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Enhancing Mathematical Communication and Self-Efficacy through Discovery Learning Approaches

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Abstract

E-worksheets developed with interactive features encourage students to explore mathematical concepts independently. This measures students' mathematical communication skills and self-efficacy using a discovery learning model assisted by E-worksheets. This research is a quasi-research conducted at MTs Negeri 1 Yogyakarta. The sample was 64 class VII students who were divided into two sample groups, namely the experimental group and the control group. The E-worksheet assisted discovery learning model was applied to the experimental group and the conventional model was applied to the control group. The instruments used were mathematical communication ability test instruments and self-efficacy questionnaires. The t-test is used to analyze the effect of learning models on mathematical communication skills and self-efficacy. The research results found that students' achievement of mathematical communication skills and self-efficacy were higher compared to the control group. The E-worksheet assisted discovery learning model has a significant influence on students' mathematical communication skills and self-efficacy. These findings provide a significant contribution to current knowledge about the influence of the discovery learning model assisted by LKPD E-worksheets to improve students' mathematical communication skills and self-efficacy on lines and angles.

Keywords: *Discovery Learning; Lkpd E-Worksheet; Mathematical Communication Skills; Self Efficacy*

Introduction

Mathematics education not only includes mastery of mathematical concepts and skills, but also emphasizes the development of critical thinking skills, creativity and mathematical communication skills. Basic mathematical abilities, as described by Sumarmo (2006), include five standards, namely recognition, understanding and application of mathematical concepts; solve math problems; mathematical reasoning; make mathematical connections; and mathematical communication. In this context, geometry is a branch of mathematics that plays an important role in improving students' mathematical communication skills.

Geometry is not just teaching material, but also a place to develop students' abilities to think and communicate mathematically. Geometry brings students to understand and apply mathematical concepts, as stated by Petrus et al. (2017), who see geometry as a vehicle for training students to become good

problem solvers and able to communicate and reason mathematically. However, challenges arise when geometry material, especially the topic of lines and angles, is presented as an abstract object for students. This is in line with the findings of Puspitasari et.al. (2023), which emphasizes the need for the right approach to teaching this material.

Current reality shows that students' mathematical communication skills are still low. Based on the results of interviews with mathematics teachers at MTs Negeri 1 Yogyakarta, information was obtained that students were not able to communicate mathematical ideas well. Students have not been able to convey their ideas. When the teacher asks questions, students are still not able to organize their arguments well. Learning is still dominated or teacher-centered. And students are also not able to express a situation or problem in the form of symbols, diagrams or mathematical models. Thus, it can be said that students' mathematical communication skills are still low. In order for this problem to be resolved, an innovation is needed that can be carried out to stimulate increased mathematical communication through mathematical resilience, namely using a learning model that can stimulate students' curiosity, self-confidence and perseverance. In recent times, learning approaches have increasingly shifted towards a student-centered approach, of which discovery learning is one of them. Discovery learning has the meaning of a learning process that does not provide the whole but involves students to organize, develop their knowledge and skills to solve various kinds of problems (Ana, 2018). This is where the Discovery Learning learning model comes into play. As a learning approach that emphasizes exploration and discovery, Discovery Learning has been proven to improve students' mathematical communication skills, especially in understanding and applying the concepts of lines and angles (Sahrul et al., 2020).

Previous research, such as that conducted by Sahrul et al. (2020), shows encouraging results regarding the development of Discovery Learning-based mathematics learning tools to facilitate students' mathematical communication skills. Likewise, research by Puspitasari, et al. (2023), concluded that the application of the Discovery Learning model was able to improve mathematical communication skills and student learning outcomes on lines and angles.

Education in this century demands a more holistic learning approach, emphasizing collaboration, communication, problem solving, critical thinking, creativity and innovation (Lase, 2019; Hadisaputra et al., 2020). Therefore, the implementation of learning activities must consider not only aspects of lesson content, but also conditions and factors that influence learning effectiveness, such as facilities and infrastructure (Fatmawati et al., 2019).

One aspect that cannot be ignored in increasing learning effectiveness is the development of teaching materials that are relevant and interesting for students (Yuni et al. 2018; Ramdoniati et al., 2019; Zakaria et al., 2020). Student Activity Sheets (LKS) or Worksheets are a type of educational material that can be used in the learning process (Suryaningsih & Nurlita, 2021). Furthermore, with advances in technology, the development of worksheets in electronic form, such as E-Worksheets, can be an interesting and interactive alternative for students (Soenarko et al., 2022). E-Worksheets not only facilitate discovery learning through the use of multimedia, but also open up opportunities to improve students' decision-making skills and scientific attitudes (Soenarko et al., 2022). The successful implementation of Discovery Learning-based E-Worksheets in this research was an inspiration to further explore the potential of this learning model.

The Discovery learning model, as suggested by the Minister of Education and Culture Regulation and the theory put forward by Bruner (Roza et al., 2018), offers a student-centered learning process. Students are not only recipients of information, but also active learning subjects, with lecturers acting as trainers and facilitators. The discovery learning model, as described by Putriani & Rahayu (2018), teaches students to acquire knowledge without direct, partial or complete notification by discovering their own knowledge.

When discussing mathematics learning, mathematical communication has a central role in expressing, explaining, describing and understanding mathematical concepts. The National Council of Teachers of Mathematics (NCTM) states that through mathematical communication, ideas can become objects of reflection, refinement, discussion and change (NCTM, 2016). Therefore, in learning mathematics, mathematical communication skills become essential, not only as a tool for solving problems or drawing conclusions, but also as a social skill needed for interactions between students and interactions with lecturers (Tiffany et al., 2017).

Student self-efficacy, as a belief or self-assessment of their ability to achieve goals, is also an important aspect in the learning process (Bandura, 1997). Self-efficacy can be influenced by various factors, including past performance experiences.

Previous research has highlighted the success of the Discovery Learning model in improving various aspects of student learning. Findings from previous studies show that this model not only improves student learning outcomes, but also contributes to the development of spatial abilities, self-efficacy, learning achievement, problem solving abilities, mathematical connections, learning motivation, active learning, and increasing critical thinking skills. mathematics, self-confidence, students' adaptive reasoning abilities, as well as mathematical analogy abilities (Arifudin, Wilujeng, & Utomo, 2016; Fajri, Johar, & Ikhsan, 2016; Imamah & Toheri, 2014; Kristin & Rahayu, 2016; Kusmaryono, 2015; Maduretno, Sarwanto, & Sunarno, 2016; Parno, 2015; Patandung, 2017; Persada, 2016; Pigawati & Basuki, 2016; Rahman & Maarif, 2014; Salo, 2016; Sari, Ridlo, & Utami, 2016; Wahyudi & Siswanti, 2015; Yusmanto & Herman, 2015).

Efforts to improve communication skills and mathematical connections are not limited to the Discovery Learning model alone. Several other learning models have also been proposed and implemented, including the problem-based learning model, the TSTS Learning Model with a Scientific Approach, the mind mapping learning method, the contextual approach, and the CTL approach (Ainurrizqiyah, Mulyono, & Sutarto, 2015; Bernard, 2015; Choridah, 2013; Faelasofi, Arnidha, & Istiani, 2015; Nuriadin, 2015; Permata, Kartono, & Sunarmi, 2015; Yuliani, 2015). Although there have been various efforts to improve mathematical communication skills, there has not been much research that specifically uses the Discovery Learning Model assisted by E-Worksheets for lines and angles.

In this case, this research wants to explore the latest developments by utilizing the Discovery Learning Model supported by E-Worksheets in improving students' mathematical communication skills and self-efficacy, especially in line and angle material. The main aim of this research is to assess whether the use of this learning model can improve students' mathematical communication skills better than conventional learning. Thus, this research not only brings new contributions to the understanding of mathematics learning concepts, but also enriches the practical knowledge of teachers and students in the field. The aim of this research is to find out that the Discovery Learning learning model assisted by LKPD E-Worksheets is effective in improving mathematical communication skills and self-efficacy between students who are taught using the Discovery learning model and the Conventional Learning Model in the experimental group and control group.

Methods

Research is a quasi-experimental research which aims to identify the effect of treatment on the dependent variable under controlled conditions, in accordance with the research method described by Creswell & Creswell (2017). The location of the research was at MTs Negeri 1 Yogyakarta. The research population involved all class VII students with a total of 256 students. Sampling was carried out using a cluster random sampling technique, with a total sample of 64 people. The sample was divided into two groups, namely the experimental group and the control group. In the experimental group, learning was carried out using a discovery learning model supported by E-Worksheet based Student Worksheets

(LKPD). Meanwhile in the control group, the learning method used was conventional learning. Data collection was carried out by conducting tests on students' mathematical communication skills and self-efficacy. Data was collected before and after implementing the learning model, using instruments in the form of mathematical communication ability tests and student self-efficacy questionnaires. The research will be carried out from March 2023 to April 2023.

Students' mathematical communication abilities are assessed based on three main indicators, namely the ability to express mathematical ideas through writing, demonstration and visualization; ability to understand, interpret, and evaluate mathematical ideas orally, in writing, and visually; and the ability to use terms, mathematical notations, and structures to present ideas, and describe relationships with situation models. The technique for assessing students' mathematical communication skills is based on classical mastery on a scale of 0 to 100. Data analysis was carried out using the Independent Sample t Test hypothesis test to assess differences in the average level of communication skills and self-efficacy between the experimental group and the control group. Before the t test, prerequisite tests were carried out on the data, namely the normality test and homogeneity test, as an absolute requirement before carrying out the T Test. Data processing and statistical analysis were carried out using SPSS version 26 software.

Findings and Discussion

The following are the results of the findings and discussion in the Discovery Learning Learning Improvement research on students' Mathematical communication skills and Self-efficacy

Findings

In this research, a discovery learning model supported by E-Worksheet based Student Worksheets (LKPD) was implemented with the aim of improving students' mathematical communication skills and self-efficacy. The research data shows that the data is normal and homogeneous, as can be seen in Table 1.

Based on the analysis of Table 1, data on students' mathematical communication skills and self-efficacy meet the analysis requirements. The t test was carried out at a significance level of 0.05 to assess the differences between the Discovery Learning model assisted by LKPD E-Worksheets and conventional learning on mathematical communication skills and self-efficacy in the experimental class and control class. The test results are summarized in Table 2.

Table 1. Uji Normalitas dan Homogenitas Kemampuan Komunikasi Matematika dan Self Efficacy

Tests of Normality		
Analysis		Communication Skills and Student Self-Efficacy
N		64
Significance Level		0,05
Decision		
Class	Pretest Eksperiment	0.2 > 0,05, Normal distribution
	Postest Eksperiment	0,1 > 0,05 , Normal distribution
	Control Pretest	0,196 > 0,05 , Normal distribution
	Control Posttest	0.2> 0,05, Normal distribution
	Pretest SelfEfficacy	0.2> 0,05, Normal distribution
	Postest SelfEfficacy	0.2> 0,05, Berdistribusi normal
Test of Homogeneity of Variance		
Significance Level		0,05
Decision		.325 > 0,05 Homogenity Variant

Table 2. Hypothesis Testing of Mathematical Communication Ability and Self Efficacy

Paired Samples Test		
Significance Level 5%		
Pair	Analysis	Decision
Pair 1	Pre-Test Eksperimen - Post-Test Eksperimen	.000 < 0,05 (there is a difference)
Pair 2	Pre-Test Kontrol - Post-Test Kontrol	.000 < 0,05 (there is a difference)
Pair 3	PreSelf-Efficacy - PostSelf-Efficacy	.000 < 0,05 (there is a difference)
Independent Samples Test		
Taraf Signifikansi 5%		
Equal variances assumed		Sig. (-tailed) 0.000 < 0,05 (there is a difference)

Based on the results of the output data for pairs 1, 2, and 3, a significance value (2-tailed) was obtained of 0.000, which is less than 0.05. This indicates that there is a significant difference between the learning model that uses Discovery Learning and the conventional learning model on students' mathematical communication skills and self-efficacy in the experimental and control groups. This significant difference is reinforced by the higher average score of the experimental group compared to the control group, as seen in Table 3.

Table 3. Comparison of Students' Mathematical Communication Skills

Group	Average	Highest Score	Lowest Score
Eksperiment (Discovery Learning)	92.69	100	83
Control (Conventional)	77.09	95	77

Table 4. Hypothesis Test One Sample Test Self Efficacy

One-Sample Test			
	Test Value = 72		
	t	df	Sig. (2-tailed)
Self-Efficacy	15.192	31	.000

In Figure 1, the indicators for the experimental and control groups are presented. The Pre-Test Average of the Experimental Group using the Discovery Learning model (59.88) shows the initial level of mathematical communication ability tests. Meanwhile, the Post-Test Average of the Experimental Group was higher (92.69) indicating a significant increase after implementing the Discovery Learning model assisted by the E-Worksheet LKPD.

On the other hand, the average Pre-Test of the control group (60.69) and Post-Test of the Control group (77.09) provides an overview of the abilities at the beginning and after treatment in the control group. This proves that there has been an increase in students' mathematical communication skills after using the Discovery Learning model assisted by E-worksheets compared to students who were taught using conventional learning models.

This finding is also consistent with previous research by Riani et al. (2022), which shows that the Discovery Learning learning model based on local wisdom is effective, with a learning implementation percentage of 94.12% and student responses reaching 89.50%. These results confirm the existence of significant differences in communication skills and self-efficacy between experimental and control class students.

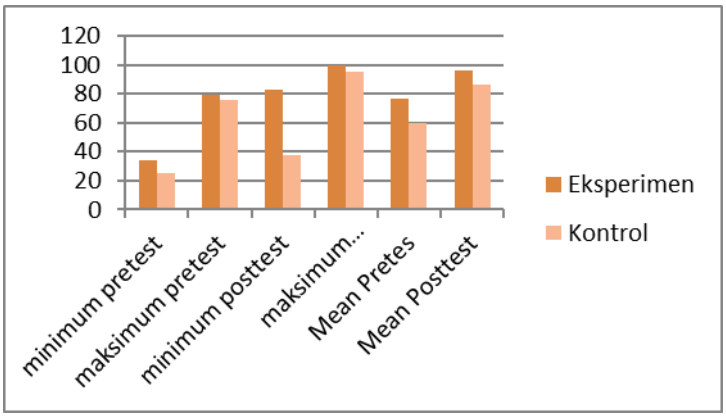

Figure 1. Comparison of students' communication abilities in the experimental group and the control group

Based on Table 4, the Sig. (2-tailed) is 0.000 < 0.05, so, according to the basis for decision making above, H0 is rejected. Thus, it can be interpreted that the average value of student self-efficacy after applying the Discovery Learning model is not the same as 72. Furthermore, based on the t-count value of 15,192 > 2.039, H0 is rejected. Therefore, it can be concluded that the average score of students' self-efficacy after applying the Discovery Learning model is not the same as 72. Although the average score of the experimental group is higher than the control group, statistically, the differences between the two groups are not significantly different. .

Discussion

Table 3 shows that students' mathematical communication abilities and self-efficacy differ between groups. The experimental group had a higher average score than the control group. This difference proves that the discovery learning model assisted by E-Worksheets can improve students' mathematical communication skills and students' self-efficacy. The application of the Discovery Learning model assisted by E-Worksheet based Student Worksheets (LKPD) is effective in improving students' mathematical communication skills and self-efficacy. Based on data analysis, it appears that there is a significant difference between the experimental group (using the Discovery Learning model) and the control group (using conventional learning). The high significance value (2-tailed) in the t test of 0.000 indicates that this difference did not occur by chance. These results are consistent with previous research conducted by Riani et al. (2022), who also found that the Discovery Learning learning model can effectively improve students' communication skills and self-efficacy.

Further analysis of the pre-test and post-test data showed that the experimental group experienced a significant increase in mathematical communication skills after implementing the Discovery Learning model. Meanwhile, the control group, which used conventional learning, also experienced improvement, but not as much as the experimental group. Although the average self-efficacy score of the experimental group was higher, statistical analysis showed that the differences between the experimental group and the control group were not significantly different. This may be caused by other factors outside the learning model which also contribute to student self-efficacy.

Overall, these findings support the idea that the E-Worksheet assisted Discovery Learning model can be an effective approach in improving students' mathematical communication skills. In line with the findings of (Ariyanto., et al, 2023), it is concluded that the application of the *Discovery Learning model* can improve mathematical communication abilities and students' learning outcomes regarding lines and angles, and also the results of this research are in line with those stated by (Riani et al., 2022) This research found that the Discovery Learning learning model based on local wisdom was effectively used

with a learning implementation percentage of 94.12% and student response of 89.50%. So there are differences in communication skills and self-efficacy between experimental and control class students, as evidenced by the sig value. (2-tailed) 0.000005 between control and experimental groups. This research also found that there was a greater increase in communication skills and self-efficacy of students who were taught using *Discovery Learning* based on local wisdom compared to conventional learning, as seen from the average score of 76.12 (experimental group) and 58.00 (control group). , which indicates that the increase is 12 0.04%. Furthermore, research results (Soenarko et al., 2022) suggest that E-Worksheets influence discovery learning to improve decision-making skills and scientific attitudes of eleventh grade science students. ***Discovery Learning*** -based e-Worksheets are practical and successful in improving the decision-making skills and scientific attitudes of class XI Science students, in accordance with research objectives and findings. (Ummul, 2023) states that the level of student self-efficacy has a sufficient relationship with cognitive learning outcomes. Thus, there is an influence of the Problem Based Learning model assisted by LKPD Liveworksheets on self-efficacy and cognitive learning outcomes.

Based on the results of research that has been conducted (Ariyanto et al., 2023), there is an increase in mathematical communication skills and student learning outcomes. This is proven by the increase in students' mathematical communication skills and student learning outcomes from pre-cycle to cycle II. The increase in students' mathematical communication skills can be seen through the percentage of students' mathematical communication skills in the pre-cycle of 55.88%, cycle I of 69.61%, and cycle II of 85.78%. Meanwhile, the increase in student learning outcomes can also be seen through the percentage of student learning outcomes in each cycle, namely pre-cycle at 41.18%, cycle I at 64.71%, and cycle II at 82.35%. It can be concluded that the application of the discovery learning model to line and angle material can improve mathematical communication skills and student learning outcomes. In line with the findings (Rakhima et al., 2019) regarding the application of discovery learning can improve students' mathematical communication skills.

Conclusion

The results of this research conclude that the application of the Discovery Learning model assisted by E-Worksheet based Student Worksheets (LKPD) is effective in improving students' mathematical communication skills. This increase was significant in the experimental group compared to the control group. Although students' self-efficacy scores were higher in the experimental group, this difference was not statistically significant. In future research it is recommended to involve additional variables such as social support and intrinsic motivation to understand other factors that influence self-efficacy, developing this learning model for material other mathematics and evaluate its long-term impact, assess teacher perceptions and participation in implementing the learning model to understand barriers and sustainability, and involve more schools and grade levels to expand the generalizability of research results.

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