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Original article

The Effect of Length Measurement Instruction in Out-of-School Learning Environments on Primary School Students Attitudes Towards and Motivation for Mathematics

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Abstract

The present study investigates the impact of length measurement instruction implemented in out-of-school learning environments (OSLEs) on primary school students' mathematics motivation and their attitudes toward mathematics activities. A quasi-experimental design with pretest–posttest control groups was employed, involving fourth-grade students. Data were collected using the Mathematics Motivation Scale and the Attitude Scale toward Mathematics Activities. The intervention was carried out in OSLEs over a five-week period, comprising a total of 30 instructional hours. For data analysis, independent-samples t-tests, multivariate analysis of variance (MANOVA), and repeated-measures ANOVA were conducted. The findings indicate that instruction delivered in OSLEs leads to statistically significant improvements in students' motivation toward mathematics and their attitudes toward mathematics activities. Moreover, the results demonstrate large effect sizes and reveal that these improvements are sustained over time, as evidenced by retention test scores. Overall, the findings suggest that mathematics instruction conducted in OSLEs constitutes an effective approach for enhancing students' affective outcomes in mathematics. Based on these results, it is recommended that such environments be integrated into instructional practices in a more systematic and intentional manner, particularly for mathematics topics closely connected to real-life contexts, such as measurement and geometry.

Keywords: Out-of-school learning, Length measurement, Attitude toward math, Math motivation

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INTRODUCTION

Measurement is a fundamental component of mathematics education, enabling individuals to make sense of and interact with the physical world through the quantification of attributes and phenomena. Although measurement constitutes a core domain within mathematics education, the body of research addressing how measurement is taught and learned remains relatively limited when compared to more extensively studied areas such as number and operations (Sarama et al., 2011; Sarama et al., 2022). In general terms, measurement competence refers to the capacity to quantify a particular attribute of an object or phenomenon by assigning it a numerical value (National Council of Teachers of Mathematics [NCTM], 2000). As such, measurement represents one of the most practical and frequently encountered applications of mathematics in everyday life (Hannighofer et al., 2011). Moreover, it plays a crucial role in fostering students' quantitative reasoning skills. Among different measurement types, length measurement is especially significant, as it is often one of the earliest measurement concepts introduced to learners and serves as a foundational basis for understanding more advanced measurement concepts (Sarama et al., 2022). However, studies show that students have difficulty understanding the conceptual principles underlying measurement processes and that teachers may also have limited conceptual knowledge in this regard (Smith et al., 2011). This situation underscores the importance of research aimed at developing curricula and instructional practices for measurement instruction (Sarama et al., 2011).

Length measurement is a central component of mathematics instruction, as it is both widely encountered in everyday contexts and serves as a foundation for understanding more advanced measurement concepts such as perimeter, area, and volume (Van de Walle et al., 2018). While children often develop an initial, intuitive sense of length and distance through their daily experiences, acquiring a deeper and more systematic understanding of measurement requires structured instructional support. In particular, competencies such as using appropriate units, recognizing the need for consistent and equal units, correctly handling measurement tools, and interpreting the relationship between unit iteration and total length are typically developed through intentional teaching processes (Barrett et al., 2017; Sarama et al., 2011). To address the challenges encountered in mathematics learning, researchers have emphasized the importance of employing diverse instructional approaches and learning environments that actively engage students in the learning process. Learning experiences that promote exploration, hands-on activities, collaboration, and meaningful connections with everyday life may enhance both cognitive and affective outcomes in mathematics education. Within this perspective, OSLEs have gained increasing attention as alternative settings that extend learning beyond the traditional classroom and provide authentic contexts for mathematical experiences. In this context, OSLEs can provide opportunities for students to learn the concept of measurement through concrete experiences, such as comparing the lengths of different objects, measuring with standard and non-standard units, and comparing estimation and measurement results. Such environments, by enabling students to directly relate mathematical ideas to real-life contexts, are considered to support a more meaningful understanding of length measurement while also fostering the development of mathematical reasoning skills.

Theoretical Framework

OSLEs and Length Measurement

OSLEs refer to educational settings beyond the traditional classroom that provide opportunities for learners to engage in authentic, experiential, and context-rich learning experiences. These environments may include schoolyards, parks, museums, science centers, botanical gardens, historical sites, sports facilities, and other community-based settings (Behrendt & Franklin, 2014). Rather than functioning independently from classroom instruction, OSLEs are considered complementary learning spaces that enable students to transfer and apply school-based knowledge to real-life situations (Ames, 2013; Sen et al., 2021). Accordingly, they can be integrated across different subject areas and educational levels to support both cognitive and affective learning outcomes. In the context of mathematics education, OSLEs offer concrete and experiential opportunities that help learners connect abstract mathematical concepts with everyday experiences (van Dijk-Wesselius et al., 2020). Research has demonstrated that learning experiences in such environments positively influence academic achievement, scientific reasoning, and learning motivation (Browning & Rigolon, 2019; Waite et al., 2016). Despite these potential benefits, teachers are reported to make limited use of OSLEs, and empirical research examining their implementation in mathematics education remains insufficient (Feille & Nettles, 2019). In the present study, OSLEs were conceptualized as accessible learning spaces outside the conventional classroom setting, specifically including the schoolyard, park, and basketball court, where students participated in authentic length measurement activities embedded in their everyday surroundings. In this context, it is essential to use OSLEs more effectively and systematically in mathematics instruction.

OSLEs enhance the meaningfulness and retention of learning by allowing students to transfer and apply classroom knowledge to real-life situations (Sen et al., 2021). Accordingly, effective learning requires a deliberate integration of in-school and out-of-school experiences so that they function in a complementary manner (Ames, 2013). In the context of mathematics education, such environments present concrete and experiential learning opportunities that enable learners to relate abstract mathematical concepts to everyday life (van Dijk-Wesselius et al., 2020). Research shows that OSLEs positively affect academic achievement, scientific reasoning, and learning motivation (Browning & Rigolon, 2019; Waite et al., 2016). However, despite their potential, teachers are reported to benefit from these environments to a limited extent, and studies in this field remain insufficient (Feille & Nettles, 2019). This context, it is essential to use OSLEs more effectively and systematically in mathematics instruction.

Length measurement is one of the first physical measurement quantities that students frequently encounter in daily life and are introduced to during the educational process (Sarama et al., 2022; Van de Walle et al., 2018). Measurement is characterized as the procedure of assigning a numerical worth to a measurable attribute of an object or event, in which the value is determined by the number of times a selected unit is contained within the measured attribute (Van den Heuvel-Panhuizen & Elia, 2011). Since length underlies many measurement concepts, such as perimeter, area, and volume, it is central to the field of measurement (Van de Walle et al., 2018). Therefore, establishing a strong conceptual foundation for length measurement is considered an important prerequisite for learning other types of measurement (Clements, 2003). Although children begin to develop an intuitive understanding of length through experiences such as comparing objects or their heights in the preschool period, the transformation of this understanding into a mathematical structure is supported by planned instructional experiences (Drake, 2020; Sarama et al., 2011).

The development of length measurement skills includes conceptual gains such as students being able to compare objects by aligning their endpoints, evaluating the lengths of objects that cannot be directly compared through a third object, and interpreting measurement results by using units in the measurement process (Barrett et al., 2017; Sarama et al., 2011). At the primary school level, students are introduced to standard units such as meters and centimeters and learn to measure the lengths of different objects using tools like rulers and measuring tapes (Clements & Stephan, 2004). In this process, students' engagement in measurement activities with both non-standard units and standard units, making estimations, and comparing measurement results contribute to their learning of the measurement concept in a more meaningful way (NCTM, 2006). However, studies show that students may experience various difficulties in making sense of the concept of length and correctly implementing the measurement process (Battista, 2006). On the other hand, studies examining how length measurement instruction is addressed in curricula are limited (Tan Sisman & Aksu, 2016). This situation reveals the need to develop effective instructional practices for length measurement teaching and to increase research in this field.

Attitude toward Mathematics

Attitude is a mental tendency that expresses a person's readiness to react to a situation or event and constitutes the psychological basis of behavior (İnan-Tutkun & Yazıcı, 2025). Attitude toward mathematics is a multidimensional construct encompassing students' feelings, beliefs, and behavioral tendencies toward mathematics (Moenikia & Zahed-Babelan, 2010). This attitude is shaped by students' experiences with mathematics (Davadas & Lay, 2017). Learners who hold good attitudes toward math are more inclined to take pleasure in engaging with mathematical activities, perceive the subject as worthwhile, and demonstrate higher levels of self-confidence. These positive dispositions, in turn, promote greater persistence and effort in the learning process (İnan-Tutkun & Yazıcı, 2025). In contrast, negative attitudes toward mathematics are often associated with avoidance behaviors, reduced interest, and limited participation in mathematical tasks (Cho & Hwang, 2019; Chouinard et al., 2007).

Supporting this statement, students with negative attitudes experience greater distraction when dealing with mathematics and are less successful (Ajisuksmo & Saputri, 2017).

Research shows that attitude toward mathematics is closely related to students' mathematics achievement (Çanakçı & Özdemir, 2011; Else-Quest & Grabe, 2012). For this reason, attitude is regarded as a key affective factor influencing learning processes and outcomes in mathematics education (Zan & Di Martino, 2020). Attitudes toward mathematics are commonly conceptualized as comprising three core dimensions: enjoyment of mathematics, perceived value of mathematics, and confidence in one's mathematical abilities (Di Martino & Zan, 2010; Hwang & Son, 2021). The enjoyment dimension refers to the positive emotions and interest students experience while engaging in mathematical activities, whereas the perceived value dimension reflects students' beliefs about the usefulness and importance of mathematics in their lives. Confidence in one's mathematical abilities relates to students' perceptions of their competence and their beliefs about their ability to succeed in mathematical tasks (Di Martino & Zan, 2010; Hwang & Son, 2021). Because these dimensions develop through interactions with learning experiences and educational contexts, attitudes toward mathematics may be shaped by various environmental and instructional factors (Zan & Di Martino, 2020). In addition, it is reported that teachers' affective support, family influence, and instructional methods can affect students' attitudes toward mathematics (Davadas & Lay, 2018). In fact, research indicates that different instructional practices, such as realistic mathematics education, computer-assisted instruction, STEM, and game-based instruction, positively shape students' attitudes toward mathematics (Ersoy, 2023; Harris, 2022; Hudakova & Kralova, 2016; Merritt, 2016; van Putten et al., 2022).

Mathematics Motivation

Motivation is an important psychological force that activates individuals and ensures the continuity of their behavior, and it plays a determining role in training and instruction processes (Schunk et al., 2014). Mathematics motivation is defined as a multidimensional construct that includes students' approaches to difficulties in the mathematics learning process, their perceptions of their mathematical abilities, their anticipations of success, and the value they give to mathematics (Gottfried et al., 2007). Due to its abstract nature, mathematics is a field in which students need a high level of motivation; therefore, the importance of approaches that increase motivation is emphasized. Students with high motivation for learning mathematics tend to engage in meaningful and permanent learning by exerting more effort in learning activities and also develop positive emotions during the learning process (Özgöl & Güler, 2025). Conversely, low levels of motivation can give rise to negative emotional experiences, including frustration, boredom, and feelings of inadequacy or failure. Accordingly, the mathematics education literature highlights low motivation as a significant factor underlying students' difficulties in learning mathematics (Tella, 2007). Although Hannula (2006) states that motivation is often addressed under the concept of motivational orientation in mathematics education research, it is seen that studies in this field have increased in recent years (Ay & Doğan, 2024; Bohrnstedt et al., 2024; Fazlı & Avcı, 2022; Morano et al., 2021). Furthermore, research indicates that both motivation and self-confidence play a pivotal role in the process of mathematical problem-solving (Gunawan & Muflihati, 2022; Rosidah et al., 2025) and that students with these characteristics participate more actively in the learning process and show higher performance in mathematics (Setiawan et al., 2022; Han, 2025; Wu et al., 2022).

The Current Study

When the literature on mathematics instruction in OSLEs is examined, these environments appear to contribute positively to students' affective engagement with mathematics. Pambudi (2022) reported that outdoor mathematics learning increased primary school students' motivation and suggested that repeated exposure could further enhance both motivation and achievement, while Ayhanöz et al. (2022) found that nature-based mathematical activities reduced mathematics anxiety, improved attitudes toward mathematics, and strengthened students' connection with the natural environment. Similarly, Altuntaş and Çetin (2023) observed that students developed more positive attitudes, enjoyed mathematics more, and became more aware of its real-life applications beyond the classroom. Aliustaoğlu et al. (2024) also reported improvements in students' attitudes toward mathematics, particularly in the enjoyment dimension, and Duatepe-Paksu et al. (2022) found that participation in a six-day out-of-school mathematics program fostered more positive attitudes and favorable perceptions of learning mathematics outdoors. Collectively, these studies suggest that OSLEs can enhance motivation, reduce mathematics-related anxiety, strengthen positive attitudes, and increase students' awareness of the connections between mathematics and everyday life. In addition, it is emphasized that OSLEs support students’ active participation and social interaction (Kır et al., 2021; Barrett-Rodger et al., 2026). However, when the literature is critically evaluated, it is clear that a considerable portion of studies focus on general mathematics instruction, mostly employ qualitative designs or short-term implementations, and that experimental evidence for specific mathematics topics remains limited (Eğe et al., 2025). Moreover, some studies have reported that out-of-school learning activities do not always lead to significant changes in attitude (Çağlar et al., 2018; Evcan et al., 2020). This finding implies that the effectiveness of OSLEs is likely contingent upon factors such as the duration of implementation, the design of activities, and the specific learning context.

A review of the literature on length measurement instruction indicates that existing studies have primarily focused on cognitive aspects of learning. For example, Lee and Smith (2011) examined how length measurement was represented in elementary mathematics curricula, finding a strong emphasis on procedural knowledge and differences in the presentation of conceptual and procedural content. Studies adopting a learning trajectory perspective have explored how children's understanding of length measurement develops over time. Sarama et al. (2022) showed that learning trajectory-based instruction supported children's progression to more advanced measurement thinking, while Vanegas et al. (2025) demonstrated how such approaches can improve mathematics teaching by aligning instruction with children's developmental pathways. Research has also examined children's conceptual understanding of measurement. Chen et al. (2025) found that Conceptual PlayWorld experiences helped young children build informal understandings of length measurement through imagination and dramatized situations. In addition, Clements et al. (2022) analyzed children's performance and strategy use in length measurement tasks, providing insights into the concepts and procedures underlying their strategies. Taken together, these studies suggest that the literature on length measurement has mainly emphasized curriculum organization, conceptual development, learning trajectories, and strategy use within the cognitive domain. In addition, some studies have examined students' misconceptions about measurement and teachers' pedagogical interventions, highlighting the importance of appropriate instructional activities for learning the concept of measurement (Bofferding et al., 2023; Chang et al., 2011; Dogan-Coskun & Isiksal-Bostan, 2025). More specifically, previous research has primarily focused on cognitive dimensions of learning, such as conceptual understanding, strategy use, and procedural performance, revealing a methodological limitation in terms of examining affective outcomes (Chen et al., 2025; Clements et al., 2022; Vanegas et al., 2025). Moreover, a contextual gap exists, as relatively little attention has been paid to how length measurement instruction can be designed and implemented in OSLEs (Eğe et al., 2025). From a theoretical perspective, there is also limited understanding of whether the unique affordances of OSLEs can influence students' affective characteristics, such as motivation and attitudes toward mathematics, alongside their cognitive development. Therefore, addressing these methodological, contextual, and theoretical gaps may contribute to a more comprehensive understanding of length measurement learning across diverse educational settings.

In this context, the present investigation addresses an essential gap in the literature by analyzing the effect of length measurement instruction delivered in OSLEs on primary school students' mathematics motivation and attitudes toward mathematics activities. The study makes an original contribution to the literature by evaluating length measurement instruction not only in terms of cognitive learning outcomes but also in relation to students' affective characteristics toward mathematics. In addition, addressing length measurement through experiential activities in OSLEs provides an alternative approach to mathematics instruction, enabling learners to participate in abstract mathematical concepts in more concrete and meaningful ways within real-life contexts.

This study investigates the impact of length measurement instruction implemented in OSLEs on primary school students' attitudes toward mathematics and their motivation, guided by the following research questions.

1. Is there an important distinction in posttest scores between the experimental and control groups in terms of mathematics motivation and attitudes toward mathematics activities following length measurement instruction in OSLEs?

2. Do length measurement instructions conducted in OSLEs have a significant joint (multivariate) effect on students' mathematics motivation and their attitudes toward mathematics activities?
3. Does the effect of length measurement instruction conducted in OSLEs on students' mathematics motivation show permanence over time (pretest, posttest, retention test)?

MATERIALS and METHODS

Research Design

This research, which examines the impact of length measurement instruction conducted in OSLEs on primary school students' attitudes toward mathematics and motivation, used a pretest-posttest control group quasi-experimental method, one of the experimental study methods (Büyüköztürk, 2023). The quasi-experimental design provides the researcher with a strong statistical basis for examining the impact of the experimental procedure applied on the dependent variable and was preferred because it allows the obtained results to be interpreted within the framework of cause-and-effect relationships (Büyüköztürk, 2023). Based on pretest results conducted before implementation, one class with similar characteristics was given to the experimental group, and the different to the control group, in an unbiased manner. While the length measurement instruction process was carried out in OSLEs in the experimental group, the existing instructional process was continued in the control group without any intervention.

Participants

The participants in this research are fourth-grade learners in a stand-alone primary school with a middle socio-economic level, located in a provincial center in the Eastern Black Sea region. While determining the study groups, attention was paid to selecting groups with equal or nearly equal average values for certain variables (Büyüköztürk, 2023). The learners are between 10 and 11 years old. Since the study group consisted of two separate classes, the experimental group (52% female and 48% male, n = 25) and the control group (48% female and 52% male, n = 25) were comparable in terms of group size and gender distribution, thereby reducing the likelihood of demographic differences influencing the variables examined.

While determining the groups, a pretest was administered to all classes in the school. The pretest scores obtained from the mathematics motivation and attitudes toward mathematics activities scales were used to identify two classes with similar characteristics. One of these classes was assigned as the experimental group and the other as the control group. To verify the equivalence of the groups prior to the intervention, independent samples t-tests were conducted using the pretest scores. As shown in Table 1, the assumptions underlying the analysis were met, and no statistically significant differences were found between the experimental and control groups in terms of mathematics motivation and attitudes toward mathematics activities. These findings indicate that the experimental and control groups were equivalent at baseline.

Table 1. Results of the independent samples t-test for the pretest scores of students in the experimental and control groups

Instruments	Groups	n	*M*	SD	Levene		*t*	*p*
					F	p		
Math motivation	Experimental	25	128.76	14.91	.005	.94	.274	.79
	Control	25	127.60	15.08				
Math attitude	Experimental	25	63.68	5.79	.319	.58	-1.01	.32
	Control	25	65.28	5.43				

p < .05*

As shown in Table 1, the independent samples t-test results indicated that there were no statistically significant differences between the experimental and control groups in terms of their pretest scores on mathematics motivation, t(48) = .27, p = .79, and attitudes toward mathematics activities, t(48) = -1.01, p = .32. In addition, the results of Levene's test were not statistically significant for either mathematics motivation (F = .01, p = .94) or attitudes toward mathematics activities (F = .32, p = .58), indicating that the assumption of homogeneity of variances was met. These findings suggest that the experimental and control groups were comparable prior to the intervention and had similar baseline characteristics with respect to mathematics motivation and attitudes toward mathematics activities.

Data Collection Tools

The study data were gathered utilizing the Mathematics Motivation Scale and Mathematics Attitude Scale. In this context, permissions to use the scales, detailed information on which is presented below, were obtained, and they were administered to the learners as a pretest and a posttest.

Mathematics Motivation Scale (MMS)

The scale, created by Tahiroğlu and Çakır (2014), is a 5-point Likert-type instrument designed to assess fourth-grade primary school learners' motivation to learn mathematics. As a result of the principal components analysis conducted using the Varimax rotation method, it was determined that the scale consists of five factors and 32 items explaining 51.93% of the total variance. The scale's factors were named "interest toward mathematics," "motivation for success," "effort toward learning," "enjoyment of mathematics," and "extrinsic motivation." In analyses to determine the suitability of the data for factor analysis, the Kaiser-Meyer-Olkin (KMO) value was 0.88, and the Bartlett test of sphericity was significant (χ^2 = 7943.18, df = 1128, p < .001). The Cronbach's Alpha internal consistency coefficient for the scale's reliability was 0.93. In addition, it was determined that the item-total correlations of all items were above 0.20. In the scale adaptation study, a test-retest analysis conducted at approximately four-week intervals yielded an overall reliability coefficient of 0.91, indicating high time-dependent consistency of the scale. The obtained findings show that the scale is a valid and reliable measurement tool for measuring primary school students' motivation toward learning mathematics.

Mathematics Attitude Scale (MAS)

The MAS, created by Ocak and Dönmez (2010), is designed to assess fourth-grade learners' attitudes toward mathematics-related activities. Findings from the factor analysis indicated that item loadings ranged from 0.56 to 0.80, with a KMO value of 0.90, indicating sampling adequacy. The overall internal consistency coefficient (Cronbach's alpha) was reported as 0.92. This study, the instrument was administered as a 19-item, five-point Likert-type scale, with 10 positively worded and 9 negatively worded statements. The scale is structured around three sub-dimensions: Confidence, interest, and independence. These dimensions include 9, 5, and 5 items, respectively. The reliability analysis conducted within the scope of this study yielded an overall Cronbach's alpha value of 0.93. For the sub-dimensions, the reliability coefficients were calculated as 0.88 for confidence, 0.82 for interest, and 0.74 for independence. These results indicate that the scale provides a valid and reliable measure for evaluating students' attitudes toward mathematics activities.

Implementation Process

The implementation process was structured around the objectives determined in the geometry sub-learning domain at the fourth-grade primary school level. In this context, the length measurement instruction lasted 5 weeks, and pretests and posttests were administered before and after the implementation. The implementation was carried out outside school hours, three days a week, for two session each day, in OSLEs. Each session was a 40-minute session, and instruction was completed in 30 sessions. The first researcher implemented the intervention through whole-class and small-group instruction. Instruction was generally conducted as whole-class instruction, with small-group instruction used only during activity implementation. The second researcher conducted lesson observations during all whole-class instruction sessions and contributed to the implementation of activities during small-group instruction. While the control group continued their regular instruction as prescribed by the curriculum, the students in the experimental group participated in length measurement instruction in OSLEs (see Figure 1).

Figure 1. Sample images from length measurement instruction

The length measurement instruction was conducted according to lesson plans developed by the researchers. In developing the lesson plans, the fourth-grade length measurement objectives were determined by taking into account the primary school mathematics curriculum. Then, four lesson plans for each objective were prepared for implementation in OSLEs. The OSLEs used in this study included the schoolyard, a nearby park, and the basketball court, all of which provided authentic contexts for students to engage in hands-on length measurement activities. Expert opinions were obtained from two faculty members with experience in OSLEs and in primary school mathematics education for the prepared lesson plans. At the same time, the opinions of four classroom teachers working at the school where the implementation would take place were also obtained. The experts and teachers evaluated the lesson plans for their suitability to the learner level and the subject, and concluded they were appropriate. Then, a pilot implementation of one lesson plan was conducted with a different class with similar characteristics that was not included in the study. Information about the content of the lesson plans prepared for length measurement instruction to be carried out in OSLEs is presented in the Table 2.

Table 2. Length measurement instruction to be conducted in OSLEs

Topic	**Content**
Uses of the millimeter	In the activity, students examine natural objects with very small lengths, such as leaf veins, tree bark cracks, small stones, insect traces, and flower stems in the provincial forest. They first estimate the lengths of these objects and then measure them in millimeters using a ruler. In this way, why millimeters are necessary and in which situations they are used are understood through concrete experiences. At the end of the activity, students classify the objects they measured and discuss where millimeters are used in daily life (for example, pencil tip, notebook line spacing, small objects).
Length measurement units and conversions	Students measure real objects (trees, benches, signboards, etc.) in the schoolyard using meters and make sense of these measurements by converting them into different units. In this process, students discover the relationships between length measurement units by constructing them through concrete materials (cardboard strips). In the continuation of the activity, students draw a sketch of the area they measured, visualize mathematical knowledge, and relate it to real life. At the end of the process, through reflective discussions, students evaluate which units they used and why, and where this knowledge is useful in daily life.
Length estimation and measurement	In the activity, students first estimate the lengths of the objects they identify in the park, then measure them using a measuring tape or ruler, and compare the results. In this process, students make sense of the concept of measurement in a real-life context by discussing which measurement unit is more appropriate. At the end of the process, through evaluations, students' estimation accuracy and unit selection are reviewed; they are encouraged to reflect on the reasons for the differences between estimation and measurement.
Solving length measurement problems	The activity begins with a brief reminder about unit conversions. Then, students take measurements of real objects such as walking paths, benches, building entrances, and trees on the campus and perform multi-step operations using these data in line with problem cards. In this way, students have opportunities to relate mathematical operations to real-life situations, which may support their understanding of mathematical concepts. In the continuation, groups share their solution methods and discuss the operations used and their unit preferences. At the end of the process, through reflective evaluations, students question their problem-solving strategies and the use of unit conversions.

Data Analysis

The data obtained from the research were analyzed using SPSS. Before proceeding to the main analyses, preliminary data screening procedures were conducted to examine missing data, outliers, and the assumptions required for parametric statistical tests. The normality of the data distribution was evaluated using skewness and kurtosis coefficients along with the Kolmogorov-Smirnov test. The results obtained showed that the skewness and kurtosis values were within the acceptable range (±1), indicating that the data were close to a normal distribution. Therefore, parametric statistical techniques were used in subsequent analyses.

Before implementation, an independent-samples t-test was conducted on the pretest scores of both scales to determine whether the experimental and control groups were equivalent at the outset. As a result of the analyses, it was determined that there was no statistically significant difference between the pretest scores of the groups. To examine the effect of length measurement instruction conducted in OSLEs on students' mathematics motivation and attitudes toward mathematics activities, the posttest scores of the experimental and control groups were compared using an independent-samples t-test. In addition, multivariate analysis of variance (MANOVA) was applied to examine the effect of length measurement instruction conducted in OSLEs on students' mathematics motivation and attitudes toward mathematics activities. In this analysis, the posttest scores from the mathematics motivation and attitudes toward mathematics activities scales were included as dependent variables, with group (experimental and control) as the independent variable. Thus, the multivariate effect of the intervention on students' motivation and attitude levels was evaluated together. Since the assumption of homogeneity of regression slopes, one of the basic assumptions of ANCOVA, was not met, covariance analysis could not be applied; therefore, MANOVA was preferred to examine the effect of the intervention on the dependent variables (Tabachnick & Fidell, 2012).

To assess the intervention's permanence, a retention test was administered to the experimental group 3 weeks after the posttest. A one-way repeated-measures analysis of variance (ANOVA) was conducted to examine changes in pretest, posttest, and retention test scores for the experimental group. When significant differences were found in the analysis, the Bonferroni multiple-comparison test was used to determine which measurements differed. In all statistical analyses, the significance level was accepted as .05. In addition, effect size values were calculated to reveal the magnitude and practical significance of the obtained results. Cohen's d values were reported for t-test analyses, and partial eta squared (η^2) values were reported for MANOVA and repeated measures ANOVA (Cohen, 1992). The calculated effect sizes were interpreted in line with widely accepted criteria in the relevant literature.

RESULTS

Under this heading, before presenting the conclusions connected to the study questions, the normality of the data is assessed. Whether the pretest and posttest data obtained from the students' mathematics motivation and attitudes toward mathematics activities scales show a normal distribution in the experimental and control groups was determined using the Kolmogorov–Smirnov test (see Table 3).

Table 3. Normality test results for mathematics motivation and attitudes toward mathematics activities scores

	Group	Test	Skewness		Kurtosis		Normality Test		
							Kolmogorov-Smirnov		
			Statistic	Standart Error	Statistic	Standart Error	Statistic	df	Sig.
MMS	Experimental	Pretest	.07	.46	-.67	.90	.11	25	.20
		Postest	-.42	.46	-.51	.90	.12	25	.20
	Control	Pretest	.19	.46	-.72	.90	.09	25	.20
		Postest	-.36	.46	-.97	.90	.15	25	.16
MAS	Experimental	Pretest	-.22	.46	-.93	.90	.14	25	.20
		Postest	.77	.46	.24	.90	.11	25	.20
	Control	Pretest	-.02	.46	-.99	.90	.11	25	.20
		Postest	.25	.46	-.76	.90	.13	25	.20

According to the outcomes of the Kolmogorov-Smirnov test, the significance values for all groups in the pretest and posttest scores of the mathematics motivation and attitudes toward mathematics activities variables are greater than .05 ($p > .05$). This indicates that the data meet the assumption of normal distribution. Therefore, parametric statistical methods were used in subsequent analyses in the research.

Comparison of Posttest Scores between Experimental and Control Groups in terms of Mathematics Motivation and Attitudes

In Table 4, the results of the independent-samples t-test comparing the posttest scores of the experimental and control group students on mathematics motivation and attitudes toward mathematics activities are presented. Before the analysis, the assumption of homogeneity of variances was examined using Levene’s test. It was determined that the variances were homogeneous for both mathematics motivation (F = 0.36, $p = .55$) and attitudes toward mathematics activities (F = 3.28, $p = .08$) variables ($p > .05$). Therefore, the values in the “Equal variances assumed” row were taken into consideration in the interpretation of the t-test results.

Table 3. T-test results comparing posttest scores of experimental and control groups in mathematics motivation and attitudes toward mathematics activities

		n	M	SD	t	*p*	Cohen’s *d*
MMS	Experimental	25	135.36	13.88	3.435	0.001	0.97
	Control	25	122.64	12.25			
MAS	Experimental	25	71.68	8.34	3.151	0.003	0.89
	Control	25	63.00	10.96			

When Table 4 is reviewed, it is evident that there are substantial differences in posttest scores between the experimental and control group learners in terms of mathematics motivation and attitudes toward mathematics activities after the length measurement instruction conducted in OSLEs. In terms of mathematics motivation posttest scores, it was decided that the experimental group learners' mean (M = 135.36, SD = 13.88) was higher than the control group learners' mean (M = 122.64, SD = 12.25). As a result of the independent-samples t-test, this distinction was found to be statistically important ($t_{(48)}$ = 3.44, *p* = .001, *d* = 0.97). Similarly, when posttest scores on attitudes toward mathematics activities were reviewed, it was determined that the experimental group learners' mean (M = 71.68, SD = 8.34) was higher than the control group learners' mean (M = 63.00, SD = 10.96). The independent-samples t-test results also showed that this distinction was important ($t_{(48)}$ = 3.15, *p* = .003, *d* = 0.89). When the effect sizes were examined, it was found that the values for mathematics motivation (*d* = 0.97) and attitudes toward mathematics activities (*d* = 0.89) correspond to large effect sizes according to Cohen's (1988) category. These conclusions show that length measurement instruction conducted in OSLEs significantly and strongly increases students' mathematics motivation and their attitudes toward mathematics activities.

Multivariate Comparison of Mathematics Motivation and Attitudes toward Mathematics Activities

MANOVA was conducted to investigate discrepancies in posttest scores between the experimental and control groups on mathematics motivation and attitudes toward mathematics activities. Before the analysis, the assumptions of MANOVA were examined, and as a result of Box's M test, it was determined that the covariance matrices were equal (Box's M = 4.14, p = .27). In addition, Levene's test showed that the variances were homogeneous for the mathematics motivation variable (F = 0.36, p = .55). Attitudes toward mathematics activities (F = 3.28, p = .076) (p > .05). In Table 5, the results of the MANOVA regarding the posttest scores of the experimental and control groups in terms of mathematics motivation and attitudes toward mathematics activities are presented.

Table 4. MANOVA results for posttest differences between experimental and control groups in mathematics motivation and attitudes

Effect	Wilks' λ	F	df	*p*	Partial η²
Group	0.70	9.97	(2, 47)	< .001	.30

As seen in Table 5, the group variable has a important multivariate impact on the dependent variables (Wilks' λ = 0.70, F (2,47) = 9.97, *p* < .001, η^2 = .30). Following the significant multivariate effect, the corresponding univariate results are reported in Table 6. In addition to statistical significance, Table 6 presents partial eta squared values, which indicate the proportion of variance in the dependent variables explained by group membership and provide information about the magnitude of the observed effects.

Table 5. Univariate analysis results for the posttest scores of math motivation and attitudes toward math activities

Variable	Group	n	M	SD	F	*p*	Partial η²
MMS	Experimental	25	135.36	13.88	11.80	.001	.20
	Control	25	122.64	12.25			
MAS	Experimental	25	71.68	8.34	9.93	.003	.17
	Control	25	63.00	10.96			

When the univariate analysis results presented in Table 6 are examined, it is determined that the group variable has a significant effect on mathematics motivation ($F(1, 48) = 11.80$, $p = .001$, $\eta^2 = .20$) and attitudes toward mathematics activities ($F(1, 48) = 9.93$, $p = .003$, $\eta^2 = .17$). When the mean scores are examined, it is seen that the mathematics motivation (M = 135.36) and attitudes toward mathematics activities (M = 71.68) scores of the experimental group are higher than those of the control group (M = 122.64; M = 63.00). The partial eta squared values indicate that approximately 20% of the variance in mathematics motivation and 17% of the variance in attitudes toward mathematics activities can be explained by group membership. According to commonly accepted benchmarks, these values represent large effect sizes, suggesting that the intervention had a substantial practical impact on students' affective outcomes. These findings show that length measurement instruction conducted in OSLEs has a significant, positive impact on learners' mathematics motivation and attitudes toward mathematics activities.

Changes in Experimental Group Mathematics Motivation Over Time

To examine changes in the pretest, posttest, and retention test scores of the experimental group learners in mathematics motivation and attitudes toward mathematics activities, a one-way repeated-measures analysis of variance was conducted. Before the analysis, the assumption of sphericity was examined using Mauchly's test. It was determined that the assumption of sphericity was not met for the variables of mathematics motivation ($W = .11$, $p < .05$) and attitudes toward mathematics activities ($W = .05$, $p < .05$). Therefore, multivariate test results that are independent of the sphericity assumption were taken into consideration in the interpretation of the analysis results, and the results were reported using Wilks' Lambda statistic. In Table 7, the results of a repeated-measures ANOVA and Bonferroni post hoc comparisons for the pretest, posttest, and retention test scores of the experimental group students regarding mathematics motivation and attitudes toward mathematics activities are presented.

Table 6. Repeated-measures ANOVA and Bonferroni results for experimental group scores on mathematics motivation and attitudes (Pretest, Posttest and retention)

	Measurement	**n**	**M**	**SD**	**F**	***p***	**Partial η²**
MMS	Pretest	25	128.76	14.91			
	Posttest	25	135.36	13.88	32.0	< .001	.74
	Retention test	25	136.28	13.67			
MAS	Pretest	25	63.68	5.79			
	Posttest	25	71.68	8.34	30.60	< .001	.56
	Retention test	25	72.08	7.77			

The analysis results showed that students' mathematics motivation scores differed significantly across measurements (Wilks' $\lambda = .26$, $F(2, 23) = 32.0$, $p < .001$, $\eta^2 = .74$). The partial eta squared value indicates that approximately 74% of the variance in mathematics motivation scores was attributable to differences across measurement occasions, representing a large effect size. When the mean scores were analyzed, it was seen that the mathematics motivation scores were 128.76 in the pretest, 135.36 in the posttest, and 136.28 in the retention test. Likewise, it was determined that the attitudes toward mathematics activities scores also differed significantly across measurements (Wilks' $\lambda = .34$, $F(2, 23) = 22.86$, $p < .001$, $\eta^2 = .67$). Similarly, the partial eta squared value indicated that approximately 67% of the variance in attitudes toward mathematics activities scores was explained by measurement occasion, also reflecting a large effect size. When the mean scores were analyzed, it was seen that the attitude scores were 63.68 in the pretest, 71.68 in the posttest, and 72.08 in the retention test.

According to the outcomes of the Bonferroni multiple comparison test completed to decide between which measurements the discrepancy occurred, significant differences were found in the mathematics motivation variable between pretest and posttest, pretest and retention test, and posttest and retention test scores ($p < .05$). In the attitudes toward mathematics activities variable, while a substantial discrepancy was found between pretest and posttest and between pretest and retention test scores ($p < .001$), no significant difference was found between posttest and retention test scores ($p > .05$). These findings reveal that length measurement instruction conducted in OSLEs increases students' mathematics motivation and their attitudes toward mathematics activities, and that this effect continues and shows permanence in the retention test.

DISCUSSION

Discussion of Posttest Differences in Motivation and Attitudes

In this study, it was decided that there is a substantial discrepancy between the posttest scores of the experimental and control group learners in terms of mathematics motivation and attitudes toward mathematics activities after the length measurement instruction conducted in OSLEs. It was observed that the learners in the experimental group had significantly higher motivation and attitudes toward mathematics activities than those in the control group. The positive influence of OSLE-based length measurement instruction on students' motivation and attitudes toward mathematics activities may be interpreted in light of the distinctive learning opportunities offered by these environments. Unlike traditional classroom settings, OSLEs provide authentic and meaningful contexts in which mathematical ideas can be experienced, explored, and applied in real-life situations. From a constructivist perspective, engaging learners in concrete experiences and active participation may facilitate the development of positive affective responses toward learning by enabling them to perceive mathematics as relevant, purposeful, and accessible. Moreover, the autonomy, collaboration, and experiential nature of OSLE activities may support students' sense of competence and enjoyment, which are considered important determinants of motivation and positive attitudes toward learning.

The outcomes of the research are consistent with studies showing that mathematics instruction in OSLEs positively affects students' motivation and attitudes toward mathematics. As a matter of fact, the investigation found that outdoor-based mathematics instruction increases students' motivation to learn mathematics and strengthens their interest in the subject (Kır et al., 2021; Pambudi, 2022). Similarly, in another study, it was reported that nature-based mathematics activities positively affect students' attitudes toward mathematics and reduce their anxiety about mathematics (Ayhanöz et al., 2022). In addition, the literature states that mathematics activities conducted in outdoor learning environments contribute to students' greater awareness of the relationship between mathematics and daily life and to the positive development of their attitudes toward mathematics (Altuntaş & Çetin, 2023). These findings suggest that the affective benefits associated with OSLEs may stem not merely from a change in physical setting, but from the opportunities these environments provide for meaningful participation, social interaction, and the contextualization of mathematical ideas within students' lived experiences. In this context, the findings support the literature, showing that OSLEs provide effective settings that improve students' interest in and positive attitudes toward mathematics in mathematics instruction.

The instructional process, carried out in experiential and real-life contexts, was effective in producing the results obtained in the study. In this research, length measurement instruction was conducted across different OSLEs, including a forest area, schoolyard, park, and university campus. In these environments, students actively participated in activities such as measuring real objects, estimating, and comparing measurement results. The fact that the topic of measurement is directly related to daily life may have contributed to students' learning of mathematical concepts through concrete experiences. In fact, it has been reported that OSLEs provide important opportunities for students to relate mathematical concepts to daily life (Evcan et al., 2020). Because length measurement naturally involves interaction with physical objects and spatial experiences, the alignment between the nature of the content and the affordances of OSLEs may have strengthened students' emotional engagement with mathematical activities. Rather than perceiving mathematics as a set of abstract procedures, students may have experienced it as a practical tool for understanding and interacting with their environment. This situation may have contributed to students' perceiving mathematics as a more meaningful and interesting field of learning.

Discussion of Multivariate Effects on Mathematics Motivation and Attitudes

The results of the multivariate analysis of variance, conducted to address the second research question of the study, show that the length measurement instruction conducted in OSLEs has a significant joint effect on students' mathematics motivation and their attitudes toward mathematics activities. The joint influence of OSLE-based length measurement instruction on mathematics motivation and attitudes toward mathematics activities suggests that affective responses to mathematics may develop through interconnected rather than isolated processes. This finding indicates that learning environments extending beyond the classroom can simultaneously shape multiple dimensions of students' engagement with mathematics by fostering interest, enjoyment, and willingness to participate in mathematical experiences.

Studies in the literature also show that OSLEs make important contributions to students' mathematics learning processes, both cognitively and affectively. In the study that obtained teachers' opinions, teachers stated that learning activities conducted in out-of-school settings create more engaging and enjoyable learning environments for students and that students participate more actively in the lesson (Kır et al., 2021). In the same study, it was stated that OSLEs contribute to students' cognitive, affective, and psychomotor development. Similarly, in other studies, it was found that mathematics activities conducted in OSLEs improve students' attitudes toward mathematics and encourage more willing participation in the mathematics learning process (Aliustaoğlu et al., 2024; Duatepe-Paksu et al., 2022).

One important reason OSLEs contribute positively to students' mathematics learning is that the activities in these environments support students' active participation. Students who solve mathematical problems in real-life contexts, collaborate with their peers, and actively participate in the learning process can increase their interest in mathematics. In fact, the study states that outdoor learning environments increase students' participation in the learning process, reduce anxiety, and support collaborative learning (Barrett-Rodger et al., 2026; Karamustafaoğlu & Pektaş, 2023). Such learning environments may help students approach the mathematics learning process more positively.

Discussion of the Retention Effects on Mathematics Motivation

The findings from the third research question of the study show that length measurement instruction conducted in OSLEs has lasting effects on students' mathematics motivation and attitudes toward mathematics activities. It was determined that the experimental group students' mathematics motivation and attitudes toward mathematics activities scores increased significantly from pretest to posttest, and that this increase continued in the retention test. The persistence of improvements in students' mathematics motivation and attitudes toward mathematics activities suggests that affective gains derived from OSLE experiences may extend beyond the immediate instructional period. Rather than producing temporary emotional responses, repeated engagement in authentic, meaningful, and participatory mathematical experiences may contribute to the internalization of positive dispositions toward mathematics. This finding highlights the potential of OSLEs to support the sustained development of affective characteristics by enabling students to experience mathematics as relevant, enjoyable, and connected to their everyday lives.

Some studies in the literature also show that OSLEs can create lasting effects on students' mathematics learning processes. The literature reports that out-of-school mathematics activities improve students' mathematical thinking skills and deepen their understanding of mathematical concepts (Bočková & Rumanová, 2024). Similarly, in another study, it is stated that outdoor learning environments increase students' participation in the learning process, reduce learning anxiety, and foster a more positive approach to mathematics learning (Barrett-Rodger et al., 2026).

However, studies in the literature also show that OSLEs do not always lead to significant changes in students' attitudes toward mathematics. In one study, it was found that although mathematics activities conducted in OSLEs had significant effects on students' achievement and anxiety levels, they did not significantly change attitudes toward mathematics (Evcan et al., 2020). Similarly, in another study, it was concluded that mathematical activities conducted in school corridors used as OSLEs produced a statistically significant difference in the anxiety and necessity sub-dimensions of attitude, but did not produce a significant difference in the interest and study sub-dimensions (Çağlar et al., 2018). This suggests that the effect of out-of-school learning activities on students' attitudes may depend on factors such as the duration of implementation, the nature of the activities, and the level of students' participation in the learning process. In this study, the intensive implementation over five weeks and the design of activities to support students' active participation may have contributed to the lasting effects observed.

Taken together, the findings suggest that OSLE-based length measurement instruction may provide conditions that support not only immediate affective engagement but also the sustained development of positive motivational and attitudinal orientations toward mathematics. Given the limited number of experimental studies focusing on specific mathematical topics within OSLE contexts (Eğe et al., 2025), the present study contributes to the literature by offering evidence regarding the potential long-term affective benefits of teaching length measurement in authentic learning environments.

Conclusion and Implications for Practice

The findings of this research show that length measurement instruction conducted in OSLEs has positive effects on students' mathematics motivation and their attitudes toward mathematics activities. These results reveal that the planned and systematic use of OSLEs in mathematics instruction can increase learners' interest in mathematics and their motivation. In this context, it can be recommended that learning environments such as schoolyards, parks, and similar settings be included in the instructional process, especially in the teaching of mathematics topics directly related to daily life, such as measurement and geometry.

The findings of the study also provide important implications for teachers. Mathematics activities conducted in OSLEs can contribute to making lessons more engaging and meaningful by increasing students' active participation in the learning process. Therefore, it can be recommended to develop in-service training programs, implementation guides, and sample activities and materials included in the curriculum so that teachers can use these environments effectively.

This study has several limitations. The sample consisted of a relatively small group of fourth-grade students from a single primary school located in a provincial center. Therefore, the generalizability of the findings may be limited, particularly across different socio-economic contexts and educational settings. In addition, the study focused only on affective variables such as students' mathematics motivation and attitudes toward mathematics activities, and students' conceptual learning levels and mathematical achievement in the subject of length measurement were not directly examined. Moreover, the fact that the implementation was limited to a certain period made it difficult to comprehensively evaluate long-term effects.

In future studies, the effects of mathematics instruction conducted in OSLEs on students' conceptual learning, mathematical reasoning, and problem-solving skills can be examined. In addition, studies to be conducted at different grade levels, on different mathematics topics, and in schools with different socio-economic characteristics can contribute to a more comprehensive understanding of the role of OSLEs in mathematics instruction. Furthermore, mixed-methods studies in which student opinions, teacher experiences, and observational data are used together can reveal more deeply the effects of OSLEs on students' learning experiences.

Additional Declaration

Author Contributions

The authors contributed equally to this study, sharing responsibility for the conceptualization of the research, data analysis, manuscript preparation, and revision processes.

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Responsible Artificial Intelligence Statement

No artificial intelligence support was received in any part of this study.

Conflicts of Interest

The authors declare that there are no conflicts of interest related to the publication of this study.

Ethics Approval

In all processes of this study, the principles of Pen Academic Publishing Research Ethics Policy were followed.

The study received ethical approval from the Ethics Committee of Bayburt University on May 16, 2025 (Approval No: 2025/283).

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