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Boosting Numeracy Through Differentiated Outdoor Learning in Mathematics: A Learning Material Development Study

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ABSTRACT: This research and development study aimed to develop, validate, and determine the effectiveness of differentiated learning materials in Outdoor Learning Mathematics (OLM) for enhancing students' numeracy skills. Following the 4D development model (Define, Design, Develop, and Disseminate), the research meticulously crafted a learning module, Student Worksheets (LKPD), and a numeracy skills test package tailored for seventh-grade students. The materials underwent rigorous validation by expert lecturers and teachers, confirming their validity with all components achieving a 'Valid' category ($Va \geq 3$). Their practicality was established through classroom observations, demonstrating an average implementation score of 83.37% ('Good' category). The effectiveness was primarily assessed via a quasi-experimental design involving an experimental class (n=29) and a control class (n=27) at SMP Nahdlatuth Thalabah Kesilir Wuluhan. Although pre-test and post-test data were not normally distributed (Shapiro-Wilk Sig. < 0.05), their variances were homogeneous (Levene's Sig. ≥ 0.05 for "Based on Mean"). A Mann-Whitney U test revealed a significant difference in post-test numeracy skills between the experimental and control classes (Asymp. Sig. (2-tailed) = 0.009, $p < 0.05$), indicating a positive influence of the developed materials. The experimental class also showed higher classical mastery (75%) and a greater proportion of students reaching 'proficient' numeracy levels. These findings suggest that the differentiated OLM materials are highly effective in improving students' numeracy skills through contextual and engaging problem-based learning experiences.

KEYWORDS: Differentiated Learning, Numeracy Skills, Outdoor Learning Mathematics.

INTRODUCTION

In the evolving landscape of 21st-century education, numeracy skills have emerged as a foundational competency, recognized globally as essential for effective participation in society and the workforce [OECD, 2023]. Numeracy encompasses the ability to understand and apply mathematical concepts, processes, and reasoning in various real-world contexts [Kemendikbud, 2017]. Despite its critical importance, national assessments and international benchmarks, such as the Programme for International Student Assessment (PISA), consistently indicate that the numeracy levels of Indonesian students remain a significant challenge [OECD, 2023; PISA, 2022]. This persistent issue is often attributed to conventional teaching methods that may lack variety, relevance, and engagement, thereby failing to cater to diverse student learning needs and foster a deep, conceptual understanding of mathematics. Observations at SMP Nahdlatuth Thalabah Kesilir Wuluhan similarly revealed low student numeracy levels and a lack of varied teaching approaches, highlighting an urgent need for innovative learning materials.

To address this challenge, this study proposes the development and implementation of differentiated learning materials in Outdoor Learning Mathematics (OLM). Differentiated instruction is a pedagogical approach that tailors teaching to meet the individual needs of students, acknowledging their varied readiness, interests, and learning profiles [Tomlinson, 2014; Santrock, 2011]. This personalized approach helps minimize frustration and build confidence, ensuring every student receives appropriate support and challenge. Concurrently, outdoor learning offers a dynamic and engaging environment where abstract mathematical concepts can be concretized through real-world experiences [Ratnasari, 2020; Ratnasari, 2021]. Moving beyond the confines of the traditional classroom, outdoor settings promote active participation, critical observation, and problem-solving using authentic contexts, thereby enhancing motivation and multisensory engagement.

The learning materials in this study are specifically designed with a Problem-Based Learning (PBL) model. PBL encourages students to actively engage with real-life problems, fostering critical thinking, independent learning, and collaborative problem-solving [Almulla, 2020; Fidan & Tuncel, 2019]. By integrating PBL within an outdoor, differentiated framework, students can apply mathematical reasoning to solve practical problems such as calculating purchase and selling prices, profit/loss percentages, or discounts in a simulated real-world market scenario. This synergy—where differentiated instruction tailors the learning process, outdoor environments provide authentic contexts, and PBL drives problem-solving—is expected to create a holistic, relevant, and motivating learning experience that effectively develops students' numeracy skills. The Student Worksheets (LKPD) developed within this framework are instrumental in facilitating this diverse and adaptive learning experience, offering differentiated tasks that encourage exploration and problem-solving in tangible settings [Marshel & Ratnawulan, 2020; Novitasari et al., 2022; Melawati et al., 2022].

This research aims to develop, validate, assess the practicality, and determine the effectiveness of differentiated learning materials in Outdoor Learning Mathematics to enhance students' numeracy skills. The findings of this study are expected to provide valuable insights for educators seeking to implement innovative, student-centered approaches to mathematics education, ultimately contributing to the improvement of numeracy proficiency among junior high school students, in alignment with the goals of the Merdeka Curriculum.

RESEARCH METHODS

This study employed a Research and Development (R&D) method, aiming to develop, validate, and determine the effectiveness of differentiated learning materials in Outdoor Learning Mathematics (OLM). These materials specifically included a Learning Module, Student Worksheets (LKPD), and a Numeracy Skills Test Package. The development process meticulously followed Thiagarajan's Four-D (4D) model, encompassing its distinct Define, Design, Develop, and Disseminate stages.

The research was conducted at SMP Nahdlatuth Thalabah Kesilir Wuluhan, Jember, East Java, Indonesia, during the even semester of the 2024/2025 academic year. This school was selected due to its prior lack of implementation of differentiated OLM for numeracy enhancement, the inadequacy of existing learning materials in fostering numeracy skills, and the proactive willingness of the school administration to host the research. For sample selection, probability sampling using a simple random sampling technique was applied to ensure all seventh-grade classes had an equal chance of selection. From the six available classes, three were randomly chosen: a trial class, an experimental class (Class VII C, n=29), and a control class (n=27). Crucially, the same mathematics teacher delivered instruction to both the control and experimental classes. The experimental group received the treatment using the newly developed differentiated OLM materials, while the control group utilized the teacher's standard learning materials, which incorporated a Problem-Based Learning (PBL) model within a traditional classroom setting and maintained heterogeneous student grouping.

To ensure clarity and consistency, key terms were operationally defined. Learning materials in this context referred to the developed module, LKPD, and numeracy test package. Numeracy skills were defined as students' ability to apply mathematical concepts, procedures, facts, and tools to solve real-life problems, with indicators including using numbers and symbols in diverse contexts, analyzing information from various forms (graphs, tables, charts), and interpreting results for decision-making. Lastly, Differentiated Learning in Outdoor Learning Mathematics described the adjustment of outdoor mathematics activities to match individual student understanding and learning needs, primarily focusing on process differentiation through ability-based student grouping and tailored support.

The research procedures strictly adhered to Thiagarajan's 4D Model. The Define stage involved an initial-end analysis through interviews with teachers and students to identify current practices and numeracy challenges, followed by student analysis, detailed concept analysis of Social Arithmetic, task analysis for numeracy skill elicitation, and the specification of clear learning objectives. In the Design stage, appropriate media and formats for the differentiated OLM materials were selected, culminating in the creation of Draft 1 of the Learning Module, LKPD, and Numeracy Skills Test Package, alongside the development of research instruments. The Develop stage began with rigorous Expert Validation of Draft 1 by two mathematics education lecturers and one mathematics teacher, with revisions made until 'Valid' criteria ($V_a \geq 3$) were met. Subsequently, Field Trials commenced, starting with a small group trial (six students representing different ability levels) to assess readability. This was followed by a larger field test in the trial class (Class VII E) to determine practicality. Once practical, Draft 3 was finalized and subjected to an Effectiveness Test using a Non-Equivalent Control Group Design. Pre-tests and post-tests were administered to both experimental and control classes to compare numeracy skill improvements. Finally, the Disseminate stage involved distributing the validated, practical, and effective materials offline (school library, mathematics teachers) and online through Google Sites links shared on social media platforms (TikTok, Instagram, Facebook).

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Data collection involved multiple methods. Observation was conducted directly using student activity and learning implementation sheets to assess material practicality and student engagement. The Test method comprised administering pre-tests and post-tests, consisting of two essay questions on Social Arithmetic designed to measure numeracy skills. Interviews, semi-structured in nature, were conducted with the mathematics teacher (before and after intervention) and students (in the trial class) to gather qualitative insights. Lastly, Questionnaires were administered to students in the trial class to gauge their responses and perceptions regarding the learning materials and activities.

Data analysis was systematically performed for validity, practicality, and effectiveness. The validity of learning materials and research instruments was assessed using a Likert scale, deemed valid if the validity coefficient (V_a) fell within $3 \leq V_a < 4$. Practicality was confirmed if the average implementation score from observations met the "good" criterion ($80\% \leq SR \leq 100\%$) and the teacher confirmed ease of use. Effectiveness was determined by three indicators: classical mastery in numeracy tests (at least 70% of students achieving KKM 70), positive student responses ($\geq 75\%$ positive responses on questionnaires), and statistical analysis. Prerequisite statistical tests included Normality Test (Shapiro-Wilk) and Homogeneity Test (Levene's Test based on Mean). For hypothesis testing, given the non-normal distribution but homogeneous variances of the post-test data, the non-parametric Mann-Whitney U test was employed. The primary decision criterion was that if the Asymp. Sig. (2-tailed) value was less than 0.05, the null hypothesis (H_0) would be rejected, indicating a significant influence of the differentiated OLM materials on students' numeracy skills.

RESULT AND DISCUSSION

Data The development process of differentiated learning materials in Outdoor Learning Mathematics followed the 4D model, encompassing four main stages: define, design, develop, and disseminate. Each stage involved a series of specific steps.

During the define stage, an in-depth initial analysis was conducted, which identified a pressing need for differentiated learning materials integrated with outdoor learning mathematics to effectively stimulate students' numeracy skills. Subsequently, the design stage focused on creating the core elements of the learning materials. This included a learning module, Student Worksheets (LKPD), and a numeracy skills test package, all meticulously tailored to the needs identified in the define stage. The outcome of this stage was the initial draft of the product, known as Draft 1. The next stage was develop, where product validation and trials were executed. The validation process involved two expert lecturers in Mathematics Education from FKIP Jember University and a mathematics teacher from SMP Nahdlatuth Thalabah Kesilir Wuluhan. Once the materials were declared valid, trials were conducted. First, a small group trial was performed to evaluate the readability of the materials. Then, a large group trial was carried out to assess the effectiveness and practicality of the materials in a real learning context. Following the trial in Class VII E at SMP Nahdlatuth Thalabah, the learning materials were proven to be valid, practical, and effective. The final stage, disseminate, was conducted both offline at SMP Nahdlatuth Thalabah and online. Online dissemination involved uploading Google Sites links to various popular social media platforms such as TikTok, Instagram, and Facebook, ensuring wide accessibility for other teachers who might need these learning materials.

The validity level of the learning materials and research instruments was assessed by three validators. Every obtained validation score was then averaged for each material. Based on the validation data analysis, the validity coefficient (V_a) for the learning materials with an infusion approach is presented in Table 1.

Table 1. Validity Coefficient of Learning Materials

No.	Material	Validity Coefficient	Category
1	Learning Module	3,60	Valid
2	LKPD	3,52	Valid
3	Test Package	3,69	Valid

All three learning materials were declared valid, as their validation results fell within the score range of $3 \leq V_a < 4$. This indicates that the materials accurately measure what they are intended to. Furthermore, the research instruments were also validated by the three validators. Based on the data analysis, the validity coefficient (V_a)) of the research instruments is presented in Table 2.

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Table 2. Validity Coefficient of Research Instruments

No.	Instrument	Validity Coefficient	Category
1	Student Activity Observation Sheet	3,38	Valid
2	Learning Material Implementation Observation Sheet	3,43	Valid
3	Student Response Questionnaire	3,50	Valid
4	Interview Guide Sheet	3,50	Valid

The validation results show that all four research instruments have scores within the range of $3 \leq V_a < 4$, indicating their validity. This means that the instruments have accurately performed their measurement function. Therefore, it can be concluded that the differentiated learning materials in Outdoor Learning Mathematics and the research instruments have met the validity criteria.

The assessment of the practicality of differentiated learning materials in Outdoor Learning Mathematics was conducted through observation of their implementation over two meetings. This assessment involved the researcher and the model teacher at SMP Nahdlatuth Thalabah Kesilir Wuluhan, covering aspects of learning stages, social systems, principles of reaction and management, support systems, instructional impact, and accompanying impact. The observation results of the implementation of differentiated learning materials in Outdoor Learning Mathematics are presented in Figure 1.

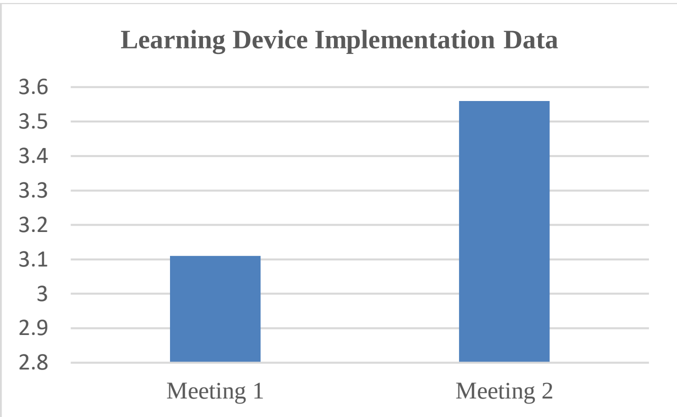

Figure 1. Observation Results od Learning Materials

The observation results showed a positive trend, with an average implementation score of 3.11 in the first meeting and 3.56 in the second meeting. After conversion, these average scores indicate that the learning materials fall into the "Good" category with an interval of $80\% \leq SR \leq 100\%$, signifying high practicality in their classroom implementation. A brief recapitulation of the observation of learning material implementation for the first and second meetings is presented in Table 3.

Table 3. Percentage and Practicality Criteria of Learning Materials

No.	Activity	Average Aspect Value	Percentage
1.	First Meeting	3,11	77,75%
2.	Second Meeting	3,56	89%
Total Percentage		83,37%	
Criteria		Good	

This conclusion is further strengthened by interview data from the mathematics teacher who acted as an observer, confirming the ease and practicality of the materials in teaching and learning activities.

The effectiveness criteria in this research were measured using three indicators: mastery of learning outcomes data in the form of numeracy skills, student response questionnaires, and statistical tests.

In the third meeting, students took a numeracy skills test consisting of two essay questions. These questions were developed based on numeracy indicators and had been validated by experts. The overall results of the learning outcomes test are presented in Table 4.

Table 4. Numeracy Skills Test Results of Trial Class

Highest Score	100
Lowest Score	33
Class Average	73
Number of students achieving score > 70	12
Number of students achieving score < 70	4
Percentage of classical mastery	75%

Overall, the test results show a classical mastery of 75%, which means the majority of students in the trial class achieved the mastery standard. Therefore, it can be concluded that the learning outcomes of Class VII E students at SMP Nahdlatuth Thalabah Kesilir Wuluhan, who used the differentiated learning materials in Outdoor Learning Mathematics, achieved mastery both individually and classically.

The measurement of the second indicator was based on student response data obtained from a questionnaire administered in the last meeting, after the post-test. A brief recapitulation of the student questionnaire results is presented in Table 5.

Table 5. Student Response Questionnaire Results

Statement	Students Response Percentage (%)				
	Very Agree	Agree	Less Agree	Disagree	Very Disagree
The learning materials were presented attractively	56,25%	43,75%	0%	0%	0%
The differentiated learning materials in this outdoor mathematics learning experience significantly increased my enthusiasm for studying mathematics, as they incorporated real-life problems	0%	81,25%	18,75%	0%	0%
These learning materials made learning mathematics less tedious and easier to comprehend	25%	56,25%	18,75%	0%	0%
The presentation of material in the Student Worksheet (LKPD) motivated me to utilize various symbols related to basic mathematics to solve problems	18,75%	81,25%	0%	0%	0%
The presentation of material in the Student Worksheet (LKPD) motivated me to analyze information presented in various forms (e.g., analytical, graphical, tabular)	0%	75%	25%	0%	0%
The presentation of material in the Student Worksheet (LKPD) motivated me to draw accurate conclusions from existing problems	0%	75%	25%	0%	0%
This learning approach supported me in enhancing my numeracy skills	12,5%	68,75%	18,75%	0%	0%
The presentation of material in the Student Worksheet (LKPD) encouraged me to engage in discussions with peers	43,75%	37,5%	18,75%	0%	0%
I enjoyed participating in the differentiated outdoor learning mathematics experience	43,75%	37,5%	18,75%	0%	0%

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Statement	Students Response Percentage (%)				
	Very Agree	Agree	Less Agree	Disagree	Very Disagree
The group discussions were instrumental in helping me understand the subject matter, particularly Social Arithmetic	31,25%	68,75%	0%	0%	0%
I agree that this learning approach should also be applied to other subjects	31,25%	50%	0%	18,75%	0%
Average (%)	23,86%	61,36%	13,06%	1,70%	0%

The brief recapitulation in Table V shows that the percentage of positive student responses reached 85.22%. Therefore, the learning materials meet the effectiveness category when viewed from student responses.

Quantitative data analysis was performed on the pre-test and post-test results of the experimental and control classes using IBM SPSS Statistics 27. The analysis aimed to identify the influence of differentiated learning materials in Outdoor Learning Mathematics—which had met the criteria of validity, practicality, and effectiveness—on students' numeracy skills. Before hypothesis testing, prerequisite tests, namely normality and homogeneity tests, were conducted. For hypothesis testing, the Mann-Whitney U test was chosen as the data were not normally distributed.

The normality test was conducted to determine whether the pre-test and post-test scores of students in the experimental and control classes were normally distributed. This test used the Shapiro-Wilk statistic. The results are shown in Table 6.

Table 6. Normality Test Results of Pre-Test and Post-Test

	Group	*Shapiro-Wilk* *Statistic*	df	Sig.
Pre-Test Score	Experimental	0,909	29	0.016
	Control	0,868	27	0,003
Post-Test Score	Experimental	0,895	29	0,008
	Control	0,910	27	0,023

Based on Table 6, it is known that the pre-test score of the experimental class has a Sig. value of 0.016 (Sig. <0.05), the post-test score of the experimental class has a Sig. value of 0.003 (Sig. <0.05), the pre-test score of the control class has a Sig. value of 0.008 (Sig. <0.05), and the post-test score of the control class has a Sig. value of 0.023 (Sig. <0.05). Referring to the hypothesis previously stated, the decision is to reject H_0, which concludes that the pre-test and post-test scores in both the experimental and control classes are not normally distributed.

The homogeneity test was conducted to evaluate whether the variance of test scores between the experimental and control classes was homogeneous. In this study, Levene's Statistic was used for the homogeneity test. The homogeneity test results for the pre-test and post-test of the experimental and control classes are presented in Table 7.

Table 7. Homogeneity Test Results of Pre-Test and Post-Test

		Levene Statistic	df1	df2	Sig.
Post-Test Score	*Based on Mean*	0,216	1	54	0,644
	Based on Median	0,259	1	54	0,613
	Based on Mediaan and with adjusted df	0,259	1	52,910	0,613
	Based on trimmed mean	0,138	1	54	0,712
Pre-Test Score	*Based on Mean*	3,673	1	54	0,061
	Based on Median	4,092	1	54	0,048
	Based on Mediaan and with adjusted df	4,092	1	42,882	0,049
	Based on trimmed mean	3,755	1	54	0,058

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Based on Table 7, it was found that the pre-test and post-test scores of both classes showed homogeneous variances. This is supported by the significance (Sig.) values in the homogeneity test for pre-test and post-test, which are 0.644 (≥ 0.05) and 0.061 (≥0.05) respectively for "Based on Mean". Referring to the previously stated criteria, this indicates that the null hypothesis (H_0) is accepted, meaning the pre-test and post-test data from the experimental and control classes indeed have homogeneous variances.

Hypothesis testing was conducted to determine the influence of implementing differentiated learning materials in Outdoor Learning Mathematics on students' numeracy skills. Based on the results of the prerequisite analysis tests, although the pre-test and post-test data in the experimental and control classes were not normally distributed, their variances were proven homogeneous. Therefore, further data analysis used the non-parametric Mann-Whitney U test. The Mann-Whitney U test results for the experimental and control classes are shown in Table 8.

Table 8. Hypothesis Test Results with Mann-Whitney U Test

	Post-Test Score
Mann-Whitney U	234,000
Wilcoxon W	612,000
Z	-2,603
Asymp. Sig. (2-tailed)	0,009

Based on Table 8, the Asymp. Sig. (2-tailed) value is 0.009, which is less than 0.05(α<0.05). Referring to the hypothesis previously stated, the decision is to reject H_0 and accept H_1. This indicates a significant difference in the students' post-test numeracy skills between the experimental and control classes, implying an influence of the implementation of differentiated learning materials in Outdoor Learning Mathematics on students' numeracy skills.

DISCUSSION

The findings of this development research on seventh-grade students demonstrate that the developed learning materials are valid, practical, and effective. The validity of the materials was confirmed through expert judgment by three validators to ensure their appropriateness as measurement tools. Practicality was assessed by observing the implementation of the learning materials, while effectiveness was determined by students' numeracy skills test results and their responses via questionnaires.

The development process diligently followed the 4D model (Define, Design, Develop, and Disseminate). The define stage identified a critical need for differentiated learning materials integrated with Outdoor Learning Mathematics (OLM) to address low student numeracy, a concern consistent with national PISA results [OECD, 2023], and observed teaching practices at SMP Nahdlatuth Thalabah Kesilir Wuluhan. This stage underpinned the subsequent design stage, where Draft 1 of the learning package—comprising the module, Student Worksheets (LKPD), and numeracy skills test package—was meticulously crafted to meet these identified needs.

The develop stage rigorously validated and trialed these materials. Expert validation, involving two mathematics education lecturers and a mathematics teacher, confirmed the validity of both the learning materials and research instruments, as all validity coefficients (V_a) exceeded the minimum criterion of $3 \leq V_a < 4$ (see Table 1 and Table 2). This rigorous validation process ensures the theoretical soundness and relevance of the materials for assessing numeracy skills. Furthermore, the practicality of the materials was evident during their implementation, with an average execution score of 83.37% (ranging from 77.75% in Meeting 1 to 89% in Meeting 2), placing them in the "Good" category (80%≤SR≤100%) (see Table 3 and Figure 1). This indicates the materials are user-friendly and adaptable, a finding corroborated by interview data from the observing mathematics teacher who affirmed their ease of use in teaching and learning activities. This aligns with principles of effective educational tools, emphasizing both robust design and practical applicability.

The effectiveness of the differentiated OLM materials was substantiated by multiple indicators. Firstly, the numeracy skills test results showed a classical mastery of 75% (with a KKM of 70) in the trial class (see Table IV). This signifies that the majority of students successfully attained the learning objectives, indicating the materials' capability in facilitating numeracy mastery. Notably, one student achieved a perfect score (100), although one student also recorded the lowest score (33). Further analysis of student responses revealed some confusion and difficulties for certain students, with interview data suggesting a desire for more than one meeting to cover the material thoroughly. Secondly, the high student response rate (85.22% positive responses) from the questionnaires (see Table 5) signals a positive learning experience and high student engagement, factors known to significantly influence learning motivation and outcomes [Pambudi, 2022].

Qualitative observations during the trial further elucidated the learning dynamics. Initially, some students were passive in group discussions during the first meeting. However, in subsequent stages, particularly during the second meeting, students displayed greater enthusiasm, conducive learning activity, and active collaboration, especially within the "needs guidance" group. This evolution underscores the adaptive nature of the differentiated approach.

The integration of Project-Based Learning (PBL), outdoor learning, and differentiated instruction creates a powerful synergy for enhancing students' numeracy skills. This aligns with PBL's characteristics, which promote active engagement in real-world problems, foster new solutions, facilitate knowledge sharing, and encourage collaboration [Almulla, 2020]. PBL also empowers students to define their own learning needs, become independent learners, and participate actively in problem-solving [Fidan & Tuncel, 2019]. When PBL is implemented in an outdoor learning context, the natural environment becomes a rich, living laboratory for numeracy. Students can directly calculate, compare, and analyze data from real-life scenarios, such as determining purchase and selling prices, calculating profit or loss percentages, or assessing discounts during shopping. These concrete experiences help concretize abstract numeracy concepts, making them more comprehensible and memorable [Ratnasari, 2020; Ratnasari, 2021]. Outdoor settings also boost student motivation and engagement, as physical activity and natural exploration alleviate boredom and stimulate various senses [Ratnasari, 2020].

Furthermore, differentiated instruction ensures tailored support and challenge for each student. Teachers can facilitate process differentiation by providing varied guidance among student groups. "Highly proficient" groups receive minimal guidance and more complex challenges, fostering independence. "Proficient" groups receive more directed guidance to solidify understanding. Meanwhile, "needs guidance" groups receive intensive support and more structured instruction to help them master foundational numeracy concepts [Tomlinson, 2014; Santrock, 2011]. This approach acknowledges diverse student readiness, interests, and learning profiles, thereby preventing frustration and boosting confidence in numeracy learning [Fauzi et al., 2024]. Thus, the combination of these three elements creates a holistic, relevant, motivating, and effective numeracy learning experience for every student.

The developed Student Worksheets (LKPD) are crucial for supporting differentiated learning in outdoor mathematics to enhance numeracy skills. These LKPDs are designed to provide diverse and adaptive learning experiences, considering varying student needs. The appropriateness of LKPDs as learning media is vital, as they must be relevant to learning objectives and content, and equipped with suitable evaluation tools [Marshel & Ratnawulan, 2020]. Problem-based LKPDs, when applied in an outdoor learning context, have been shown to improve student learning outcomes [Novitasari et al., 2022]. Additionally, LKPDs are highly beneficial for encouraging student activity and self-reliance in learning, ultimately maximizing learning outcomes [Melawati et al., 2022]. By integrating outdoor learning and differentiation, these LKPDs strive to create a dynamic and relevant learning environment, enabling students to develop their numeracy skills through exploration and problem-solving in real-world settings.

The differentiated OLM materials, validated as valid, practical, and effective in Class VII E, were then implemented in the experimental class (Class VII C with 29 students) at SMP Nahdlatuth Thalabah Kesilir Wuluhan. The control class (27 students) used the teacher's usual learning materials, which involved a PBL model with lecturing methods conducted indoors. Pre-test results indicated a descriptive difference in numeracy skills between the experimental class (mean = 21.52, SD = 10.102) and the control class (mean = 15.11, SD = 5.598).

Before conducting the hypothesis test, prerequisite tests were performed on the pre-test and post-test data. The normality test using Shapiro-Wilk (due to sample size less than 50) showed that the Sig. values for pre-test (experimental = 0.016; control = 0.003) and post-test (experimental = 0.008; control = 0.023) were all less than 0.05 (see Table VI). This indicates that the pre-test and post-test scores for both experimental and control classes were not normally distributed. The subsequent homogeneity test using Levene's Test (Based on Mean) revealed Sig. values of 0.061 for pre-test and 0.644 for post-test (see Table 7). As both values are greater than the significance level of 0.05, it is concluded that the variances of the two samples from the experimental and control classes are homogeneous. This implies that the numeracy skills of students in both classes exhibit similar characteristics in terms of data variability.

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Given the non-normal distribution but homogeneous variances, the non-parametric Mann-Whitney U test was appropriately employed to compare numeracy skills between the experimental and control groups in the post-test. The Mann-Whitney U test results (see Table VIII) showed an Asymp. Sig. (2-tailed) value of 0.009, which is less than 0.05($\alpha<0.05$). This leads to the rejection of H0 and acceptance of H1, indicating a significant difference in the students' post-test numeracy skills between the experimental and control classes. The Mean Rank analysis further supports this, with the experimental class (Mean Rank = 33.93) showing significantly higher numeracy skills than the control class (Mean Rank = 22.67) after the intervention.

Experimental findings in both classes showed similar maximum post-test scores of 100, but differing minimum scores (17 in experimental and 28 in control). The fact that a control class student achieved 100 aligns with insights from the practicing teacher, who noted this student's superior numeracy and familiarity with non-routine problems. Despite the control class using conventional materials, the experimental class's average post-test score (74.31) was notably higher than the control class's (61.41) indicating a more substantial improvement in the experimental group. This is further evidenced by the distribution of competency categories: 58.6% and 31% of experimental class students achieved "proficient" and "competent" categories respectively, compared to 29.6% and 44.4% in the control class. This suggests a higher proportion of students with "proficient" numeracy levels in the experimental class.

The observed significant difference in the impact of the differentiated learning materials in outdoor learning mathematics is consistent with previous research. The substantial improvement in numeracy skills within the experimental group aligns with findings by Kurnia, Sugianto, and Permana [2022] on the effectiveness of differentiation in mathematical problem-solving, as this approach allows for material and process adjustments based on student needs [Fitriyah & Azizah, 2021]. Furthermore, the use of OLM in this study is supported by recent research by Setiawan and Haryani [2023], which found that outdoor learning enhances mathematical concept understanding through real-world contexts. Rohmah and Pratiwi [2020] also emphasized the effectiveness of exploring outdoor environments in developing numerical literacy, consistent with the increased proportion of "proficient" students in the experimental group. Overall, these findings affirm the positive synergy between differentiated learning and outdoor learning mathematics. This is consistent with recent literature emphasizing the importance of contextual and experience-based learning [Sari & Susilawati, 2024; Indrawati & Nugraha, 2021], which has proven effective in facilitating deeper numeracy understanding and empowering students to achieve higher competency levels, as evidenced by the dominance of the "proficient" category in the experimental class.

Despite these strengths, some limitations were identified. The study's short duration (two meetings for specific material) was a weakness; ideally, four meetings would allow for more in-depth coverage and mastery. Additionally, scheduling conflicts with school farewell preparations sometimes disrupted optimal lesson delivery, affecting learning continuity and focus. However, the developed materials possess several strengths: 1) The learning module is aligned with the latest Merdeka Curriculum, integrating differentiated and outdoor learning methods with systematic steps for ease of implementation by teachers and clear learning flow for students. 2) The LKPDs are specifically designed to cater to individual student needs, offering three differentiated versions per meeting (for highly proficient, proficient, and "needs guidance" groups), ensuring appropriate challenge levels. 3) The LKPDs are tailored to enhance numeracy skills, developed based on relevant numeracy indicators and integrated with PBL, training students to solve contextual problems that require numeracy. 4) The material and problems in the LKPD are highly relevant to students' surroundings and effectively utilize outdoor learning, allowing direct application of mathematical concepts in real-world contexts, making learning more meaningful and engaging.

CONCLUSION

This study successfully developed valid, practical, and effective differentiated learning materials in Outdoor Learning Mathematics (OLM), demonstrating their significant positive influence on students' numeracy skills. The rigorous 4D model ensured the quality of the developed module, Student Worksheets (LKPD), and numeracy test package. Empirical evidence, derived from expert validation, practicality observations, student learning outcomes (including 75% classical mastery), and statistical analyses (Mann-Whitney U test, with an Asymp. Sig. (2-tailed) = 0.009, $p<0.05$), unequivocally confirmed the effectiveness of these materials. They particularly fostered a higher proportion of students in "proficient" numeracy competency levels compared to conventional methods. This success stems from the seamless integration of differentiated instruction with contextual, experience-based outdoor learning, rooted in Problem-Based Learning, which collectively creates a powerful, engaging, and tailored learning environment that effectively addresses diverse student needs and improves real-world mathematical application.

Given these compelling findings, it's highly recommended that teachers adopt and adapt these differentiated OLM materials. Their proven effectiveness extends beyond merely enhancing numeracy, potentially benefiting other subjects suitable for outdoor learning by supporting diverse learning needs and promoting collaboration among students. For further development, replicating similar materials for other educational levels or subjects is encouraged, potentially including specific assessments for collaboration and care. Additionally, future researchers could explore the long-term impact of these materials on both numeracy and social skills, investigate their effectiveness across more diverse student populations (e.g., special needs or remote areas), compare their efficacy against other learning models, and delve into the role of technology in supporting outdoor learning initiatives.

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