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Research Article

The use of Thinglink Web 2.0 Tool in out-of-school learning environments in mathematics teaching: Pre-service teachers' experiences

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The aim of this study is, examining the experiences of the pre-service mathematics teachers (PMTs) on the use of Thinglink in out-of-school learning environments in mathematics teaching. Within this study, a descriptive case study methodology was employed. This study was conducted during the 2022-2023 academic year and involved a total of 60 pre-service mathematics teachers, consisting of 49 females and 11 males. The participants were PMTs who were in their sixth semester and were enrolled in the 'Out of School Learning Environments' course at a university. Within the scope of the study, the 11-week part of the 'Out of School Learning Environments' course was conducted theoretically, and the 3-week part included presentations containing Out-of-School Learning Activities Designed Using Thinglink prepared by PMTs. The data utilized in this study emanates from two primary sources: Out-of-School Learning Activities Designed Using Thinglink [OSLADTs] and course materials, including lesson plans, worksheets, and brochures, all of which were developed by PMTs. Content analysis was employed to assess the alignment of the OSLADTs and course materials (lesson plans and worksheets), created by PMTs, with the criteria established by Bunting (2006) for defining out-of-school learning activities. In conclusion, this study underscores the positive impact of OSLADTs on mathematics education when effectively integrated into the curriculum by PMTs. The findings suggest that OSLADTs hold significant potential for enhancing students' engagement, understanding, and appreciation of mathematical concepts.

Keywords: Thinglink, out-of-school learning, mathematics education, pre-service teachers

1. Introduction

Learning is considered under three headings: formal, informal and non-formal learning. Formal learning refers to learning that is associated with the education system, which is generally carried out in schools, compulsory, curriculum-based, structured, teacher-led, and associated with the education system (Bozkurt & Ucar, 2021; Dib, 1988; Eshach, 2007; Johnson & Majewska, 2022; Melnic & Botez, 2014). Non-formal learning, on the other hand, is learning that takes place in institutions outside the school, is pre-arranged, is carried out under the leadership of a teacher or guide, and learning is generally not assessed (Bozkurt & Ucar, 2021; Dib, 1988; Eshach, 2006; Melnic & Botez, 2014; Nygren et al., 2019). Although formal and non-formal learning are partly similar, the main difference between the two is that non-formal learning is usually voluntary, takes place in learning environments outside the classroom (laboratory, museum, school garden, etc.) and student participation is not compulsory (Nygren et al., 2019). Formal education often needs to be supported by non-formal learning experiences (Dib, 1988; Melniz & Botez, 2014). As can be understood from these statements, the non-formal education model has a flexible content and is usually adapted to the needs of the participants (Bozkurt & Ucar, 2021). Informal learning, on the other hand, unlike formal and non-formal learning, refers to learning that is unstructured, motivation is completely intrinsic, voluntary, learner-led, learning is not evaluated, non-gradual and spontaneous (Bozkurt & Ucar, 2021; Eshach, 2007). Although informal learning is quite different from formal and non-formal learning, in some cases it can be closely related to both (Dib, 1988; Melnic & Botez, 2014). For example, it is present in the institutional context, inside and outside formal education, but when informal learning takes place in educational institutions, it is not based on classroom activities and is not necessarily structured (Melnic & Botez, 2014; Nygren et al., 2019). Therefore, it can be stated that informal learning does not conform to a regular and systematic understanding of education (Melnic & Botez, 2014), and in fact, it is precisely in this respect that schools have gained even greater importance at a time when they are limited in meeting all of society's needs for science (Şen, 2021). As a matter of fact, today, with the effect of developments in information and communication technologies, people are more curious about learning and mostly learn spontaneously and out of school (Bozkurt & Ucar, 2021). Although the terms out-of-school learning and informal learning can often be used interchangeably in the literature (Eshach, 2007), out-of-school learning does not mean formal learning or informal learning alone (Çağlakpınar, 2022). Yet, out-of-school learning, like informal learning, can be considered as a supporter and complement to formal and non-formal learning (Haidari, 2023; Johnson & Majewska, 2022). Out-of-school learning can be defined as guided trips and activities carried out in a planned and programmed manner in environments outside the school in line with predetermined outcomes etc. related to a discipline area (Haidari, 2023; Lâçin Şimşek, 2011). As can be understood from this definition, out-of-school learning includes all activities carried out outside the classroom to enrich the educational curriculum and refers to the learning life and products that progress with the student's own efforts and decisions in the socio-cultural field (Bolat & Köroğlu, 2020). For example, school gardens, city parks, museums, science centres, botanical gardens, farms, nature parks, residential centres and natural landscapes can be considered as out-of-school learning environments (Haidari, 2023; Remmen & Iversen, 2022).

The basic philosophy of the out-of-school teaching approach is that individuals learn by doing and experiencing through their own experiments, examinations, and discoveries (Çağlakpınar, 2022). In this respect, it is understood that out-of-school learning overlaps with the constructivist learning philosophy that is widely adopted today. The goal of strengthening knowledge and skills in various curriculum areas that come to the fore with the constructivist philosophy has created the understanding that using knowledge in a context other than the isolated subject area in which it is presented provides a unique context for that knowledge or skill (Bunting, 2006). In this context, both its relationship with constructivist philosophy and the understanding that learning should not be limited to the four walls have led to an increase in the number of studies on out-of-school learning. These studies have revealed many benefits of out-of-school learning environments. Among the benefits of out-of-school learning environments are students' attitude (Behrendt & Franklin, 2014; Demircioğlu & Aslan, 2018; Eshach, 2007; Schneiderhan-Opel & Bogner, 2021), motivation (Behrendt & Franklin, 2014; Bolat & Köroğlu, 2020; Demircioğlu & Aslan, 2018; Sarıoğlan & Küçüközer, 2017; Schneiderhan-Opel & Bogner, 2021), learning potential (Schneiderhan-Opel & Bogner, 2021), academic achievement (Behrendt & Franklin, 2014; Hamilton-Ekeke, 2007), cognitive, affective and social skills (Rickinson et al., 2004), meaningful, effective and permanent learning (Bolat & Köroğlu, 2020; Sarıoğlan & Küçüközer, 2017; Sontay et al., 2016; Ulu, 2019) and promoting 21st century skills (Büyükkurt, 2023; Demircioğlu & Aslan, 2018; Öztürk & Bozkurt Altan, 2018). On the other hand, out-of-school learning environments provide naturally occurring opportunities for teachers and students to perceive and understand interrelationships and interconnections (Bunting, 2006), with opportunities such as hands-on work and exposure to different phenomena (Henriksson, 2018). Thus, effectively designed, planned, taught and monitored out-of-school learning environment activities will provide students with opportunities to develop their knowledge and skills in a way that adds value to their daily experiences in the classroom (Dillon et al., 2006). From this point of view, it can be stated that out-of-school learning environments offer a more flexible environment to support teachers' teaching and to increase the quality of teaching by enabling students to construct knowledge through concrete experiences, and therefore, their integration into teaching environments is important. As mentioned above, there are many out-of-school learning environments that can be utilised instructionally. One of these out-of-school learning environments is digital environments (Şen, 2021). As a matter of fact, with the effect of the developments in information and communication technologies today, people are more curious about learning and learn mostly spontaneously and incidentally in digital environments, just like in out-of-school learning environments (Bozkurt & Uçar, 2021). Especially considering the educational potential of Web 2.0 technologies, it should not be forgotten that these technologies are already part of the out-of-school learning environment for learners (Luckin et al., 2008).

The term Web 2.0, which has rapidly consolidated its place on the agenda in recent years, is defined as "a social phenomenon that adopts an approach to producing and distributing web content, characterised by open communication, decentralisation of authority and freedom to share and reuse" (Collis & Moonen, 2008). The introduction of Web 2.0 tools has brought a global dimension to education, economy, and scientific projects (Başaran & Kızılınçarslan, 2021). Web 2.0 tools have revolutionised many points from accessing information to storing and even sharing information. In this context, the development of Web 2.0 tools can be considered as a technological innovation that supports the change in the education system and can be easily used (Elmas & Geban, 2012). The most important advantage of Web 2.0 tools is that they encourage teachers and students to go outside the classroom and become information sharers (projects, environments, ideas and connections) worldwide (Horzum, 2010). As a matter of fact, students who use Web 2.0 tools are transformed from individuals who only consume the information given in the classroom to an active student group who produce, manipulate, question the source of information and produce new information (Elmas & Geban, 2012). Therefore, it is understood that Web 2.0 technologies offer flexibility by encouraging interaction between in-school and out-of-school spaces and environments (Glowinski & Bayrhuber, 2011; Luckin et al., 2009). Despite this, studies have revealed that there are very few studies on the integration and use of Web 2.0 tools in out-of-class education programmes (Bolliger & Stepherd, 2017; Kulakli & Mahony, 2014). For this reason, for those of us who are interested in exploring how Web 2.0 technologies can better support learning, it has become important to question what kind of skills and activities can support learning in formal and informal settings prepared through Web 2.0 technologies (Luckin et al., 2009). Thinglink, one of the many different Web 2.0 tools used for educational purposes today, attracts attention with its very intuitive interface (Batista et al., 2022). Thinglink is an award-winning education technology platform that makes it easy to enrich images, videos, and virtual tours with additional information and links such as text, audio recordings, quizzes, surveys, and various other content (Batista et al., 2022; Edwards-Smith, 2022; Thinglink, 2023). Therefore, embedding images and multimedia is expressed as one of the strengths of Thinglink as an open-source tool (McKeeman & Oviedo, 2015). This Web 2.0 tool offers many opportunities for both teachers and students. For example, while virtual tours that can be taken with this interactive Web 2.0 tool allow students to access real-world environments and situations that they would not normally be able to access (Thinglink, 2023), also 360° images and videos help develop contextual understanding, academic vocabulary and skills in remote locations, cultures, work environments or social situations (Asatillayevna, 2022, Thinglink, 2023). This tool allows the development of various skills such as critical thinking through individual or group learning, depending on the learning speed of each student (Batista et al., 2022; Edwards-Smith, 2022). On the other hand, it offers teachers the opportunity to create interactive images with options such as adding notes, videos or websites to a point in the image (Asatillayevna, 2022; Şentürk, 2020). It also offers educators the flexibility and opportunity to assess student understanding through embedded tools and conditional progress settings (Edwards-Smith, 2022). It can be stated that these advantages for both teachers and students and the opportunity to bring together various environments that are difficult to reach under normal conditions with a single application make Thinglink an effective tool for out-of-school learning environments. In this context, this study focuses on the use of Thinglink, one of the Web 2.0 tools, as an out-of-school learning environment.

When the literature is examined, it is seen that research on out-of-school learning has been conducted in many different disciplines such as science, language, social studies, science and technology (e.g., Aslan & Arslan, 2021; Aslan & Demircioğlu, 2019; Karademir, 2013; Eshach, 2007;

Schneiderhan-Opel & Bogner, 2021; Sontay et al., 2016; Özdemir, 2019). However, there are very few studies on out-of-school learning environments in mathematics (e.g. Bonotto, 2005; Büyükkurt, 2023; Çağlakpınar, 2022; Duatepe-Paksu et al., 2022; Wager, 2012). Nevertheless, it is important to make connections between out-of-school practices and mathematical practices and notations in school by associating school mathematics with strong practices that provide meaning with out-of-school practices (Wager, 2012). In one of these studies, out-of-school learning environments guidebooks were analyzed in terms of the outcomes of the primary school mathematics programme and at the end of the research, more studies on out-of-school learning environments in mathematics teaching were recommended (Çağlakpınar, 2022). In another study, Bonotto (2005) presented a teaching experiment consisting of a series of activities based on the use of appropriate cultural artifacts, interactive teaching methods and the introduction of new socio-mathematical norms and stated that the teaching/learning environment created had a positive effect on achieving the learning objectives of the teaching/learning environment. Wager (2012) conducted an application with teachers to determine how teachers incorporate children's cultural and out-of-school mathematics into teaching. The researcher stated that the application supported teachers to build relationships with students and enabled them to see how school mathematics is used outside the school and how out-of-school mathematics is used in school. Büyükkurt (2023) examined teachers' views on the integration of out-of-school learning environments in mathematics lessons. As a result of the study, teachers stated that they need out-of-school learning environments, out-of-school learning environments support students' lifelong learning process, permanent learning takes place, but they experience some problems, and they need to improve their knowledge and skills to do these activities. As a result of a project study conducted by Duatepe-Paksu et al. (2022) with secondary school students, it was determined that mathematics activities carried out in out-of-school environments provided positive changes in students' attitudes and beliefs towards mathematics and had positive effects on learning mathematics. On the other hand, Williams and Dixon (2013), who examined articles between 1990 and 2010, found that garden-based learning, which can be considered as one of the out-of-school learning environments, has a positive effect on students' academic success in mathematics. Another study found that out-of-school environments improved students' mathematical connections (Haji et al., 2016). Consequently, studies show that out-of-school learning environments can be effective in increasing students' academic achievement in mathematics teaching and that teachers' knowledge and experience have an important role in designing and implementing an effective out-of-school learning environment. As a matter of fact, Eshach (2007) emphasised that teachers' personal interest, preparation, actions during the visit and follow-up are important factors affecting children's short and long-term attitudes, and therefore teachers' awareness, interest and skills about out-of-school learning environments are important. Thus, in addition to supporting the teachers who are currently working in this process, it is necessary to overcome the deficiencies of future teachers who graduate from education faculties every year (Tatlı et al., 2016). In this context, in this study, pre-service teachers, who are the teachers of the future, were given a training on out-of-school learning environments and the use of these environments in mathematics teaching, and it was aimed to examine the experiences of the pre-service mathematics teachers [PMTs] on the use of Thinglink Web 2.0 tool in out-of-school learning environments in mathematics teaching. Considering that there are limited studies in the literature on the use of out-of-school learning environments in mathematics teaching, it is thought that this study will contribute to the literature. It is also believed that this study will serve as an example of how the Thinglink Web 2.0 tool can be used in designing an out-of-school learning environment in mathematics teaching.

2. Method

2.1. Research Design

Within this study, a descriptive case study methodology was employed. This approach involves conducting a comprehensive investigation of a specific system, employing various data collection methods to systematically acquire insights into its operations and functionality (Chmiliar, 2010). Descriptive case studies play an important role in educational sciences research because they provide in-depth understanding, monitor learning processes, evaluate context, and contribute to the process of solving problems in education. The choice of this method was deliberate, as it enables a thorough exploration of the Out-of-School Learning Activities Designed Using Thinglink [OSLADTs] developed by PMTs. This approach is particularly suitable for reflecting the knowledge and experiences accumulated by PMTs throughout their participation in the 'Out of School Learning Environments' course.

2.2. Participants

This study was conducted during the 2022-2023 academic year and involved a total of 60 participants, consisting of 49 females and 11 males. The participants were PMTs who were in their sixth semester and were enrolled in the 'Out of School Learning Environments' course at a university situated in the Eastern Black Sea Region of Turkey. In this regard, convenience sampling, which allows for easier and faster access to participants of this nature, was preferred (Christensen et al., 2015; Ekiz, 2015). Ethical principles were adhered to throughout the research process, the study group was informed about the procedure, voluntary participation was ensured, and their identities, as well as the name of the university and faculty where the research was conducted, were kept confidential (Çepni, 2010; Ekiz, 2015).

2.3. Procedure

Throughout an 11-week segment of the 'Out of School Learning Environments' course, the curriculum encompassed the theoretical foundation associated with the processes of conceiving, executing, and assessing activities within diverse out-of-school learning settings. The presentations featuring the OSLADTs which were crafted by the PMTs, were scheduled for the final three weeks of the course. Table 1 provides an extensive overview of weekly course content.

Table 1
The overview for the Out of School Learning Environments course

Weeks	*Promoted content of the week*
Week 1	Introduction to Out-of-School Learning Environments
Week 2	Theoretical Foundations of Learning Beyond the Classroom
Week 3	Designing Learning Activities for Out-of-School Settings
Week 4	Implementing Out-of-School Learning Activities
Week 5	Assessment and Evaluation in Out-of-School Environments
Week 6	Environmental and Safety Considerations
Week 7	Community Engagement and Partnerships
Week 8	Technology and Digital Tools for Out-of-School Learning
Week 9	Cultural and Diversity Issues in Out-of-School Learning
Week 10	Reflection and Best Practices
Week 11	Example applications in teaching mathematics
Week 12-14	Presentations of OSLADTs (Out-of-School Learning Activities Designed Using Thinglink) developed by PMTs

This course provides a comprehensive exploration of the principles, strategies, and practical aspects of facilitating learning experiences in various out-of-school environments.

2.4. Data Collection Tool and Data Analysis

The data for this study were obtained from 44 contents, which encompassed out-of-school learning environment activities supported by the Thinglink application, conducted by PMTs individually or in groups of 2 or 3. The data utilized in this research emanates from two primary sources: Out-of-School Learning Activities Designed Using Thinglink (OSLADTs) and course materials, including lesson plans, worksheets, and brochures, all of which were developed by PMTs. To address the research inquiries, content analysis was employed to examine the PMTs' OSLADTs and course materials. The findings of these analyses are presented in the following phases:

- *Content Analysis:* Content analysis was employed to assess the alignment of the OSLADTs and course materials (lesson plans and worksheets), created by PMTs, with the criteria established by Bunting (2006) for defining out-of-school learning activities. The outcomes of this analysis were visually represented through graphics and tables, enhancing their interpretability.
- *Alignment with Curriculum:* The OSLADTs and course materials were scrutinized to determine their correspondence with the secondary school mathematics curriculum. This analysis entailed categorizing activities based on units, subjects, and learning objectives. The results are presented in tabular format.
- *Learning Environments (LEs):* The study identified the types of learning environments (LEs) favored by PMTs in their OSLADTs. The findings are organized into tables according to grade levels.
- *Integration with the 5E Learning Model*: The research investigated the stage at which PMTs incorporated OSLADTs into the lesson plans they devised, utilizing the 5E learning model. Graphical representations were employed to convey these findings.
- *Compatibility with Thinglink Content:* Thinglink is a tool used to create interactive visual content. In this study, the compatibility of the worksheets created by PMTs with this interactive visual content was assessed. Compatibility is based on how similar and consistent the worksheets are with the Thinglink content in terms of learning objectives, visual elements, and interactivity. Specific criteria were used to evaluate this compatibility. Graphics were employed to illustrate the findings in a clearer manner.

Throughout the analytical process, two researchers collaboratively reviewed and analyzed the research data, which encompassed Thinglink recordings, learning activities, and course materials. Consensus was reached among the researchers during the analysis phase.

Additionally, the data analysis procedures were subjected to validation by an external expert. Inter-rater reliability was assessed using Miles and Huberman's (1990) formula, yielding a reliability rate of 93%.

3. Results

3.1. Findings Regarding the Attributes of the Developed Activities

The outcomes pertaining to the alignment of PMTs' developed OSLADTs with the criteria defining the characteristics of out-of-school learning activities, as proposed by Bunting (2006), are visually depicted in Figure 1.

Figure 1 illustrates that among the OSLADTs examined, 32 (72%) exhibited an experimental structure capable of engaging students through hands-on activities, while 28 (64%) did not meet the criteria for fostering a connection with the natural environment. Additionally, it was observed that 23 (51%) of the activities lacked suitability in terms of promoting reflection and discussion, meaning that the content did not encourage students to engage in reflection, generalization, and application within the context. As a final observation, it was noted that 21 (48%) of the OSLADTs did not facilitate the establishment of interdisciplinary connections. The findings resulting from the analysis of the OSLADTs crafted by PMTs with respect to subject disciplines are visualized in Figure 2.

Figure 1
Distribution of OSLADTs Based on Bunting's Eligibility Criteria

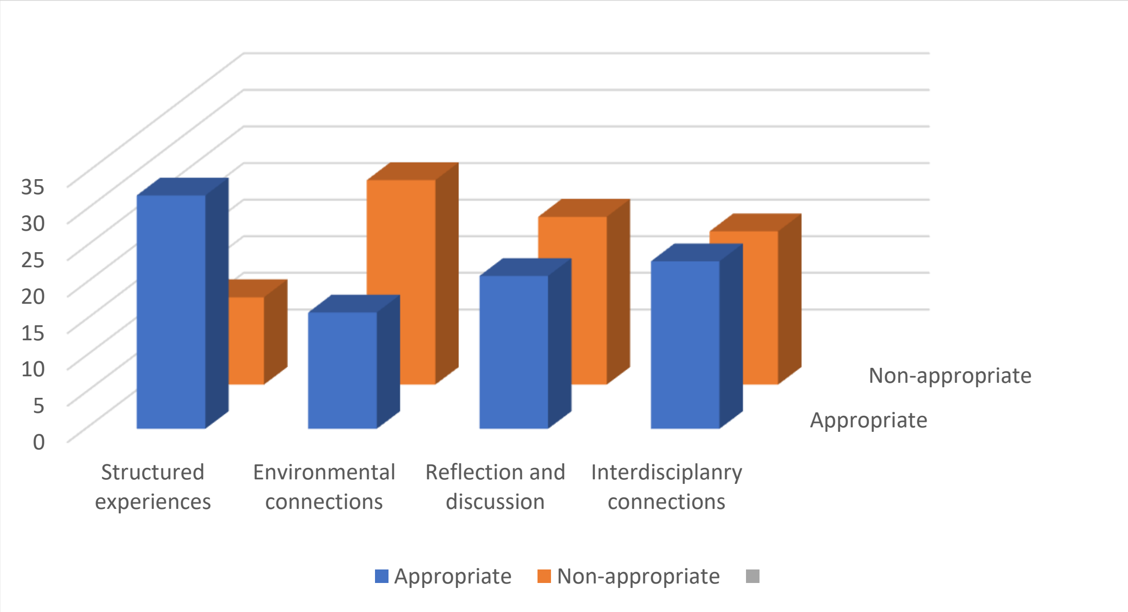
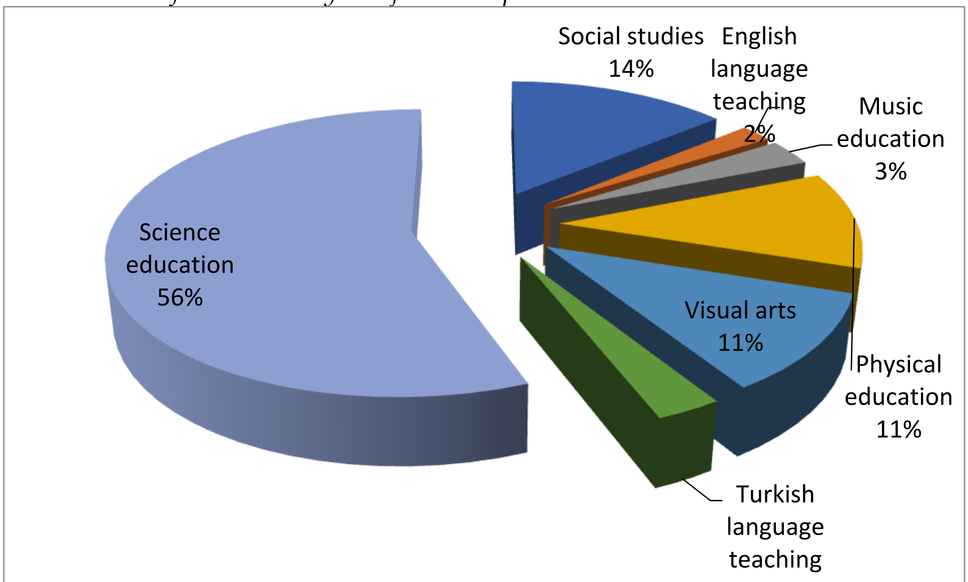


Figure 2
Distribution of Activities by Subject Discipline



When OSLADTs were examined, it was seen that PMTs generally associated science discipline (%56) with mathematics. On the other hand, associations were made with courses such as visual arts, social studies, physical education, music education, and Turkish and English language teaching (see Figure 2).

3.2. Findings Regarding the Distribution of Activities Across Grade Levels and Learning Objectives

The allocation of learning objectives favored by the PMTs for their OSLADTs, categorized by grade level, is displayed in Table 2.

Table 2
Allocation of acquisitions by grade level

Grade Level	*Unit*	*Topic*	*Acquisition*		*f*
5th Grade	Numbers and operations	Natural numbers	M.5.1.1.3	3	5
		Fractions	M.5.1.3.6	2	
	Geometry and measurement	Basic geometric concepts and drawings	M.5.2.1.2	2	4
			M.5.2.1.6	2	
		Triangles and quadrilaterals	M.5.2.2.1	2	2
		Area measurement	M.5.2.4.1	1	1
	Data processing	Data collection and evaluation	M.5.3.1.1	2	3
			M.5.3.1.2	1	
6th Grade	Numbers and operations	Sets	M.6.1.3.1	10	21
		Integers	M.6.1.4.1	3	
			M.6.1.4.2	2	
		Ratio	M.6.1.7.1	3	
			M.6.1.7.2	3	
	Geometry and measurement	Circle	M.6.3.3.3	2	5
			M.6.3.3.1	2	
			M.6.3.3.2	1	
	Data processing	Data collection and evaluation	M.6.4.1.1	2	8
		Data analysis	M.6.4.2.1	3	
			M.6.4.2.2	1	
			M.6.4.2.3	2	
7th Grade	Numbers and operations	Operations with Integers	M.7.1.1.1	1	5
		Ratio and Proportion	M.7.1.4.1	2	
			M.7.1.4.2	1	
			M.7.1.4.3	1	
	Geometry and measurement	Lines and angles	M.7.3.1.2	1	3
		Polygons	M.7.3.2.1	1	
			M.7.3.2.3	1	
	Data processing	Data Analysis	M.7.4.1.1	2	5
			M.7.4.1.2	2	
			M.7.4.1.3	1	
8th Grade	Algebra	Linear equations	M.8.2.2.2	2	5
			M.8.2.2.3	2	
		Inequalities	M.8.2.3.1	1	
	Geometry and measurement	Transformation geometry	M.8.3.2.1	1	5
			M.8.3.2.2	1	
			M.8.3.2.3	1	
		Geometric objects	M.8.3.4.2	1	
			M.8.3.4.3	1	
	Data processing	Data Analysis	M.8.4.1.2	1	1
	Probability	Probability of simple events	M.8.5.1.2	1	1

When examining Table 2, it is observed that the 6thgrade acquisitions are preferred the most by pre-service mathematics teachers, with a total of 34 acquisitions. Following this preference, the 5th grade acquisitions come in second with 15 acquisitions, followed by the 7thgrade with 13 acquisitions, and the 8th grade with 12 acquisitions.

Within the framework of the fifth-grade curriculum, it was observed that PMTs predominantly emphasized the acquisitions within the Numbers and Operations unit (see to Picture 1). The acquisition coded as M.5.1.1.3, which pertains to "The rule creates the desired steps of the given number and shape patterns" was found to be the most frequently chosen for this grade level.

Picture 1
Images from the OSLADT sample taken in fifth grade (Ünye Museum House, Ordu)

The content prepared with Thinglink support for the teaching of the acquisition numbered M.5.1.1.3 includes consideration of the sub-acquisition 'Examples of shape patterns from our historical and cultural works (architectural structures, carpet decorations, rugs, etc.)' are given.

In the context of the sixth-grade curriculum, it was noticed that PMTs primarily focused on the acquisitions within the Numbers and Operations unit (refer to Picture 2). The learning objective coded as M.6.1.4.1, related to 'Recognizing integers and depicting them on the number line,' was identified as the most frequently employed for this grade level.

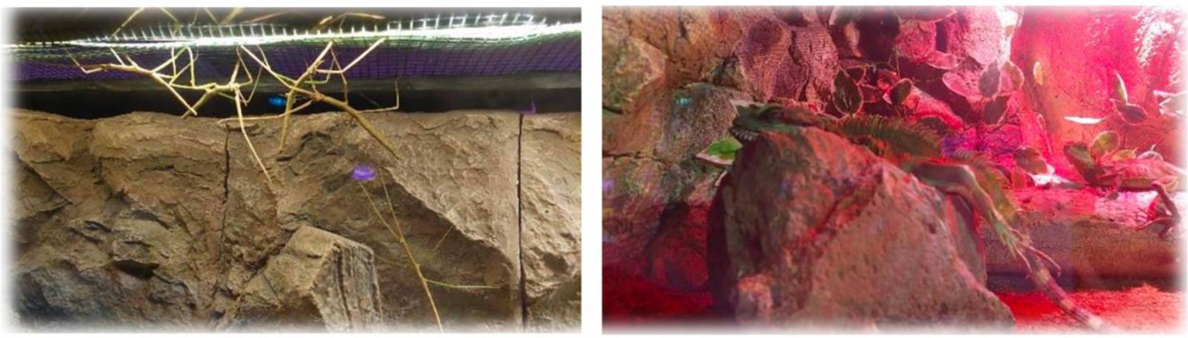
Picture 2
Images from the OSLADT sample taken in sixth grade (Regional Directorate of Meteorology, Erzurum)

Picture 2 continued

In the Thinglink content where visuals are shared as an example, the PMTs posed the question to students about where integers can be encountered in daily life. Subsequently, she created a virtual visit to the regional meteorology department to facilitate the answering of this question. Additionally, the pre-service teacher posed guiding questions to encourage students to contemplate the relationship between the objects within the environment and their relevance to the science lesson.

In the context of the seventh grade curriculum, it was determined PMTs mostly focused on the acquisitions of the topics in the Numbers and Operations unit (see Picture 3). The numbers of acquisitions as "M.7.1.4.2. Given one of the two quantities in proportion, finds the other, M.7.1.4.3. Determines whether two quantities are proportional by examining real-life situations" were found to be the most frequently preferred for this grade level.

Picture 3
Images from the OSLADT sample taken in seventh grade (Aquirium, Trabzon)



During the aquarium trip, the pre-service teacher attempted to exemplify the concept of ratio and proportion to the students by using the physical characteristics of different organisms (such as the number of legs, etc.). Additionally, they tried to establish connections with everyday life situations.

In the context of the eighth grade curriculum, it was determined PMTs mostly focused on the acquisitions of the topics in the Algebra unit (see Picture 4). The numbers of acquisitions as "M.8.2.2.2 Recognizes the coordinate system with its features and shows ordered pairs, M.8.2.2.3 It expresses with a table and equation how one of two variables that have a linear relationship between them changes depending on the other" were found to be the most frequently preferred for this grade level.

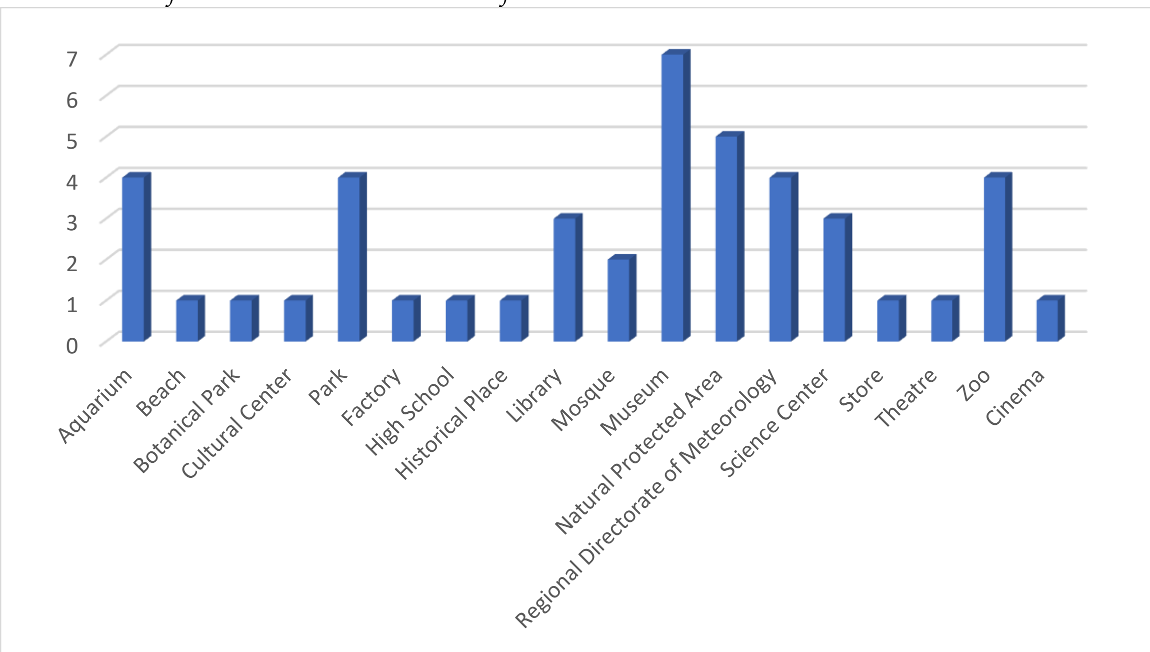
Picture 4
Images from the OSLADT sample taken in eighth grade (Cinema, Trabzon)

The pre-service teacher enabled students to perceive the relationship between the seating arrangement in the cinema and the coordinate system. It was observed that the sub-objective 'Studies aimed at associating location determination on the coordinate system with real-life situations are included' was attempted to be realized within the cinema environment.

3.3. Findings from OSLADTs by LEs

To address another research question, the selected locations where participants prepared their OSLADTs were examined. The distribution of preferred locations in OSLADTs developed by PMTs is presented in Figure 3.

Figure 3
Distribution of OSLADTs in the context of LEs



According to Figure 3, the most preferred venues are, in order, "Museum", "Regional Directorate of Meteorology", and "Aquarium". These three venues have a considerably higher preference level compared to all other venues. Among the medium-preferred venues are "Botanical Park", "Factory", "Store", and "Zoo". In addition, venues such as "Cultural Center", "Park", "High School", "Historical Place", "Library", "Mosque", "Natural Protected Area", and "Theatre" have low preference levels.

Table 3
Distribution of preferred LEs at the fifth grade level

LEs in OSLADTs	*City*	*Acquisition*
Museum	Trabzon	M.5.2.2.1
		M.5.3.1.2
	Ordu	M.5.1.1.3
		M.5.3.1.1
	Gaziantep	M.5.1.3.6
	Samsun	M.5.1.1.3
		M.5.2.4.1
Beach	Trabzon	M.5.1.1.3
Park	Trabzon	M.5.2.1.2
	Elazığ	M.5.2.1.2
		M.5.1.1.3
Factory	Giresun	M.5.3.1.2
Historical Place	Trabzon	M.5.2.2.1
Natural Protected Area	Erzincan	M.5.2.1.2
Zoo	Kayseri	M.5.2.1.6
Science Center	Kayseri	M.5.2.1.6

When examining the OSLADTs associated with fifth-grade-level acquisitions, it becomes evident that eight distinct out-of-school learning environments (LEs) were employed to address nine different acquisitions across eight different provinces (see to Table 3). In their OSLADTs, PMTs strategically devised instructional plans by establishing connections between these acquisitions and various out-of-school environments, such as parks, zoo, historical places, science center and museums (e.g., Ünye Museum House, Gaziantep Toy Museum, Samsun City Museum, Trabzon Eco Park, Atatürk Pavilion, Kayseri Science Center and Zoo). Additionally, upon reviewing the acquisitions utilized by PMTs in their OSLADTs from the respective provinces, it was ascertained that PMTs had successfully established relationships between acquisitions and out-of-school learning environments for a total of three objectives. The distribution of the venues preferred by PMTs to teach sixth grade acquisitions is shown in Table 4.

Table 4
Distribution of preferred LEs at the sixth grade level

LEs in OSLADTs	*City*	*Acquisition*
Museum	Gaziantep	M.6.1.7.1
	Samsun	M.6.4.2.1
Regional Directorate of Meteorology	Trabzon	M.6.4.2.2
		M.6.1.4.1
		M.6.1.4.2
	Erzurum	M.6.1.4.1
		M.6.1.4.2
Zoo	Kayseri	M.6.1.3.1
Science Center	Kayseri	M.6.3.3.3
		M.6.3.3.1
		M.6.3.3.2
Aquarium	Trabzon	M.6.1.3.1
		M.6.4.1.1
		M.6.1.7.1
Botanical Park	Trabzon	M.6.1.3.1
Natural Protected Area	Rize	M.6.4.2.1
		M.6.4.2.2

Table 4 continued

LEs in OSLADTs	*City*	*Acquisition*
Store	Trabzon	M.6.3.3.2
High School	Erzincan	M.6.1.7.1
Cinema	Trabzon	M.6.1.3.1
		M.6.4.1.2
Library	Sinop	M.6.1.3.1
	Trabzon	M.6.1.3.1
		M.6.4.1.1
		M.6.1.7.1
Factory	Giresun	M.6.1.3.1

When analyzing the OSLADTs related to acquisitions at the sixth-grade level, it becomes apparent that twelve distinct out-of-school learning environments (LEs) were utilized to address nine different acquisitions across nine different provinces (refer to Table 4). Within their OSLADTs, PMTs strategically developed instructional plans by establishing connections between these acquisitions and various out-of-school settings, such as museums, the Regional Directorate of Meteorology, zoos, botanical parks, libraries, and aquariums (e.g., Trabzonspor M. Şamil Ekinci Museum, Gaziantep Toy Museum, Trabzon Regional Directorate of Meteorology, Trabzon Aquarium, Kayseri Science Center and Zoo). Additionally, upon reviewing the acquisitions employed by PMTs in their OSLADTs from the respective provinces, it was confirmed that PMTs had effectively forged associations between acquisitions and out-of-school learning environments for a total of three objectives. The distribution of the venues selected by PMTs for teaching seventh-grade acquisitions is presented in Table 5.

Table 5

Distribution of preferred LEs at the seventh grade level

LEs in OSLADTs	*City*	*Acquisition*
Regional Directorate of Meteorology	Rize	M.7.1.1.1
	Trabzon	M.7.4.1.1
Eco Park	Trabzon	M.7.4.1.3
Aquarium	Trabzon	M.7.1.4.1
		M.7.1.4.2
		M.7.1.4.3
Store	Trabzon	M.7.3.2.1
		M.7.3.2.3
Zoo	Gaziantep	M.7.4.1.3
Library	Osmaniye	M.7.3.1.2
Science Center	Kayseri	M.7.4.1.2

When examining the OSLADTs associated with seventh-grade-level acquisitions, it becomes evident that seven distinct out-of-school learning environments (LEs) were employed to address ten different acquisitions across five different provinces (refer to Table 5). In their OSLADTs, PMTs strategically devised instructional plans by establishing connections between these learning objectives and various out-of-school environments, such as Regional Directorates of Meteorology, zoo, eco park, library, science center, store and aquarium (e.g., Trabzon and Rize Regional Directorates of Meteorology, Trabzon Aquarium, Kayseri Science Center, Gaziantep Zoo, Kadirli District Library). Additionally, upon reviewing the acquisitions utilized by PMTs in their OSLADTs from the respective provinces, it was ascertained that PMTs had successfully established relationships between acquisitions and out-of-school learning environments for a total of three objectives. The distribution of the venues preferred by PMTs to teach eighth grade acquisitions is shown in Table 6.

Table 6
Distribution of preferred LEs at the eigth grade level

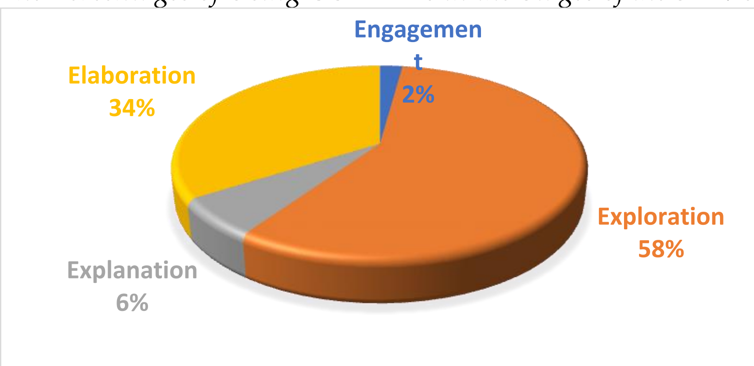
LEs in OSLADTs	*City*	*Acquisition*
Museum	Trabzon	M.8.4.1.2
	Ordu	M.8.5.1.2
Theatre	Trabzon	M.8.2.2.2
Cultural Center	Trabzon	M.8.2.2.2
Mosque	Amasya	M.8.3.2.1
		M.8.3.2.2
		M.8.3.2.3
Factory	Giresun	M.8.3.4.3
Natural Protected Area	Trabzon	M.8.2.2.3
	Ordu	M.8.2.3.1
Cinema	Trabzon	M.8.2.2.2

When analyzing the OSLADTs linked to eighth-grade-level acquisitions, it becomes apparent that seven distinct out-of-school learning environments (LEs) were employed to address ten different acquisitions across four different provinces (see Table 6). Within their OSLADTs, PMTs strategically crafted instructional plans by forging connections between these acquisitions and a variety of out-of-school settings, including museums, theaters, mosques, factories, cinemas, cultural centers, and natural protected areas (e.g., Trabzonspor M. Şamil Ekinci Museum, Trabzon State Theater, Trabzon Lara Cinema, Trabzon Hamamizade İhsan Bey Cultural Center, Tirebolu Tea Factory). Furthermore, upon reviewing the learning objectives utilized by PMTs in their OSLADTs from the respective provinces, it was confirmed that PMTs had successfully established associations between learning objectives and out-of-school learning environments for a total of four objectives.

3.4. OSLADTs within the Framework of the 5E Model Phases

The findings pertaining to the stage at which PMTs incorporated OSLADTs into their lesson plans, following the 5E learning model, are illustrated in Figure 4.

Figure 4
The Percentages of Using OSLADTs in the Stages of the 5E Model



As illustrated in Figure 4, it is evident that 61% of the OSLADTs were utilized during the exploring phase of the 5E model in the lesson plans prepared by PMTs. Meanwhile, 30% of the OSLADTs were employed in the elaboration phase, with 7% allocated to the explanation phase, and a mere 2% designated for the engagement phase. Notably, none of the OSLADTs were applied in the evaluation phase.

3.5. Findings Regarding the Compatibility of Worksheets with Thinglink Content

Figure 5 depicts the outcomes of the analysis conducted to assess the alignment between the worksheets created by PMTs for the OSLADT development process and the accompanying Thinglink app content.

Figure 5
The Count of Compatibility Instances between Thinglink Apps and PMTs' Worksheets

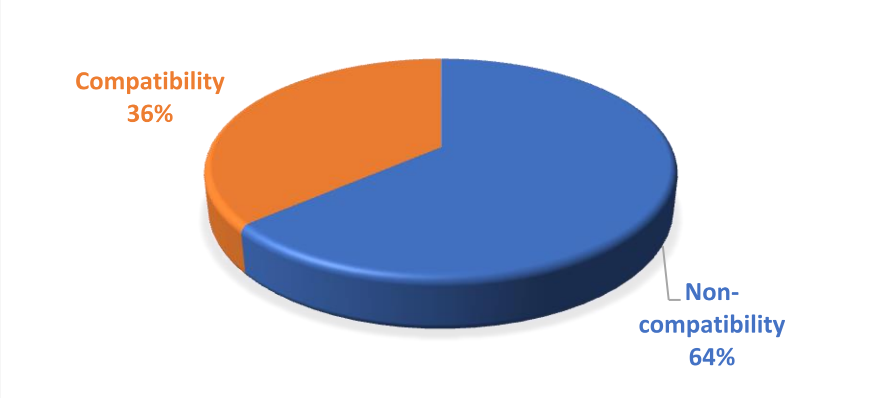


Figure 5 illustrates the alignment of questions in worksheets created by PMTs to support their teaching activities in OSLADTs with the instructions provided in the Thinglink content. While learning environment-related worksheets were developed by PMTs for 16 (36%) of the 44 Thinglink contents, incompatible and not learning environment-related worksheets were developed for 28 (64%) Thinglink contents.

4. Discussion

The findings presented in this study provide valuable insights into the development and utilization of OSLADTs (Out-of-School Learning Activities Designed Using Thinglink) by pre-service mathematics teachers within the context of Turkish primary mathematics education. Several key points emerge from the analysis of PMTs' OSLADTs and their alignment with specific criteria and learning objectives.

It is noteworthy that a significant majority of the OSLADTs (72%) exhibited an experimental structure designed to engage students through hands-on activities. This emphasis on experiential learning aligns with contemporary educational approaches that recognize the importance of active participation in the learning process. PMTs' recognition of the value of hands-on activities within out-of-school environments indicates their intention to provide students with immersive and interactive learning experiences.

The field of mathematics is closely related to many other disciplines. In this study, it was observed that pre-service teachers mostly associated their mathematics course achievements with science classes (Figure 2). Mathematical problems are used in solving real-world problems, and mathematical solutions can be interpreted to address real-world issues. Lehrer and Schauble (2002) posit that there exists a shared form of symbolic communication between mathematics and science, specifically concerning concepts and relationships. In this regard, mathematical concepts and processes gain practical significance when applied within the context of science (NCTM, 1989). Heflich et al. (2001) argue that exposure to real-world phenomena expressible through mathematical concepts can significantly enhance the learning of scientific concepts. PMTs demonstrated a tendency to associate mathematics with other subject disciplines, such as visual arts, social studies, physical education, Turkish, music, and English. This interdisciplinary approach can enrich students' learning experiences by illustrating the real-world applicability of mathematical concepts in diverse contexts. Art and design use mathematical ideas of ratio and proportion, as well as concepts of similarity and scale. Furthermore, mathematical ideas related to patterns, shapes, and transformations are taught as part of art and design. Art and design also contribute to the construction aspect of shape, space, and measurement within mathematics. Additionally, they enhance students' problem-solving, communication, and logical reasoning skills (Yeasmin, 2017).

The study revealed that PMTs effectively incorporated OSLADTs into their lesson plans, aligning them with specific learning objectives across different grade levels. Notably, sixth-grade acquisitions received the most attention from PMTs, with a total of 34 acquisitions, followed by fifth, seventh, and eighth-grade acquisitions. This indicates that PMTs recognize the potential of OSLADTs to enhance student learning across various mathematical topics. It is common in many educational systems to place a significant emphasis on key mathematical concepts during the 6th-grade curriculum. For example, according to NC Department of Public Instruction (2018), in the 6th grade curriculum, students solve real-world problems using algebraic and geometric concepts. These problems may include concepts such as ratio, proportion, area, and statistics. Students seek the meaning of a problem and look for effective ways to represent and solve it. On the other hand, some mathematical concepts, such as data collection, evaluation, and analysis, are inherently practical and can be readily applied to real-world scenarios. PMTs may be more selective of 6th grade outcomes because they adapt well to out-of-school learning environments (library, movie theater, aquarium, etc.) where students can collect data and analyze it in context, promoting a deeper understanding of these concepts.

PMTs exhibited creativity in selecting various out-of-school learning environments (LEs) to complement their OSLADTs. These LEs included museums, theaters, mosques, factories, cinemas, cultural centers, natural protected areas, and more. By connecting learning objectives to these diverse environments, PMTs aimed to create engaging and authentic learning experiences for students. Museums and natural protected areas ranked first among these learning environments (Figure 3). For many students, mathematics can be difficult (Murphy, 2017; Salout et al., 2013), therefore, teaching mathematics by using real-life examples with interesting applied activities becomes a necessity. For this purpose, Berg et al. (2021) used the natural history environment and narrative to frame mathematics teaching by choosing Naturama, a natural history museum in Denmark. In this way, they were able to test differences between basic mathematical tools, measurements, statistical descriptions of the data, and subsets of data collected during the event. Şahin and Asal Özkan (2023) examined the postgraduate theses published in Turkey between 2010 and 2022 in their study in order to address the issue of out-of-school learning environments in a holistic manner and to present it with a broader perspective. According to the results of the study, science centers and museums rank first among the most preferred environments. Aslan et al. (2023) conducted a study involving experienced and inexperienced faculty members to investigate out-of-school learning environments. Their findings indicated that natural and thematic parks, science and research centers, as well as industrial organizations, are commonly suggested as effective LEs for out-of-school learning experiences.

The majority of PMTs employed OSLADTs during the exploring phase of the 5E learning model. In the exploration phase, the teacher asks questions and guides the groups to discuss. The teacher provides the time and materials that students need so that they can express their own thoughts (Bybee et al., 2006). The fact that pre-service teachers incorporate OSLADTs heavily into their lesson plans, particularly during the exploration phase, demonstrates the significance of these materials at the time when students start exploring new subjects. It's important to engage students' interest and curiosity during the exploration phase. At this point, OSLADTs can be utilized to grab students' attention and promote learning engagement. Nevertheless, it's possible to further investigate the capabilities of OSLADTs in different stages of the model, like elaboration and explanation, to enhance comprehension and strengthen the grasp of concepts.

The study identified a critical point of consideration-ensuring the compatibility of worksheets with OSLADTs. While PMTs developed environment-related worksheets for 36% of the OSLADTs analyzed, some worksheets did not align with the instructions provided in the Thinglink content. This misalignment highlights the need for PMTs to design worksheets that effectively complement and reinforce the OSLADTs, maximizing their educational benefits. Worksheets can guide and structure students' learning processes. Particularly, they can help students understand topics better in the different learning environments they experience. Students can be encouraged to delve deeper into topics by answering specific questions or performing tasks during activities. Kisiel (2003) emphasized that when students engage in activities during museum visits, worksheets can serve as valuable advance organizers. They help students effectively organize their observations and make sense of the information presented in potentially overwhelming learning environments. Similarly, Krombab and Harms (2008) conducted research that demonstrated the effectiveness of worksheets, particularly for students between the ages of 11 and 15, in enhancing their understanding of topics like biodiversity when visiting natural history museums. Worksheets serve to structure the visit, maintain students' focus on specific objects or concepts, and provide a foundation for subsequent coursework. Considering all these contributions of worksheets, it is thought that pre-service teachers should show more sensitivity when planning out-of-school learning activities.

5. Conclusion

In conclusion, this study underscores the positive impact of OSLADTs on mathematics education when effectively integrated into the curriculum by PMTs. The findings suggest that OSLADTs hold significant potential for enhancing students' engagement, understanding, and appreciation of mathematical concepts. Pre-service teachers tend to associate mathematics with other subject disciplines (science, visual arts, social studies, physical education, Turkish, music and English). Pre-service teachers were successful in integrating OSLADTs in a manner consistent with specific learning objectives for different grade levels. Sixth grade acquisitions, in particular, are among the outcomes most taken into account by PMTs. PMTs have demonstrated creativity in selecting a variety of out-of-school learning environments to provide students with engaging and authentic learning experiences. Among these environments, museums and natural protected areas stand out. PMTs relate learning objectives to different environments, with the aim of teaching mathematics to students in a real-world context. The majority of PMTs used OSLADTs, especially in the exploratory phase. This demonstrates the importance of OSLADTs to capture students' attention and encourage learning engagement at the stage when they begin to explore new topics. However, there is an opportunity to investigate how OSLADTs can be used in other phases of the model, particularly to increase in-depth understanding and facilitate consolidation of concepts. The research has revealed that compatibility of worksheets used with OSLADTs is a critical issue. Although pre-service teachers developed worksheets for OSLADTs, some worksheets were not compatible with Thinglink content. This mismatch highlights the need for pre-service teachers to design worksheets in a way that effectively complements and reinforces OSLADTs.

6. Recommendations

Future professional development and teacher training programs should consider addressing to enhance the effectiveness of out-of-school learning activities and, consequently, students' educational experiences. Additionally, research examining the impact of improved OSLADTs on student learning outcomes would provide valuable insights into the benefits of these innovative teaching strategies. Pre-service teachers should be equipped with the skills to better align the worksheets they will use with OSLADTs with Thinglink content. Also, future studies could examine the relationship between OSLADTs and student mathematics achievement indetail.

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