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Development of Mathematics Learning Tools Based on Education for Sustainable Development (ESD) Using the Outdoor Learning Mathematics Method to Enhance Mathematical Connections in Junior High School

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ABSTRACT: This research aims to develop mathematics learning tools based on Education for Sustainable Development (ESD) using the Outdoor Learning Mathematics method with the goal of enhancing mathematical connections of junior high school students in statistics. The research method employed is a mixed-methods approach combining qualitative and quantitative methods, both conducted through developmental research comprising planning, development, and evaluation stages. The sample for this research was two classes at SMPN 1 Tempeh with homogeneous mathematical abilities, where one class will be used as the experimental group and one class as the control group. Determining the research area using a purposive area sampling technique with the consideration that learning using the outdoor learning mathematics method with educational sustainable development (ESD) based learning tools has never been implemented at SMPN 1 Tempeh. The selection of eighth-grade classes is based on the consideration that statistics material is currently being taught in eighth grade, and eighth-grade students have not been subjects of research for similar studies before. The learning tools developed are designed in accordance with ESD principles and utilize outdoor mathematics learning approaches to enhance students' understanding and skills in statistics. The results from Hypothesis Testing for Pretest indicate that a p-value of 0.648 is obtained, where this value > 0.05 means H0 is accepted and H1 is rejected. Therefore, it can be concluded that there is no difference in the mean between the control and experimental groups in the pretest. Whereas the result of Posttest Hypothesis Test indicate that a p-value of 0.028 is obtained, where this value < 0.05 means H0 is rejected and H1 is accepted. So the use of ESD-based mathematics learning tools with the Outdoor Learning Mathematics method is effective in improving students' mathematical connections in statistics. The implication of this research underscores the importance of integrating mathematics education with sustainable development principles to reinforce students' understanding and skills in mathematics while also fostering awareness of environmental and social issues.

KEYWORDS: Education for Sustainable Development (ESD), Learning Outcomes, Mathematical Connections, Mathematics learning tools and Outdoor Learning, Mathematics Education.

INTRODUCTION

Education plays a pivotal role in shaping individuals' understanding, skills, and attitudes towards various subjects, including mathematics. In recent years, there has been a growing recognition of the importance of integrating sustainable development principles into educational practices to foster a more holistic and environmentally conscious approach to learning. Mathematics, as a fundamental subject, offers a unique opportunity to embed concepts of sustainability and environmental awareness into curriculum design and instructional methodologies. In line with this perspective, this research endeavors to contribute to the advancement of mathematics education by developing innovative learning tools rooted in the principles of Education for Sustainable Development (ESD). The focus is on enhancing students' mathematical connections and learning outcomes, particularly in the context of statistics, through the utilization of the Outdoor Learning Mathematics method (Stukenberg, 2016).

Junior high school students represent a critical stage in their educational journey where foundational concepts in mathematics, including statistics, are introduced. However, traditional classroom-based approaches may sometimes fall short in engaging students effectively and fostering deep understanding. By integrating outdoor learning methodologies within the framework of ESD, this study seeks to address these challenges and provide a more enriching and experiential learning experience for students.

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The research methodology adopts a mixed-methods approach, combining qualitative and quantitative techniques within a developmental research framework. This comprehensive approach allows for a thorough investigation into the effectiveness of the developed mathematics learning tools in improving students' mathematical connections and learning outcomes. Furthermore, this research aligns with broader efforts to promote sustainable development education by emphasizing the interconnectedness between mathematics education and environmental and social issues. By enhancing students' mathematical understanding and skills within the context of sustainability, this study aims to cultivate a generation of learners who are not only proficient in mathematics but also equipped with the critical thinking and awareness necessary to address complex global challenges. Overall, this research represents a significant step towards reimagining mathematics education as a platform for promoting sustainability and empowering students to become active agents of positive change in their communities and beyond.

LITERATURE REVIEW

Education for Sustainable Development (ESD) has emerged as an important framework for integrating sustainability principles into education across a variety of disciplines, including mathematics. This literature review explores key themes related to the development of ESD-based mathematics learning tools, especially using outdoor mathematics learning methods, which aim to increase mathematical connections in junior high school students.

Education for Sustainable Development (ESD)

Education for Sustainable Development (ESD) is an effort to encourage society to constructively and creatively address global challenges and to create resilient and sustainable communities. UNESCO, as a leading global organization, coordinates the implementation of the Global Action Programme (GAP) on ESD, as a follow-up to the United Nations Decade of ESD (2005-2014). Education for sustainable development enables every individual to acquire the knowledge, skills, attitudes, and values needed to shape a sustainable future.

ESD and Mathematics Learning

ESD is indirectly embedded within the curriculum or subject matter in schools, particularly in mathematics subjects. The role of mathematics teachers in integrating ESD into mathematics learning is crucial. To introduce ESD to students, teachers need to conduct a curriculum analysis. Curriculum analysis is performed by identifying Competency Standards (SK-KD) in the KTSP Curriculum and Basic Competencies (KI-KD) in the 2013 Curriculum. Therefore, teachers can determine which materials can be infused with ESD concepts.

Integration of ESD into Mathematics Education

The integration of ESD principles into mathematics education aims to equip students with the knowledge and skills necessary to understand and address sustainability issues using mathematical concepts and reasoning. This approach encourages students to explore how mathematics can contribute to sustainable development goals (Hopkins & McKeown, 2016). By contextualizing mathematical concepts in the context of sustainability, students can develop a deeper understanding of the relevance and application of mathematics outside the classroom.

Outdoor Learning Mathematics Method

Outdoor mathematics learning involves using the natural environment as a setting for teaching and learning mathematics concepts (Davis, 2017). This method emphasizes experiential learning, where students engage in hands-on activities that improve mathematical thinking and problem-solving skills in authentic outdoor environments (Ward & Hargreaves, 2019). Research shows that outdoor learning environments stimulate curiosity, creativity, and collaboration among students, thereby increasing engagement and understanding of mathematical concepts (Powers, 2020).

Mathematical Connections

Mathematics encompasses various topics that are interrelated with each other. The connections among these topics are not only within mathematics but also extend to other disciplines and have relevance to everyday life. These connections are referred to as mathematical connections. According to the National Council of Teachers (2000), mathematical connections have three indicators: 1) recognizing and using relationships among mathematical ideas, 2) understanding how ideas in mathematics are

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interconnected and form a cohesive whole, and 3) recognizing and applying mathematics in contexts outside of mathematics (Prambudi, 2020). The indicators of mathematical connections that will be used in this study are as follows:

Table 1. The indicators of mathematical connections

Indicator of Mathematical Connection Ability	Description of Indicator of Mathematical Connection Ability
Recognizing and using relationships among mathematical ideas	Students are able to identify ideas by writing down what is known and what is asked in solving problems. Students are able to use ideas to create mathematical models in solving problems.
Understanding how mathematical ideas are interconnected	Students are able to establish connections between concepts in solving problems.
Understanding the relationship between mathematics and everyday life	Students are able to interpret real-life problems into mathematical models. Students are able to apply concepts in solving real-life problems.

MATERIALS AND METHODS

The type of research used in this study is mixed-methods research. Mixed-methods research is a research method that combines both qualitative and quantitative research methods. The qualitative research method used in this study is developmental research, and the quantitative research method used in this study is experimental research method. The research design employed in this study is sequential exploratory design.

Sample and Participants

The sample for this research was two classes at SMPN 1 Tempeh with homogeneous mathematical abilities, where one class will be used as the experimental group and one class as the control group. Determining the research area using a purposive area sampling technique with the consideration that learning using the outdoor learning mathematics method with educational sustainable development (ESD) based learning tools has never been implemented at SMPN 1 Tempeh.

The selection of eighth-grade classes is based on the consideration that statistics material is currently being taught in eighth grade, and eighth-grade students have not been subjects of research for similar studies beforeFurthermore, the developed learning tools will be piloted first in one randomly selected class, but not in the same population as the experimental research. This pilot class plan will be carried out at MTS As-Salam Lumajang, eighth-grade level.Sampling is a fundamental aspect of any research project, and the type of sample selected can have a significant impact on the validity and reliability of the research results.

RESULT

Normality Test

The prerequisite analysis is conducted using a normality test to determine the suitability of using either the Independent t-test or the Mann-Whitney U test. If the Sig. value > 0.05, then the data is normally distributed, and the analysis can proceed using the Independent t-test. Conversely, if the Sig. value < 0.05, then the data is not normally distributed, and the analysis can proceed using the Mann-Whitney U test. The normality test used is the Kolmogorov-Smirnov test, and the results of the normality test are presented in the table below:

Table 2. Normality Test

Variable	Group	Sig.	Conclusion
Pretest	Control	0.200	Normal
	Exsperimental	0.200	Normal
Posttest	Control	0.075	Normal
	Exsperimental	0.089	Normal

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Based on the table above, it is obtained that for the pretest control, the Sig. value is 0.200, while for the posttest experiment, the Sig. value is 0.200. Meanwhile, for the posttest control, the Sig. value is 0.075, and for the posttest experiment, the Sig. value is 0.089. Since all Sig. values > 0.05, it can be concluded that the data is normally distributed. Therefore, the significance test of the hypothesis between the two independent unmatched samples to determine the difference between control and experiment is conducted using an independent t-test.

Homogeneity Test

Homogeneity test is a test to determine whether the data has the same variance or not. In this study, homogeneity test is conducted using Levene's test of variance with the decision-making basis that if the Sig. value < 0.05, then the two groups have different variances. Conversely, if the Sig. value > 0.05, then the two groups have the same variance. The results of the homogeneity test are presented in the table below:

Table 3. Homogeneity test

Variable	Levene Statistic	df1	df2	Sig.
Pretest	0.162	1	54	0.689
Posttest	1.122	1	54	0.294

Based on the results of the Homogeneity test in the table above, it is known that the probability value p or Sig for the pretest is 0.689, while for the posttest it is 0.294. Both variables have Sig. values > 0.05. Therefore, it can be concluded that the data is homogeneous.

Independent T-test

The Independent T-test is used to determine whether there is a difference in the means of two independent samples. This test is a parametric statistical test that requires assumptions of normality and homogeneity. The hypothesis and decision-making basis for the Independent T-test are as follows:

H_0 = There is no difference in the means between the control and experimental groups

H_1 = There is a difference in the means between the control and experimental groups

Table 4. Hypothesis Testing for Pretest

Pretest	Mean ± SD	Difference	Sig.
Kontrol	31.160 ± 4.858	-0.598	0.648
Eksperimen	31.758 ± 4.881		

Based on the table above, it is found that the pretest obtained a mean value of 31.160 for the control group, while the mean value for the experimental group is 31.758. The difference in mean values is -0.598, indicating that the control value is smaller than the experimental value.

Table 5. Posttest Hypothesis Test

Posttest	Mean ± SD	Difference	Sig.
Kontrol	70.401 ± 7.469	-5.133	0.028
Eksperimen	75.535 ± 9.455		

Based on the table above, it is found that in the posttest, the mean value for the control group is 70.401, while the mean value for the experimental group is 75.535. The difference in mean values is -5.133, indicating that the control value is smaller than the experimental value.

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DISCUSSION

The results from Hypothesis Testing for Pretest indicate that a p-value of 0.648 is obtained, where this value > 0.05 means H0 is accepted and H1 is rejected. Therefore, it can be concluded that there is no difference in the mean between the control and experimental groups in the pretest. Whereas the result of Posttest Hypothesis Test indicate that a p-value of 0.028 is obtained, where this value < 0.05 means H0 is rejected and H1 is accepted.

Therefore, it can be concluded that there is a difference in the mean between the control and experimental groups in the posttest. Implementing Mathematics Learning Tools can have a significant impact on overall student engagement. The use of Mathematics learning tools such as interactive simulations, graphing calculators, and educational applications can provide students with hands-on experiences that make abstract mathematical concepts more concrete and easier to understand. This interactivity can increase engagement by making learning more dynamic and fun. Learning tools that offer visual and spatial representations of mathematical concepts (such as visualizations of geometry or calculus) can help students develop deeper understanding. Seeing mathematical relationships visually can be more interesting than simply reading or listening to explanations. Based on the description above, it can be concluded that the development of mathematics learning tools based on ESD is able to improve mathematical connections and learning outcomes of junior high school students in statistics.

But Integrating Mathematics Learning Tools into the learning environment offers numerous benefits, but there are also challenges and limitations that need to be addressed to optimize their effectiveness. One of them is that teachers may not have training or understanding of the learning media, which can affect their ability to integrate the media effectively into teaching. Apart from that, it is not certain that the learning media is in accordance with curriculum standards or teaching objectives in the current learning period, considering that the current curriculum and learning continues to change and develop.

CONCLUSIONS

Concluded that there is a difference in the mean between the control and experimental groups in the posttest and it can be concluded that the development of mathematics learning tools based on ESD is able to improve mathematical connections and learning outcomes of junior high school students in statistics. This statement reflects the results of research or experiments that tested the effect of developing ESD-based mathematics learning tools on junior high school students. By involving two groups of students, namely the control group (who did not use ESD-based mathematics learning devices) and the experimental group (who used these devices). From the statistical analysis carried out, it is known that there is a significant mean difference between the control and experimental groups in the posttest, which shows that the use of ESD-based mathematics learning tools has a positive impact on students' comprehension or comprehension. the ability of statistical material compared with conventional methods or without using tools. And based on research results, it shows that the use of ESD-based mathematics learning tools improves students' statistics learning outcomes because students become better able to understand and apply statistical concepts after using these learning tools.

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