point connections (some aspects of the museum are related to a part of the curriculum), (5) curriculum unit integration (museum experience is directly related to a content that is currently taught in schools), (6) curriculum unit introduction/review (museum experience before or after teaching a concept), (7) implicit/opportunistic connections (finding connections throughout the curriculum naturally in the museum experience) (p. 950). These ways of connecting to the curriculum would help teachers understand the benefits of field trips. However, Kisiel argues that teachers might not be aware of these connections. Teachers' awareness of this matter is crucial to supporting their professional development in out-of-school education. Several studies in science education have suggested that teachers can be trained in universities by offering them specific courses on informal science education or establishing a partnership with museums for teachers' professional development (Anderson et al., 2006; Kisiel, 2013; Olson et al. 2001).

In this regard, this study aims to design a course on out-of-school mathematics education and examine their perspectives before and after taking this course, which was designed to raise their awareness of out-of-school mathematics education.

Method

The study employs the phenomenology method, a qualitative research method. The current study explores the changing viewpoints of pre-service mathematics teachers toward teaching mathematics in out-of-school learning environments after taking the course "Mathematics Education in Out-of-School Learning Environments". Phenomenology focuses on individuals' experiences and aims to capture the essence of the phenomenon or experience (Merriam & Tisdell, 2016; Yıldırım & Şimşek, 2011), which in this context is the essence of teaching mathematics in out-of-school learning environments.

Research Context and Participants

In Turkey, pre-service middle school mathematics teachers are prepared to instruct students from grades 5 to 8. They are enrolled in a four-year program called the "Elementary Mathematics Teacher Education Undergraduate Program" (EME). Each public university adheres to guidelines established by the Higher Education Council (HEC, 2018), outlining the mandatory and elective courses that students must successfully complete to graduate, although there may be minor variations between universities. Generally, pre-service middle school teachers take elective courses after completing their first year of university study. One of the elective courses offered is "Mathematics Education in Out-of-School Learning Environments (Matematik Öğretiminde Okul Dışı Öğrenme Ortamları)". This study was conducted within the context of this elective course. The participants in the study were 36 pre-service mathematics teachers (30 females, 6 males). The course was attended by second-year (28 students) and third-year (8 students) students from two public universities.

Description of the Course

There were fewer resources on teaching mathematics in out-of-school contexts compared to the sources available for out-of-school science education. The guide provided by the Higher Education Council (HEC, 2018) only outlined the course content, emphasizing the scope and significance of out-of-school education, teaching mathematics in out-of-school environments, methods for out-of-school education, out-of-school environments, and design of educational out-of-school activities. To adequately describe out-of-school mathematics education, the course was designed based on the previous studies on out-of-school learning or informal mathematics education. This study expands on the description of informal mathematics education provided by Nemirovsky et al. (2017), which defined informal mathematics education environments as designed learning environments such as museums. Furthermore, the categorization of Eshach (2007) was adapted to the context of the study. In addition to designed (Nemirovsky et al., 2017) or non-formal learning environments (Eshach, 2007), the current study also includes real-life or everyday life environments including outdoor environments where learning takes place with the presence of an educator. Spontaneous learning in daily life is excluded since the focus of the current study is on teacher education. The studies in out-of-school science education were also reviewed using the keywords of "out-of-school education," "informal education," "outdoor education in mathematics and science," and "connection of informal and formal education". Two major settings for out-of-school mathematics education were identified: (1) real-life environments (Eshach, 2007; Pattison et al., 2007); (2) designed learning environments (Nemirovsky et al., 2017). Drawing upon this review, two types of setting, along with their sub-components, were identified for out-of-school mathematics education, and the course was designed based on research in out-of-school education. The course spanned 14 weeks, excluding exam weeks. Table 1 provides a concise overview of the course content, including specific examples. Participants were required to submit five assignments: (1) A questionnaire at the beginning of the class; (2) an exploration and experience of two real-life applications of mathematics, presensed as a video or image; (3)a design of a lesson plan for out-of-school mathematics education focusing on real-life settings based on their examples from the previous assignment; (4) a design of a lesson plan centered on mathematics museum materials, provided to participants via videos to comprehend their underlying mechanisms; and (5) a questionnaire following completion of the class. Feedback was provided to participants upon submission of their assignments. The present study focuses on the responses to questionnaires completed before and after the class.

Table 1. Content of the Course

Weeks	Topics	Description
Week 1	Introduction of the syllabus	
Week 2	Scope of out-of-school education-1	Description of out-of-school learning by discussing the differences between informal, formal, and non-formal learning, informal education, and informal learning (e.g., Anderson, et al., 2003; Cooper, 2011; Eshach, 2007; Falk & Dierking, 1997; Pattison et al., 2017; Rogers, 2017; Tisza et al., 2020)
Week 3	Scope of out-of-school education-2	Challenges and strengths of out-of-school mathematics education
Week 4	Out-of-school learning environments	Categorization of out-of-school learning environments (e.g., Eshach, 2006; Tisza et al., 2020); Discussion of pre-service teachers' responses in their first assignments submitted at the beginning of the class
Week 5	Teacher role in out-of-school education	Importance of out-of-school education, teachers' role in bridging informal and formal education, and possible challenges faced by the teachers in out-of-school education
Week 6	Connection of mathematics with real-life and its importance	The description of the real-life context in mathematics and its importance (Le Roux, 2008; Stylianides & Stylianides, 2008)
Week 7	Real-life examples of out-of-school education-1	Giving examples of teaching mathematics in daily-life and occupational settings (e.g., grocery shopping, the use of mathematics in occupations such as carpet laying, bricklaying, and design of a building)
Week 8	Real-life examples of out-of-school education-2	Examples of outdoor mathematics education (e.g., tree measurement, car parking, measurement of slope in a ramp for disabled people)
Week 9	Discussion on assignment (real-life contexts for out-of-school mathematics education)	Discussion of pre-service teachers' real-life examples to be used in out-of-school education and their usability for out-of-school mathematics education
Week 10	Education in Science museums and Centers in Turkey	Changing perception of museums, the introduction of Science Museums (Konya and Kayseri Science Centers) and providing examples from the centers by showing pictures and videos to explain how the materials work (e.g., Bridge design and catenary curve, kaleidoscope and mathematics, robotic coding, tangram, tessellations from Islamic art, gear wheels, bridge design in Islamic architecture, geometric structure of graphene, number base system).
Week 11	Science museums abroad and sample activity designs	Introduction of examples from the Science Museum of Minnesota (measurement in human body gallery, mathematics in the exhibits of shadow fractions, scaling shapes). Showing an example of a student worksheet for each exhibit and discussion of their use before, during, and after the visit.
Week 12	Mathematics Museums in Turkey: The Case of Tales Museum	Introduction of mathematics museums by focusing on the mathematics exhibit in Tales Museum in Turkey, discussion of mathematical ideas in the materials by showing the pictures and videos to support it. The materials discussed were Hanoi disks, a manhole cover, a cycloid curve, a colorful hexagon puzzle, a T tangram, a Voronoi diagram, a caeser cipher, limit, Da Vince Bridge, and Napier's bones.
Week 13	Mathematics Museum in Abroad: The Case of MoMath	Introduction of mathematics museums exhibits by showing sample videos from the museum and discussion of mathematical ideas (e.g., square-wheeled trike, Pythagoras puzzler, wall of fire, tessellation station, monkey around, human tree)
Week 14	Art museums in Turkey and abroad, sample activities, and a summary of the course	Examples from art museums, sample activity and students' thinking processes from arts and science centres (Kus & Cakıroğlu, 2021; 2022), the introduction of the digital art museum for out-of-school mathematics education and its design for educational purposes

Data Collection and Analysis

To investigate pre-service mathematics teachers' perspectives before and after taking the course on out-of-school mathematics education, participants were asked to complete two open-ended questionnaires. In essence, participants' responses to open-ended questions were analyzed to understand their initial perspectives on teaching mathematics in an out-of-school learning environment and their evolving (new, revised, and elaborated) perspectives following their participation in the course. The pre-course questionnaire consisted of eight questions, while the post-course questionnaire comprised nine questions (see Table 2). To observe the changes in their responses, the latter questionnaire included nearly identical questions to the first one, with exception of one question regarding their experiences after the course. Pre-service mathematics teachers were encouraged to express their thoughts freely. Before commencing the study, ethical approval was obtained from the Human Research Ethics Committee, and ethical guidelines were strictly adhered to.

The research was conducted at two public universities in Turkey. Two instructors independently facilitated each course. One of the instructors, who is the author of this study, served as both an instructor and researcher in the study. The course duration spanned 14 weeks witin a single semester, with each session lasting approximately one hour. The course was delivered remotely. While instructors shared identical content with participants through the remote education portal, participants had opportunities to pose questions or write their comments within the remote education systems, which were visible to others. Both instructors utilized digital tablets to draw and write on the presentation content and simultaneously directed the classes according to the predetermined schedule and weekly meetings. Participants completed their assignments individually and submitted them through the remote education portal.

Table 2. Questions in the Questionnaires Before and After the Class

	Questions
1	How do you describe out-of-school education? [After: How do you describe out-of-school learning after taking this course?]
2	What are your experiences regarding out-of-school education? Explain briefly with examples. [After: Can you tell about your first-time experiences with out-of-school learning in this course? What was the most interesting thing in this lesson?]
3	Where can you teach mathematics outside of schools?
4	What kind of experiences have you had outside of school regarding mathematics?
5	Answer the following questions below by starting with the statement "When I became a teacher…". *I would use out-of-school education in the teaching of mathematics because…* *I would include out-of-school education in my mathematics class in the following ways: …because…* *I would include out-of-school education in my mathematics class this often… because…*
6	Discuss the strengths and limitations of these out-of-school activities to develop mathematical thinking. Explain the reasons in detail. You can give an example.
7	Please indicate the extent to which you feel competent to use out-of-school education in your teaching of mathematics, with a score between 0-10. Why did you choose such a score?

Open coding (Corbin & Strauss, 2015) was employed to analyze participants' open-ended responses. This exploratory process involves identifying concepts or categorizations that represent the meaning of raw, interpreted data. Based on these categorizations, the frequency of participants' responses was determined both before and after taking the course. While a pre-determined coding scheme was not utilized, the data analysis was not solely based on emergent raw data; it also drew upon research in out-of-school education. To examine participants' perspectives on teaching mathematics in out-of-school education, four major themes were identified: (1) identification of out-of-school environments for mathematics teaching and learning; (2) teaching contexts or examples for out-of-school mathematics education; (3) teaching purposes (motivations) for teaching mathematics in the out-of-school environments; and (4) frequency of teaching mathematics in out-of-school education and their reasons.

Out-of-school learning environments were identified based on a review of studies in out-of-school education. These environments were categorized intp two main themes: real-life settings and designed environments. Teaching contexts for out-of-school mathematics education refer to the specific examples of teaching mathematics in the out-of-school learning environments provided by participants, illustrating how students would engage with mathematics in these settings. Teaching purposes for teaching mathematics in out-of-school education refer to pre-service teachers' motivations for incorporating out-of-school learning environments into their teaching (e.g., Kisiel, 2005). The data analysis also drew upon the work of Jankvist (2009), who identified the whys and hows of using history in mathematics education. This study was interpreted within the context of the present study to determine the purposes for which teachers would utilize out-of-school education in the teaching of mathematics: out-of-school education as a goal (out-of-school education as a goal addresses meta-level issues and involves demonstrating to students mathematics is ubiquitous and the historical evolution of mathematics as a cultural artifact) and as a tool (out-of-school education is regarded as a tool to learn mathematics). Out-of-school education as a tool, which pertains to learning of mathematics, was categorized under three aspects: cognitive, affective, and social aspects. Eshach (2007) classifies it into two dimensions: cognitive (students' knowledge, understanding of concepts) and affective dimensions (attitude and motivation). The frequency of teaching mathematics in out-of-school education refers to teachers' preferred frequency of integrating out-of-school education into their teaching of mathematics. Reasons for their choices emerged from the data that gave clues about their perspectives on the limitations and strengths of out-of-school mathematics education.

After the initial analysis of the data, the author created a coding scheme. The second coder, another researcher in mathematics education, applied this coding scheme to the same data. The reliability of the coding process was ensured through iterative analysis of the data by both the author and second coder (another researcher in mathematics education). Miles and Huberman (1994) suggested that an agreement level above 80% indicates reasonable reliability. In this study, the agreement between the coders was 89.6 %. The coders then discussed the discrepancies in their coding and revised the categories until they reached a consensus. Once the codes and categories were finalized, basic descriptive statistics (frequencies) were calculated. Participants' statements were presented in the findings section using the format P8-B (Participant 8, before the class) and P8-A (Participant 8, after the class).

Findings

Environments for Out-of-School Mathematics Education

There have been notable changes in participants' responses regarding out-of-school environments for mathematics education. Table 3 illustrates the diversity of out-of-school learning environments identified by pre-service mathematics teachers. Prior to the course, their focus was primarily on the daily life settings such as markets and homes, and private tutoring services, which primarily support students' test-based performances. Notably, private tutoring services are not considered an out-of-school learning environment in the context of this study as students are merely encouraged to solve test problems in these environments rather than engaging in novel mathematical experiences. It appears that pre-service teachers initially perceived out-of-school mathematics education as any education that occurs outside of schools, rather than considering the unique nature of out-of-school learning. After completing the course, their focus shifted towards outdoor environments such as parks, schoolyards, science museums, and other designed environments. Notably, a striking finding arising from the study was that they identified mathematics museums as one of the out-of-school mathematics learning environments after the course. Prior to the course, none of the participants had mentioned mathematics museums.

Table 3. Environments for Out-of-School Mathematics Education

	Before the Course	After the Course
	f	f
Real-life environments		
Daily life settings (home, market)	26	24
Out-door settings (parks, forests, schoolyard)	5	22
Occupational settings (pharmacy, construction)	5	6

Museums and other institutional environments		
Mathematics Museum	0	17
Science and Art Museums & Centers	2	13
Other institutions (e.g., Zoo, Planetarium, History Museum, Botanical gardens)	1	10
Others		
Private tutoring, online courses	15	2

A pre-service mathematics teacher's statements before and after the course, for example, were presented as follows:

> *"Mathematics can be learned in a tutoring center, outside of school. It can be learned from the virtual lessons taught independently of tschools. There are some professions that really cannot be done without knowing some simple mathematical calculations. This sort of thing can be learned from these places as well. For example, a carpenter or a construction environment. My last examples may seem strange, but these came to my mind.*
>
> *(P8-B)"*
>
> *"I will mention parks first. Because of the toys and mathematical objects it contains and their designs, the most suitable out-of-school mathematics learning environment seems to me to be a park. Then, of course, I can say mathematics museums. Although rare, such places still increase the desire to learn because of the rich materials and inspirational images. Other workplaces like carpenters come to mind. So at least here, the student can be familiar with various measurements and 3D objects. (P8-A)"*

While he was considering private tutoring and online courses as out-of-school environments before the course, he did not no more identify them as out-of-school learning environments. Instead, he referred to outdoor environments such as parks to investigate the designs of materials in the parks and mathematics museums to explore mathematical ideas. He also gave slightly more detailed information about opportunities for learning mathematics in occupational settings such as measuring objects and exploring three-dimensional objects by imagining himself as a teacher.

Teaching Contexts for Out-of-School Education

When pre-service mathematics teachers were asked about their teaching context for out-of-school mathematics learning environments, their responses differed from their initial identification of these environments. Table 4 summarizes the four major teaching contexts identified by pre-service mathematics teachers: (1) visiting museums and other environments such as historical settings and zoos, (2) organizing out-door activities, (3) organizing in-class activities and after-class activities such as homework (projects), (4) organizing excursions to daily life environments such as markets. Table 5 also shows specific examples of teaching contexts identified by participants before and after the course.

While most of the participants identified teaching contexts as organizing outdoor activities and in-class activities before the course, they did not focus anymore on in-class activities and identified teaching contexts mostly as visiting mathematics museums and organizing outdoor activities. Before the course some participants seemed to perceive out-of-school education as education involving in-class activities in which students are active such as playing games, giving real-life examples while teaching mathematical concepts, and giving projects as homework regarding real-life use of mathematics. A pre-service mathematics teacher stated as follows: "*If I were a teacher, I would include out-of-school learning by giving research assignments, doing activities, giving project assignments, especially individual assignments. Because I don't want my students to be passive in the lessons. I want them to be active."* (P10-B).

Table 4. Teaching Contexts for Out-of-School Mathematics Education

	Before the Course	After the Course
	f	f
Visiting museums and other kinds of environments	8	19
Organizing outdoor activities	10	14
Organizing in-class and after-class activities (e.g., projects)	13	3
Organizing excursions to daily life environments (e.g., market)	4	4
No response or irrelevant response	9	8

Table 5. Specific Examples of Teaching Contexts for Out-of-School Mathematics Education

	Before the Course	After the Course
Visiting museums and other kinds of environments	Creating a graph regarding the number of animals in a zoo	Experiencing mathematical simulations such as fractal trees and 3D models
Organizing outdoor activities	Visiting parks, measuring distances, discovering Pythagoras, and finding geometric shapes in the schoolyard	Collecting the garbage and creating statistical graphs on a nature trip / Measuring the football field in schoolyard, discovering mathematical examples (e.g. golden ratio) in the schoolyard / Exploring geometric shapes through physical activities in the school gym / Exploring the patterns in the leaves in a forest
Organizing in-class activities	Giving real-life examples while teaching a mathematical concept / Playing games / Giving project assignments about the use of mathematics in real life	Giving real-life examples while teaching a mathematical concept
Visiting daily life settings	Visiting markets and learning rate and ratio concepts, and learning to buy affordable products	Visiting markets and learning basic computational skills
No response or irrelevant response	Asking students to study with people in the family	-

Following the course, participants expressed a strong interest in utilizing the resources available at mathematics museums for teaching purposes, citing specific examples such as exploring simulations and models, fractals, and three-dimensional objects. Additionally, they demonstrated a heightened awareness of outdoor mathematics, providing a variety of examples (see Table 6). For instance, a pre-service mathematics teacher's responses before and after the course highlighted this shift in perspective:

> *"If I were a teacher, I would include out-of-school learning in my math class by sending them to the market, shopping, and asking about the number of their toys because talking about the things they love attracts them more. (P35-B)"*

> *"If I were a teacher and could access the museum, I would definitely take my students to a mathematics museum, take them to the gym and have them do activities about shapes that are hard to imagine. Specific geometry concepts are one of the most difficult concepts for students and more difficult to imagine...I used to think of out-of-school learning as just the teacher taking the students to an out-of-school environment and teaching the lesson over the objects there, but I learned that museums are actually one of the out-of-school learning areas, after I started taking this lesson, I became more aware of my surroundings. For example, I would teach square, rectangle, and diagonal concepts in a kinetic way in the school gym, the patterns in the leaves of the trees in a forest, ask my students to*

find an affordable product while shopping, enable them to learn by doing the fractals in the museum and having activities related to 3-dimensional objects outside of school. (P35-A)"

Before the course, this pre-service teacher suggested organizing a trip to the markets or shopping centers as a way to incorporate out-of-school learning into their math instruction. However, after completing the course, their perspective expanded, and they proposed a wider range of more detailed and diverse contexts for teaching out-of-school mathematics education. These contexts included visiting mathematics museums and exploring fractals and other mathematical concepts within the museum environment, using the school gymnasium to engage students in kinesthetic learning of geometric shapes such as squares and rectangles, exploring the patterns in tree leaves in a forest setting, and incorporating real-world applications of mathematics by asking students to find affordable products while shopping.

Teaching Purposes of Out-of-School Mathematics Education

When pre-service mathematics teachers were asked to consider the purposes of teaching mathematics in the out-of-school context, they identified three key aspects: cognitive, affective, and social. Each of these aspects serves as a tool to support students' learning of mathematics (Table 6).

Table 6. Teaching Purposes of Out-of-School Mathematics Education

			Before the Course	After the Course
			f	f
Out-of-school mathematics education as a tool	Cognitive aspects			
		Making mathematics concrete	17	19
		Learning through experience in daily life	13	17
		Connecting with curriculum	5	13
		Supporting mathematical thinking	4	14
	Affective aspects			
		Engaging in math with a positive attitude	10	14
		Increasing interest in mathematics	9	13
		Supporting motivation	4	5
	Social aspects			
		Supporting communication skills	1	1
		Supporting social skills	1	2
Out-of-school mathematics education as a goal		Increasing awareness of math in real life	17	10
		Gaining general cultural knowledge	2	0
		Addressing equity issues in education	1	0

Pre-service mathematics teachers consistently focused more on the cognitive aspect of learning compared to the affective and social aspects, both before and after the course. The social aspects of learning mathematics were the least frequently observed aspect in participants' reflection papers. Their primary motivations for incorporating out-of-school mathematics education included making mathematics more concrete, encouraging students to engage in experiential learning in real-world settings, teaching mathematical concepts that complement the curriculum, and supporting students' mathematical thinking. A significant change was observed regarding the purposes of connecting out-of-school education with curriculum and facilitation of students' mathematical thinking after completing the course. For instance, reflection papers included statements such as "*to reinforce the topic covered, to introduce a new topic"(P18), "to connect curriculum objectives with out-of-school mathematics*" (P36), "*to measure and evaluate students' knowledge by designing activities in an out-of-school setting*" (P3), "*to reinforce students' learning because I believe that the activities done after gaining prior knowledge [about a topic] make learning more permanent*". These statements indicate that some participants aimed to integrate out-of-school education with formal mathematics education for assessment, reinforcement, and warm-up engagement purposes. Furthermore, after the course, pre-service mathematics teachers more frequently mentioned supporting mathematical thinking skills and processes such as estimation skills, spatial thinking, problem-solving, connecting, and reasoning. The following quotations from one of the participants illustrate her motivations for teaching mathematics in the out-of-school context from affective and cognitive perspectives:

> *"It [out-of-school mathematics education] makes learning more permanent. It increases students' attention, interest, and motivation. It enables them to have a positive attitude toward the lesson and the subject. As students see new environments, their horizons expand and they gain new ideas. It provides learning by doing. For these purposes, I would incorporate out-of-school learning into mathematics education. (P28-B)"*

> *"It [out-of-school mathematics education] provides efficient, permanent, learning by doing. It enables students to make connections with life. It develops students' spatial skills. It enables students to learn effectively while having fun. It enables students to develop strategies such as estimating, reasoning, making connections, problem-solving, discussion, and brainstorming. Since it provides a novel way of learning, it increases students' motivation by attracting their interest. It enables the student to have a positive attitude toward the school, the lesson, and the subject. It enables students to realize that there is mathematics outside of school as well. (P28-A)"*

The quotations show that she addressed affective aspects such as increasing interest and motivation and having a positive attitude before and after the course. After the course she seemed to have extended her opinions by considering students' mathematical thinking processes (e.g., spatial thinking, reasoning, connecting), and their awareness regarding the existence of mathematics in real life, which included both perspectives of out-of-school mathematics education as an aim and a goal.

While the number of participants who viewed out-of-school mathematics education as a goal was not high as those who saw it as a tool, some participants referred to out-of-school mathematics education as an overall goal. They emphasized the importance of increasing students' awareness of the ubiquity of mathematics in real life, broadening their general knowledge of culture, and providing equitable educational opportunities for all student. One participants stated, "*I would like to encourage my students to see mathematics as a way of life, not just a lesson. I would like to show my students that math is everywhere in our lives."* (P15-B).

Frequency of Teaching Mathematics in Out-of-School Environments and Their Reasons

Approximately half of the participants expressed their preferred frequency for teaching mathematics in out-of-school environments, specifying frequencies such as 3-5 times a week and 1-2 times a week. A small number of participants indicated a desire to teach too often (3-5 times a week) and too seldom (1-2 times a year), both after and before the course. Among participants who provided specific frequencies for out-of-school mathematics instruction, the majority (30 %) preferred teaching mathematics in out-of-school environments 1-2 times a week before the course. Conversely, after the course, this percentage decreased, with nearly half of the participants (47%) preferring to teach mathematics in out-of-school environments 1-2 times a month. This suggests a shift towards less frequent out-of-school mathematics education compared to pre-course preferences. For example, one pre-service mathematics teacher initially considered teaching in out-of-school environments "*at least one time in a week*" but later modified their preference to one or two times a month after completing the course (P26).

Table 7. Frequency of Teaching Mathematics in Out-of-School Environments

	Before the Course	After the Course
	f	f
Precise frequency		
Often (3-5 times a week)	2	0
Usually (1-2 times a week)	12	3
Sometimes (1-2 times a month)	6	17
Seldom (1-2 times a year)	1	0
Imprecise frequency	19	16

On the other hand, nearly half of them did not specify how often they would teach mathematics in out-of-school environments; instead, they described the conditions under which, when, or how often they would teach, or they used general expressions such as "*often*". For example, before the course, one of the pre-service teachers

(P33) stated she could teach mathematics "*often*" in the out-of-school context. After the course, she revised her opinion to "*one time in six weeks*".
An analysis of the participants' responses regarding their preferred teaching frequency revealed four major factors influencing their preferences/decisions (Table 8): (1) External factors, (2) factors related to the nature of mathematics and the mathematics curriculum, (3) teaching-related factors, and (4) students-related factors. Table 9 presents the type of factors and the number of participants who mentioned them in their reports before and after the course, highlighting an increase in the identification of conditions, particularly concerning teaching-related factors, following the course.

Table 8. Reasons for Frequency of Teaching Mathematics in Out-of-School Environments

	Before the Course	After the Course
	f	f
External factors		
Administrator's viewpoint	0	2
Permission issues and other procedures	3	4
Economic and physical conditions	5	7
Transportation	1	2
Weather conditions	2	0
Total	11	15
Factors regarding the nature of mathematics and curriculum		
Compatibility with all mathematical concepts and processes	3	8
Teaching-related factors		
Instructor presence	1	0
Implementation frequency	1	3
Management	0	9
Pedagogical requirements and instructional load	2	4
Time requirement	2	7
Waste of time	0	1
Variability in teaching regarding different out-of-school contexts	2	2
Total	8	26
Student-related factors		
Only for certain groups of students	0	3
Students' readiness	1	9
Students' affective characteristics	1	4
Total	3	18
None		
There is no limitation	1	2
Unanswered	16	3

Although nearly half of the participants (16 of 36) refrained from expressing an opinion on this matter, this number declined following the course. Pre-service mathematics teachers provided more detailed information about the conditions of teaching in an out-of-school environment, considering various factors ranging from external to student and teaching-related aspects. According to Table 9, after the course, participants identified more teaching and student-related factors compared to those identified before the course. Significant differences emerged regarding the recognition of teacher-related factors, particularly concerning time constraints and difficulties in managing out-of-school activities. Both before and after the course, participants acknowledged external factors such as physical, economic, administrative issues as limitations to teaching mathematics in out-of-school learning environments. For example, one of the pre-service mathematics teachers (P8), who revised his view after the course on how often he could teach mathematics in out-of-school environments from one or two times a week to one time in a month, highlighted several factors such as teaching-related aspects like class management and external factors like economic conditions and material requirements. Before the course, he did not consider any limitations regarding teaching mathematics in the out-of-school context. His reflections before and after the course were presented as follows:

"I wouldn't do it [out-of-school activity] very often. Maybe once or twice a week. The reason is that students should not completely be accustomed to the outside of the school. Of course, out-of-school learning will be more comfortable and fun than in-school learning…I don't think there will be a limitation. On the contrary, they [out-of-school activities] have strengths. When the student receives information in a different way in out-of-school education and processes information in an unfamiliar way, he/she always remembers this [information]…

(P8-B)"

"I would include out-of-school education once a month in my teaching of mathematics because it is neither frequent nor infrequent. It is very difficult to do this every day... Doing it every week can also boring for the students in the same way. If we do it once a year, it would be less…As a result, due to the fact that it is not done very often, almost every student does not forget such activities [out-of-school activities]. They always create a desire to learn constantly by transferring what they gain from such activities into their lives. The only weakness is that low-income schools cannot afford this, perhaps due to the cost of the materials. That's why such activities are either done sometimes or not at all. As another limitation, when such activities are carried out in crowded classrooms, there may be confusion and the teacher may not be able to keep his/her students together…(P8-A)"

Another notable difference between pre- and post-course emerged in relation to student-related factors, reflecting a shift in their perception of out-of-school education from a student-centered perspective. They considered their students' readiness, affective characteristics, learning styles, and participation in out-of-school education. For example, P33 expressed concern that such out-of-school activities might only attract a specific group of students, those lacking positive attitudes towards mathematics, or yet to discover its real-world applications of mathematics, stating "…*Since out-of-school activities would be more ordinary for the students without prejudice [towards mathematics], it may not contribute to students' development. Likewise, while the activities are more surprising for the student who has not discovered the mathematical situations in daily life before, the activities may be more ordinary for the students who have already discovered.*" Following the course, pre-service mathematics teachers broadened their considerations beyond student- and teaching-related factors to encompass aspects related to the nature of mathematics and mathematical learning environments, particularly the compatibility of out-of-school activities with a diverse range of mathematical concepts and processes. However, the number of participants identifying this factor remained relatively low compared to other factors.

Conclusion, Discussion, and Recommendations

This study investigated pre-service mathematics teachers' perspectives on teaching mathematics before and after a course designed to support their professional development in the burgeoning field of out-of-school mathematics education.

One of the striking findings was that there have been changes in participants' identification of out-of-school mathematics environments after the course. They seemed to perceive out-of-school mathematics education as any education that takes place outside of schools, including daily life places such as markets and homes, and private tutoring services rather than thinking of the nature of out-of-school learning. This finding is consistent with previous studies in mathematics (Aydoğdu et al., 2023) and science education (Bostan-Sarıoğlan & Küçüközer, 2017). Pre-service science teachers and mathematics teachers identified out-of-school education environments as private tutoring services, named dershane, and daily life places such as a home in addition to museums, parks, and historical places. Eshach (2007), however, argues that the distinction between formal and informal learning is not just about physical setting (in or out-of-school), but also about other factors such as nature of learning (e.g., hands-on experience, interaction with materials), motivation, and social context. This finding indicates participants' limited conceptualization of out-of-school environments before the course. The reason of such a conceptualization would be that they might have had limited experiences in out-of-school learning environments in their previous schools and might not have visited designed-learning environments before taking the course. Although the number of mathematics museums is increasing all around the world including in Turkey (Duatepe-Paksu, 2019), pre-service mathematics teachers did not mention mathematics museums or mathematics-themed exhibits in science museums before the course. They, after the course, focused more on the outdoor environments such as parks, schoolyards and designed environments such as science museums, and other kinds of environments, particularly paying attention to mathematics education, which was not mentioned before the course. Having opportunity to see various examples of interactive materials of museums in Turkey and abroad during the class and of outdoor activities might have resulted in such a change. This finding suggests that pre-service teachers' exposure to a variety of out-of-school learning settings could broaden their horizons on out-of-school mathematics learning environments.

In line with the identification of out-of-school mathematics education environments, the teaching contexts for outdoor mathematics education seemed to be slightly more diverse and richer after the course. For instance, after the course, pre-service teachers identified several teaching contexts such as measuring the football field in the schoolyard, arranging a nature trip, collecting garbage and creating statistical graphs (e.g., Watson et al., 2011), exploring the patterns in the leaves in a forest (e.g., Moss, 2009), and exploring geometric shapes such as squares and rectangles in an embodied way in the school gym. Even though some of the examples were not mentioned in the course, they seemed to envision new and novel contexts for teaching mathematics. The examples provided in the course might have evoked new examples of out-of-school mathematics in their minds. Additionally, they suggested not just visiting a mathematics museum, but also preparing mathematical exhibitions. The examples given by participants were more detailed and diverse after the course. One of the reasons for such a change could be that they were introduced to various examples of educational contexts to support students' mathematical thinking and learning. Additionally, asking pre-service teachers to explore real-life contexts to adapt to the context of out-of-school education and design educational activities would have enabled them to consider different contexts and elaborate on their ideas. After the class, they did not mention in-class activities such as giving projects as homework or giving real-life examples while teaching mathematical concepts because they were not given as examples of out-of-school education in the course. Furthermore, they added new examples regarding the interactive experience of mathematics, such as mathematical simulations. This might be due to the fact that they watched interactive videos regarding the materials in mathematics museums during the course. These findings show that offering such educational training on out-of-school education, especially in universities, would help pre-service mathematics teachers to become aware of such environments and contribute to their professional development even if they have not visited them yet, consistent with the studies in science education (Kisiel, 2013; Olson et al., 2001) where teachers became aware of their role during field trips.

Another finding arising from the study was about pre-service mathematics teachers' motivations (purposes) to teach mathematics in out-of-school education. Consistent with the model proposed by Eshach (2007), this finding showed that pre-service mathematics teachers recognized three major aspects of out-of-school education: cognitive, including instructional aspects, affective, and social aspects of out-of-school education. These findings are also complementary to the findings of Kisiel (2005), in which Kisiel examined science teachers' motivations during visits to science centers (learning science concepts, having novel experiences, supporting students' interest and motivation, and engaging in enjoyable activities). However, they did not seem to pay attention to the physical or aesthetic aspects of such environments (Eshach, 2007; Kelton & Nemirovsky, 2022). This could be due to the fact that they did not have any physical experience of visiting a mathematical museum or experience of teaching mathematics in out-of-school learning environments during the course because the course was online. They only watched videos regarding materials in science centers and mathematics museums. This finding highlights the importance of field trips to out-of-school learning environments and suggests that field trips should be a crucial part of out-of-school mathematics education to experience the physical and aesthetic aspects of the environments. Furthermore, pre-service teachers should be given opportunities to practice in informal settings. For example, when pre-service teachers had practicum experience in an aquarium, they developed a broader view of education that extended their narrow understanding of science education (Anderson, Lawson, & Mayer-Smith, 2006). Pre-service training in informal settings is crucial within the scope of museum-school partnerships to build confidence and understand the value of out-of-school education (Nichols, 2014).

Participants primarily referred to out-of-school mathematics education as a tool to support students' mathematical thinking and learning. They rarely conceptualized out-of-school mathematics as a goal that provides a meta-perspective involving the historical evolution of mathematics as a cultural knowledge, the appreciation of mathematics everywhere, and different images of mathematics. Since the course generally focused on promoting students' mathematical thinking and learning, pre-service mathematics teachers might not have difficulty perceiving the role of out-of-school education from a meta-perspective. The current design of this course could be revised by placing more emphasis on both aspects of out-of-school mathematics education (as a goal and as a tool), which would help them understand why out-of-school mathematics education is needed. Regarding the role of out-of-school as a tool in mathematics education, pre-service mathematics teachers became more aware of connections with the curriculum, such as gaining hands-on experience regarding the curriculum, learning content in the curriculum, and curriculum unit introduction/review, which are identified in the study by Kisiel (2005) and aimed to develop students' mathematical thinking. These two findings can be considered as evidence that they started to question how they could incorporate out-of-school mathematics education into their regular schedules. This might be due to the fact that they were asked to design educational activities as assignments. Even though they were not asked to connect with curricular standards, they tended to relate the educational activities that they designed with the curriculum. While the connection between museum experience and school curriculum is suggested (Price & Hein, 2007), recently Nemirovsky et al. (2017) have discussed the need for informal mathematics education that is different from traditional school programs rather than focusing on curriculum standards. Thus, it is essential to design educational programs for teachers so that they can follow a different approach than traditional educational programs.

The last major finding is that almost half of the participants (47%) preferred to teach mathematics in out-of-school environments 1-2 times a month, which was a significant decrease from 1-2 times a week before the course. The factors mentioned by the participants, such as external factors, students, and teacher-related factors, could explain this change. This finding is consistent with the three-factor model of Orion and Hofstein (1994), which included teaching factors (e.g., quality of teachers), field trip factors (e.g., weather conditions), and student factors (e.g., students' previous knowledge) affecting learning during field trips. This finding supports pre-service teachers' awareness of potential strengths and weaknesses and their critical thinking about it, rather than simply having arguments without evidence as they did before the class. On the other hand, their limited experience of physically visiting designed informal learning environments in the course might also have led them to be overly critical about out-of-school education. If they are given opportunities to practice teaching in out-of-school settings, they could build confidence in teaching in such settings (e.g., Anderson, Lawson, & Mayer-Smith, 2006). Thus, they should be given more opportunities to practice teaching at such settings and discuss not only its strengths, but also its limitations.

This study contributes to the field of out-of-school mathematics education in two significant ways. The first major contribution is the design of an online accessible educational course informed by research on out-of-school science education (Eshach, 2007; Kisiel, 2005; 2013) and out-of-school mathematics education (Nemirovsky et al., 2017; Pattison et al., 2017). This course aims to support pre-service mathematics teachers' training in the emerging field of out-of-school mathematics education. Unlike previous studies that simply identify pre-service teachers' perspectives, opinions, or perceptions (e.g., Aydoğdu et al., 2023), this study proposes a comprehensive and novel content for teaching in out-of-school mathematics education. This content is enriched by providing specific, detailed, and wide-ranging examples of out-of-school mathematics education in Turkey and around the world. Additionally, the study attempts to conceptualize out-of-school mathematics education and learning environments. This comprehensive course content can be utilized by curriculum developers, museum educators, and policymakers to design further training for teachers. Furthermore, this study contributes to the field of out-of-school mathematics education, particularly in the area of teacher education. Studies in this field are relatively limited. By exploring pre-service teachers' perspectives on teaching mathematics in out-of-school learning environments and offering a course on this topic, this study serves as a starting point for supporting the professional development of teachers in this emerging field of education.

The findings of the study should be interpreted within the context of its limitations. The findings may not be generalizable to all pre-service mathematics teachers or applicable to other similar contexts, such as museum educators and in-service teachers. The course designed in the current study can be adapted to train in-service teachers across the country regarding out-of-school mathematics education by increasing the number of participants and by employing quantitative methods. While this online course is easily accessible to pre-service mathematics teachers, it could be further enhanced by incorporating additional experiences, such as museum visits and group student activities, if feasible. Future research could also explore avenues for collaboration between museum and science center staff, educators, teachers, and universities. The findings of the study could contribute to the advancement of research on teacher education in out-of-school mathematics education.

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GENİŞLETİLMİŞ ÖZET

Okul dışı öğrenmenin önemi özellikle fen eğitimi alanında çok sayıda araştırmacı tarafından vurgulanmıştır (Dierking, Falk, Rennie, Anderson, & Ellenbogen, 2003; Eshach, 2007; Kisiel, 2013). Matematik eğitiminde ise, fen eğitimi alanına kıyasla okul dışı matematik eğitimi gelişmekte olan ve büyümekte olan bir alan olarak görülmektedir (Nemirovsky, Kelton, & Civil, 2017). Türkiye'de ve tüm dünyada matematik müzeleri ve matematik temalı etkileşimli sergilerin sayısı artmaktadır (Duatepe-Paksu, 2019). Okul dışı eğitimindeki bu tip gelişmelere rağmen, Nemirovsky ve diğerleri (2017) Amerika Birleşik Devletleri'nde informel öğretim eğitimcilerine yönelik profesyonel bir eğitim olmadığını tartışarak informel matematik eğitiminin doğasını anlamlandıran eğitimcilere ihtiyaç olduğunu vurgulamaktadır. Türkiye'de Yükseköğretim Kurulunun (YÖK, 2018) üniversitelerde matematik öğretimi için "Matematik Öğretiminde Okul Dışı Öğrenme Ortamları" seçmeli dersini müfredata dahil etmesi de öğretmen eğitiminin bu bağlamda önemine dikkat çekmektedir. Öğretmen adaylarının eğitimlerinin, üniversiteler tarafından okul dışı öğrenmeyi deneyimlemelerine yardımcı olacak dersler düzenlenerek desteklenebileceği ifade edilmiştir (Anderson ve diğerleri, 2006; Olson ve diğerleri. 2001). Bu tür mesleki eğitimler, öğretmen adaylarının müze ve park gibi okul dışı ortamlarla erken tanışmalarına ve bu tür ortamlarda öğrenmeye ilişkin algılarını genişletmelerine yardımcı olabileceği belirtilmiştir (Kisiel, 2013). Bu bağlamda, bu çalışma, matematik öğretmen adaylarının okul dışı matematik eğitiminde mesleki eğitimlerini desteklemek için fen ve matematik eğitimindeki çalışmaları dikkate alarak bir ders tasarlamayı ve bu ders kapsamında okul dışı öğrenme ortamlarında matematik öğretimine yönelik bakış açılarını incelemeyi amaçlamıştır.

Araştırmada nitel araştırma yöntemlerinden fenomenoloji yöntemi kullanılmıştır. Fenomenoloji yöntemi, insanların deneyimlerine odaklanmakta olup bir olgu veya deneyimin özünü betimlemeyi içermektedir (Merriam, 2016; Yıldırım ve Şimşek, 2011). Bu bağlamda, bu araştırma, matematik öğretmeni adaylarının "Okul Dışı Öğrenme Ortamlarında Matematik Eğitimi" dersini aldıktan sonra okul dışı öğrenme ortamlarında matematik öğretimine yönelik bakış açılarını incelemeyi amaçlamıştır. Araştırmanın katılımcılarını, iki devlet üniversitesinde Matematik Öğretiminde Okul Dışı Öğrenme Ortamları dersine kayıt yaptıran 36 matematik öğretmen adayı (30 kadın, 6 erkek) oluşturmaktadır. Derse 2.sınıf ve 3.sınıf öğrencileri (28 kişi 2.sınıf, 8 kişi 3.sınıf öğrencisi) kaydolmuştur. Okul Dışı Öğrenme Ortamlarında Matematik Eğitimi dersinin içeriği alan yazındaki araştırmalar çerçevesinde tasarlanmıştır. Bu araştırma, Nemirovsky ve diğerlerinin (2017) müze, bilim merkezi gibi tasarlanmış öğrenme ortamlarını informel matematik eğitimi ortamları olarak ele aldığı çalışmayı genişleterek, Eshach (2007) okul dışı öğrenme ortamlarına yönelik yapmış olduğu kategoriyi çalışmanın bağlamına uyarlamıştır. Bu çalışmalar çerçevesinde, okul dışı matematik eğitimi için iki temel ortam belirlenmiştir: (1) gerçek yaşam ortamları (günlük yaşam mekanları, iş yerleri, açık hava ortamları) (Eshach, 2007; Pattison ve diğerleri, 2007); (2) tasarlanmış öğrenme ortamları (müze, bilim merkezleri vb.) (Nemirovsky ve diğerleri, 2017). Okul dışı matematik eğitimi dersini almadan önce ve aldıktan sonra matematik öğretmeni adaylarının bakış açılarını araştırma için katılımcılardan iki açık uçlu anketi yanıtlamaları istenmiştir. Açık kodlama (Corbin & Strauss, 2015) tekniği ile, katılımcıların açık uçlu yanıtları analiz edilmiştir. Önceden belirlenmiş bir kodlama şeması olmamasına rağmen, veri analizi sadece ortaya çıkan ham verilere dayanmıyordu. Aynı zamanda okul dışı eğitime yönelik çalışmalara da dayanmaktadır (e.g., Eshach, 2007; Jankvist, 2009; Kisiel, 2005). Katılımcıların okul dışı eğitimde matematik öğretimine ilişkin bakış açılarını analiz etmek için dört ana tema belirlenmiştir: (1) matematik öğretimi ve öğrenimi için okul dışı ortamların belirlenmesi (2) okul dışında matematik eğitim için öğretim bağlamları veya örnekleri, (3) okul dışı ortamlarda matematik öğretimi için öğretim amaçları (motivasyonları) ve (4) okul dışı eğitimde matematik öğretiminin sıklığı ve nedenleri. Kodlamanın güvenilirliği, yazar ve ikinci kodlayıcı (matematik eğitiminde başka bir araştırmacı) tarafından verilerin yinelemeli analizi ile sağlanmıştır. İki kodlayıcı arasındaki uyum %89,6'dır. Miles ve Huberman'a (1994) göre, yüzde 80'in üzerinde olan uyum makul güvenilirlik sağlamaktadır.

Araştırmanın çarpıcı bulgulardan biri, ders sonrasında katılımcıların belirlediği okul dışı matematik öğrenme ortamlarındaki değişimlerdir. Okul dışı matematik eğitimini, okul dışında gerçekleşen herhangi bir eğitim olarak belirlemişlerdir. Bu bulgu matematik eğitimi (Aydoğdu, Aydoğdu ve Aktaş, 2023) ve fen eğitimindeki (Bostan-Sarıoğlan ve Küçüközer, 2017) önceki çalışmalarla tutarlıdır. Fen bilgisi öğretmen adayları ve matematik öğretmenleri okul dışı eğitim ortamlarını dershane gibi etüt merkezleri, ev gibi günlük yaşam mekanları ile müze, park, tarihi yerler olarak belirlemişlerdir. Ancak Eshach (2007), örgün ve yaygın öğrenme arasındaki ayrımın sadece fiziksel ortam (okul içi veya okul dışı) ile ilgili olmadığını, aynı zamanda öğrenmenin doğası (ör. malzemelerle etkileşim), motivasyon ve sosyal bağlamında önemli olduğunu ifade etmiştir. Bu, katılımcıların ders öncesi okul dışı ortamlara ilişkin sınırlı anlayışlarını göstermektedir. Türkiye de dahil olmak üzere tüm dünyada matematik müzelerinin sayısı artmasına rağmen (Duatepe-Paksu, 2019), matematik öğretmeni adayları matematik müzelerinden veya bilim müzelerindeki matematik temalı sergilerden ders öncesinde bahsetmemiştir. Okul dışı matematik eğitimi ortamlarının belirlenmesi ile paralel olarak, okul dışı matematik eğitimine yönelik öğretim bağlamları, matematik öğretmen adayları tarafından dersten sonra biraz daha çeşitli ve içerik olarak daha zengin olarak ifade edilmiştir. Örneğin, öğretmen adayları ders sonrasında okul bahçesindeki futbol sahasını ölçmek, doğa gezisi düzenlemek, çöp toplamak ve istatistiki grafikler oluşturmak (ör., Watson, vd., 2011), ormanda toplanan yaprakların şekillerindeki örüntüleri belirlemek (ör., Moss, 2009) ve okul spor salonunda kare, dikdörtgen gibi geometrik şekilleri somut bir şekilde keşfetmek (ör. Nemirovsky vd., 2013) gibi birçok öğretim bağlamı belirlemişlerdir.

Araştırmadan elde edilen üçüncü önemli bulgu, matematik öğretmeni adaylarının okul dışı öğrenme ortamlarında matematiği öğretme amaçlarına ilişkin olup, Eshach (2007) tarafından önerilen modelle tutarlı olarak, matematik öğretmeni adayları okul dışı öğrenme ortamlarında matematik öğrenimini bilişsel, duyuşsal ve sosyal yönlerden desteklemeyi amaçlamışlardır. Bu bulgular aynı zamanda Kisiel'in (2005) bilim merkezlerini ziyaretleri sırasında fen bilimleri öğretmenlerinin motivasyonlarını inceleyen bulgularını da tamamlayıcı niteliktedir. Özellikle, okul dışı öğrenmeyi müfredatı destekler nitelikte kullanmayı amaçlamaları ders sonrasında gözlenen önemli bir değişikliktir. Katılımcıların neredeyse yarısı (%47) haftada 1-2 olmak üzere okul dışı öğrenmeye yer vermeyi ders öncesinde planlarken, ders sonrasında ayda 1-2 kez okul dışı ortamlarda matematik öğretmeyi tercih etmiştir. Bu bulgu öğretmen adaylarının okul dışı öğrenmenin güçlü ve zayıf yönlerin farkında olmaya başladıklarının bir göstergesi olarak görülebilir.

Bu çalışma, matematik eğitiminde oldukça yeni ve gelişmekte olan bir alan olan okul dışı matematik eğitimine ders içeriği ile katkı sağlayarak, öğretmen eğitiminde yapılacak çalışmalara ışık tutacağı ön görülmektedir. Araştırmanın bulguları, araştırmanın sınırlılıkları içinde yorumlanmalıdır. Araştırmanın bulguları, tüm matematik öğretmeni adaylarına, müze eğitimcilerine ve öğretmenlere genellenebilir değildir. Mevcut çalışmada tasarlanan ders, çevrimiçi ve erişilebilir bir ders olması nedeniyle katılımcı sayısını artırarak ve nicel yöntemlerden de yararlanarak okul dışı matematik eğitimi konusunda ülke genelinde hizmet içi öğretmenleri yetiştirmek için kullanılabilir.