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Students' Mathematical Communication: The Effectiveness of Somatic, Auditory, Visual, Intellectual Learning and Problem-Based Learning Model on Number Pattern

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Abstract

This study aimed to analyze the effectiveness of the Somatic, Auditory, Visual, Intellectual (SAVI) learning and Problem-Based Learning (PBL) models in improving students' mathematical communication ability compared to direct learning. A quasi-experimental design was employed, with the SAVI learning model implemented in experimental class 1, PBL in experimental class II, and direct learning in the control class. The sample was selected using cluster random sampling, and data were collected through observations, interviews, and tests. Hypothesis testing, including proportion tests, one-way ANOVA, and Scheffe tests, revealed the following results: (1) students taught with the SAVI learning model demonstrated significant improvement in mathematical communication ability; (2) students instructed using the PBL model also exhibited substantial enhancement in mathematical communication ability; (3) notable differences were observed among the SAVI learning, PBL, and direct learning models, highlighting the effectiveness of both the SAVI learning and PBL models in enhancing mathematical communication ability. Moreover, the PBL model outperformed direct learning, while the SAVI learning model showed greater effectiveness than direct learning. Overall, this study provides evidence supporting the efficacy of the SAVI learning and PBL models in fostering students' mathematical communication skills.

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INTRODUCTION

Mathematics is a science that has an important contribution to life. Hasratuddin (2015) said mathematics is also referred to as human life because mathematics is a product of human intellectual thinking. According to Hudojo (2005) mathematics is a tool to improve the way of thinking, so mathematics is indispensable both for daily life and the advancement of science and technology which makes mathematics need to be provided for every student since elementary education. Therefore, mathematics is an important science that needs to be taught in schools.

Permendikbud Number 58 of 2014 related to the 2013 Curriculum of junior high schools/Tsanawiyah formulates the purpose of learning mathematics so that learners have the ability to communicate opinions, and reasoning and are able to compile mathematical evidence using complete sentences, symbols, tables, diagrams, or other media to clarify circumstances or problems. To achieve these mathematics learning objectives, NCTM (2000) mentions five standards of ability that learners must have in learning mathematics, which are mathematical communication; mathematical reasoning; solving mathematical problems; mathematical connections; Positive attitude to mathematics. So in the mathematics learning process, it is hoped that teachers can come up with these five abilities. The abilities that must be developed in learning mathematics are mathematical communication ability.

Mathematical communication ability in mathematics learning really needs to be developed (Purnama, 2016). Baroody in (Ansari, 2016) states two important reasons for the need to develop mathematical communication. First, mathematics is a langue, meaning mathematics is not only a thinking aid, but mathematics is also a tool for solving problems and for communicating various ideas. Second, mathematics learning is a social activity, meaning mathematics is a means of communication between learners that can achieve mathematical understanding. Asikin in Kumalaretna and Mulyono (2017) also revealed the importance of meaningful mathematical communication as a tool to explore mathematical ideas and help learners' ability to see various interrelationships of mathematical material, a tool to measure the growth of understanding and reflect on mathematical understanding in learners. In addition, mathematical communication abilities are also used as a tool to organize and consolidate learners' mathematical thinking as well as a tool for constructing mathematical knowledge, developing problem-solving, improving reasoning, cultivating self-confidence, and improving social ability.

However, based on the results of an interview with a mathematics teacher at SMP Negeri 13 Magelang, it is stated that learners' mathematical communication abilities are still not optimal. Due to the lack of learning motivation and students' ability to solve story questions and questions in the form of abstract problems. Students consider mathematics to be a difficult subject because of the many calculations and formulas for solving problems in mathematics. This is also evidenced by the results of the initial test of the mathematical communication ability of class VIII learners with an average score of 48.37. This means that learners' communication abilities are still relatively low. According to Awaliyah, Soedjoko, and Isnarto (2016) one of the efforts to improve the learning process is to choose the right and innovative learning model in mathematics learning.

One of the activity-based learning models that are interactive, fun, and motivating students is the SAVI (Somatic, Auditory, Visual and Intellectual) learning model. Optimal learning is when students learn a little about concepts by looking at presentations (visual), but students can learn more when they can do something (somatic), talk, or discuss what they are learning (auditory), and think and draw conclusions or information that can be applied in solving problems (intellectual) (Juwina & Amalia, 2020). This is reinforced by research conducted by Magfiroh, Baiduru, and Ummah (2017) results were obtained that mathematics learning with the SAVI learning model can improve the communication ability of students.

Permendikbud Number 34 of 2018 concerning Standards for the Primary and Secondary Education Process said that PBL is one of the learning models recommended in the 2013 Curriculum in addition to Discovery Learning (DL) and Project Based Learning (PjBL). The advantage of the PBL model is to suppress student activity by using real problems as something that learners learn to get important concepts so that they can communicate in mathematics learning (Kurnila et al., 2022). PBL model makes learners more active so that it can improve Learners' mathematical communication ability (Iskandar, Ermiana, & Rosyidah, 2021). This is strengthened by research conducted by Susanti, Juandi, and Tamur (2020) it was found that mathematics learning with the PBL model affected improving learners' mathematical communication ability.

The purpose of this study is, (1) to analyze the level of mathematical communication of Learners taught with the SAVI learning model to achieve learning goals, (2) to analyze the level of mathematical communication ability of learners who acquire a PBL model to achieve learning goals, and (3) analyze the level of mathematical communication ability of learners who received the SAVI learning and PBL model are better than the direct learning model.

RESEARCH METHODS

This research is a quantitative study with quasi-experimental methods, while the design used is the nonequivalent posttest-only control group design. The population of this study was all class VIII learners at SMP N 13 Magelang. The sampling technique used Cluster Random Sampling.

The selected samples were class VIII E as experimental class 1 which was treated by being taught using the SAVI learning model, class VIII H as experimental class 2 which was treated using a PBL model, and class VIII G as a control class using a direct learning model. The data collection techniques used are observation, interviews, and tests of students' mathematical communication skills. This test consists of 5 written test questions in the form of description questions with the following scoring guidelines (Table 1).

Before conducting research, an initial test of students' mathematical communication skills is first carried out for preliminary data analysis. Preliminary data analysis performed included normality tests, homogeneity tests, and mean similarity tests. The results of the analysis that has been carried out, shows the results that the experimental class and the control class come from a normally distributed population, have the same variance and have the same average. Then the final data is obtained after the treatment through tests. The final data analysis carried out includes normality tests, homogeneity tests, due diligence, ANOVA one-way tests, and post-ANOVA advanced tests.

Table 1. Mathematical Communication Ability Test Scoring Guidelines

No	Indicators	Score	Valuation
1	Explain the idea or solution of a mathematical problem in the form of a drawing, diagram, or table.	0	No answer
		1	Students create patterns or tables but they are not quite right.
		2	Students create patterns or tables that are relevant to the problem, complete, and precise.
2	Explain the idea or solution of a problem or image using your own language.	0	No answer
		1	Only a few of the students' statements are true
		2	The student's explanation is mathematically reasonable and correct, even if it is not logically composed or there is a slight language error
		3	The student's explanation is mathematically reasonable and clear and logically arranged.
3	Expressing everyday problems or events in a mathematical model.	0	No answer
		1	Students write down the concept of mathematical formulas from the given problem correctly but do not carry out the calculation process.
		2	Students incorrectly write down the concepts of mathematical formulas used and do incorrect calculations.
		3	Students write down the concept of mathematical formulas from the given problem correctly but are wrong in doing the calculations.
		4	Students write down the concept of mathematical formulas from the given problem correctly
		5	Students write down the concept of mathematical formulas correctly and can do calculations correctly and precisely and write down the conclusions at the end of the answers correctly and correctly

RESULTS AND DISCUSSION

Pre-Requisite Test

Before the study was carried out, preliminary data analysis was carried out with normality tests (in Table 2), homogeneity tests (in Table 3), and average similarity tests (in Table 4). The data used are the initial test scores of the mathematical communication ability of class VIII learners.

Table 2. Summary of Normality Test Results

Class	L_{obs}	L_{critic}	Decision	Conclusion
Experimental 1	0.1465	0.161	$L_{obs}<L_{critic}$	H_0 accepted
Experimental 2	0.1167	0.161	$L_{obs}<L_{critic}$	H_0 accepted
Control	0.1032	0.161	$L_{obs}<L_{critic}$	H_0 accepted

Based on Table 2, it can be seen that $L_{obs}<L_{critic}$ then H_0 is accepted. It means that the experimental class 1, experimental class 2, and control class are normally distributed.

Table 3. Summary of Homogeneity Test Results

χ^2_{obs}	χ^2_{critic}	Decision	Information
0.5346	5.9915	$\chi^2_{obs}< \chi^2_{critic}$	H_0 accepted

Based on Table 3, it can be seen that the value $\chi^2_{obs}< \chi^2_{critic}$ then H_0 is accepted. It means that the experimental class and the control class are homogeneous.

Table 4. ANOVA Summary of Test Results

Variant Source	*JK*	*dk*	*RK*	F_{obs}	F_{critic}
Between Groups	291.4667	2	145.7333	0.4554	3.1013
Within Groups	27838,13	87	319.9785		
Total	28129.6	89			

Based on Table 4, it can be seen that F_{obs}=0.455<3.101=F_{critic}. The result H_0 is accepted, it means that the experimental class and the control class have the same average ability.

Final Data Analysis

The final data analysis will be carried out with normality (in Table 6), homogeneity (in Table 7), and effectiveness tests (proportion test, one-way ANOVA, and post-ANOVA follow-up).

Table 5. Summary of Final Data Results

Kelas	X_{max}	X_{min}	$\bar{X}$	*S*
Experimental 1	92	60	79.933	8.162
Experimental 2	94	70	82.533	7.700
Control	90	56	73.533	10.207

Based on Table 5, it can be seen that the final ability test results for experimental class 1 get a maximum score of 92, a maximum score of 94 for experimental class 2, and the control class gets a score of 90. The minimum score of 60, 70, and 56 respectively for experimental class 1, experimental 2, and the control class. While the average value of the experimental class 1 was 79.933, the average of the experimental class 2 was 82.533 and the control class was 73.533.

Table 6. Summary of Normality Test Results

Class	L_{obs}	L_{critic}	Decision	Conclusion
Experimental 1	0.0754	0.161	$L_{obs}<L_{critic}$	H_0 accepted
Experimental 2	0.1019	0.161	$L_{obs}<L_{critic}$	H_0 accepted
Control	0.1031	0.161	$L_{obs}<L_{critic}$	H_0 accepted

The conclusion of the Liliefors normality test is $L_{obs}<L_{critic}$ then H_0 is accepted. It means that the experimental class and the control class are normally distributed.

Table 7. Summary of Homogeneity Test Results

χ^2_{obs}	χ^2_{critic}	Decision	Conclusion
2,6661	5.9915	$\chi^2_{obs}< \chi^2_{critic}$	H_0 accepted

Based on Table 7, in the learning model category obtained values of $\chi^2_{obs}< \chi^2_{critic}$ then H_0 is accepted. It means that the experimental class and the control class are homogeneous.

Effectiveness Test

Proportion Test

The final data proportion test was used to determine the learning completion of the experimental class group that had achieved the learning objectives, which was 75% of the number of learners. Test the proportion in this study using the *Z*-test formula, and the results are summarized in Table 8.

Table 8. Final Data Proportion Test Results

Class	Z_{obs}	Z_{critic}	Decision	Conclusion
Experimental 1	2.319	1.64	$Z_{obs}>Z_{critic}$	H_0 accepted
Experimental 2	3.162	1.64	$Z_{obs}>Z_{critic}$	H_0 accepted

Table 8, it can be seen that the $Z_{obs}>Z_{critic}$ result is H_0 is accepted. It means that learners who get treatment with the SAVI learning and PBL model have achieved learning goals.

Mean Difference Test

The final data average difference test is used to determine the effectiveness of the SAVI learning, PBL, and direct learning model. This test uses one-way ANOVA.

Table 9. ANOVA Summary of Test Results

Variant Source	*JK*	*dk*	*RK*	F_{obs}	F_{critic}
Between Groups	1287.2	2	643.6	8.391	3.101
Within Groups	6672.8	87	76.609		
Total	7960	89			

Based on Table 9, it can be seen that F_{obs}=8.391>3.101=F_{critic}. As a result, H_0 was rejected, which means that the three samples had significant differences in the mathematical communication ability of class VIII learners in the matter of number patterns between the SAVI learning, PBL, and direct learning models.

ANOVA Post Follow-Up Test

The post-ANOVA follow-up test was used to determine the difference in the mean of each pair of rows, columns, and cells. Because this study only knew that the treatments studied did not have the same effect, but did not yet know which of the treatments was significantly different from the others, it was necessary to carry out a post-ANOVA follow-up test using the Scheffe method.

Table 10. Post-ANOVA Follow-up Test Results

H_0	F_{obs}	F_{critic}	Conclusion
$\mu_1=\mu_2$	1.32	5.42	H_0 accepted
$\mu_2=\mu_3$	15.84	5.42	H_0 accepted
$\mu_1=\mu_3$	8.01	5.42	H_0 accepted

Based on Table 10, the following results are obtained. (1) $F_{1\text{-}2}=1.32<5.42=F_{critic}$, then H_0 is accepted. This means that there is no difference in learners' mathematical communication ability between learners who received the SAVI learning and PBL model. (2) $F_{2\text{-}3}=15.84>5.42=F_{critic}$, then H_0 is rejected. This means that there are differences in mathematical communication ability given by the PBL and direct learning model. (3) $F_{1\text{-}3}=8.01>5.42=F_{critic}$, then H_0 is rejected. This means that there are differences in the ability of mathematical communication given the SAVI learning with the direct learning model.

Students' Mathematical Communication Using the SAVI Learning Model

Based on one party proportion test obtained $Z_{obs}=2.319>-1.64=Z_{critic}$. Because the value z_{obs} is not included in the critical area, it is H_0 accepted. This means that the mathematical communication ability of learners who are given the SAVI learning model achieves completion. Based on the final data results in experimental class 1 can be seen in Table 5 obtained the highest value is 92, the lowest value is 60 and the average obtained is 79.933.

In general, the achievement of the results obtained in experimental class 1 shows that the SAVI learning model has a positive influence based on the completeness of learning post-test scores based on rubrics and indicators of mathematical communication ability. As already explained, the SAVI learning model is a learning model that consists of four elements that must be involved when learning. The four elements are somatic, auditory, visual, and intellectual elements that make learners actively move and think during learning. The visual element in the SAVI learning model is that the teacher invites learners in groups to observe, read and collect appropriate information to solve problems in worksheet. Where it is known that visual learning is good if learners can see examples from the real world, diagrams, and idea maps and read. The visual element in this research is actively learning to solve worksheet which contains contextual problems and images and is active in collecting information.

On the auditory element or the element that continuously captures and stores the information heard. In this study, the auditory element was found in the material delivery activities by the teacher, learners were invited to listen to the teacher's explanation and pay attention to the explanation of their friends, and exchange ideas when discussing solving problems in worksheet. This is in line with the opinion of Ayundhita and Soedjoko (2014) that group discussion interaction has an important role in a problem and then trying to solve the problem in groups.

In the intellectual element, which means learning by solving problems and reflecting. For example, learning by solving problems that exist in worksheet. Where through the intellectual element learners think and analyze problems and then discuss them with their group friends so as to produce answers in worksheet.

In somatic elements, the teacher gives freedom to learners to stimulate the mind and body in the classroom so as to create a physically active learning atmosphere by inviting learners in groups to complete the worksheet that has been shared. After solving the problem at worksheet, learners presented the results of their group work in front of the class. In this study, there are difficulties in developing learning on somatic elements, so the learning activities of these somatic elements have not been maximized. This is because somatic element learning activities only rely on solving problems in worksheet and presenting the results of group work. This resulted in only some learners actively moving during learning.

The results of this study support the results of a study conducted by Siregar (2018) which states that the SAVI learning model is effective in improving learners' mathematical communication ability. The results of this study are also supported by the findings of Minarni (2019) who states that learners' communication ability in Indonesia still has the opportunity to improve if the learning model provided is accompanied by student-centered learning such as the SAVI learning model, it is even better if the teacher applies learning media. Mathematics learning media can help demonstrate or visualize mathematical concepts as well as tools for constructing mathematical concepts.

Students' Mathematical Communication Using the PBL Model

Based on one party proportion test obtained $Z_{obs}=3.16>-1.64=Z_{critic}$. Because z_{obs} are not included in the critical area, it is H_0 accepted. The mathematical communication ability of learners who obtained the PBL model achieved completion. Based on the post-test results in experimental class 2 can be seen in Table 5, the highest value is 94, the lowest value is 70 and the average is 82.533. The achievement of learning outcomes in experimental class 2 with the PBL model is not much different from the achievement of learning outcomes of experimental class 1 learner. This is because learners who follow the PBL model can involve in mathematical communication ability in learning through the PBL model learning stage.

In the first stage which is the orientation of learners to the problem, the teacher presents contextual problems that correspond to the material to be studied and motivates learners to be actively involved in solving a given problem. The second stage is organizing learners to learn, which is to divide learners into small groups, helping learners define problem-related learning tasks. The purpose of forming this group is so that learners are trained to learn in groups, discuss and exchange ideas in solving each problem in worksheet, and help provide understanding if there are group friends who do not understand the material. In addition, discussions in small groups result in learners giving questions that can train learners' mathematical communication ability when answering them. This is in accordance with the opinion of Mitasari and Prasetijo (2016) state that learners learning activities in small groups provide opportunities for learners to carry out mathematical communication through a number of questions focused on the nature of the problem, building previous knowledge with new knowledge and using the right strategies in solving problems.

The third stage guides individual and group investigations, where teachers encourage learners to gather as much information as possible and share their own ideas to answer the problems contained in the worksheet. The fourth stage is to develop and present results. At this stage, each group is asked to convey the results of their discussion, at the time of the presentation learners convey ideas, arguments, and solutions to the given problems. For groups that do not present, they are asked to argue if there is something that is not yet understood or if there are different answers. This is in line with the opinion of Ayundhita and Soedjoko (2014) that learning using presentations is able to build learners to express student ideas derived from what is obtained when solving problems. The interaction in the Q&A session resulted in learners being able to express their ideas as freely as possible during the presentation process. In the last stage, namely analyzing and evaluating, the teacher provides reinforcement if there are difficulties in drawing conclusions from the results of the presentation and question and answer. And check learners' understanding of the learning that has taken place by giving exercises to learners.

The results of this study are in accordance with research conducted by Binjai (2019) which resulted in the conclusion that mathematics learning with the PBL model has a significant effect on learners' mathematical communication ability. In addition, the results of this study are also in line with the findings of Perwitasari and Surya (2021) which state that improving learners' mathematical communication ability in the mathematics learning process cannot be separated from the selection of learning models. The PBL model is a classroom strategy that organizes mathematics learning with everyday problems so as to provide more opportunities for learners to develop critical thinking ability, present ideas in their own language, as well as communicate mathematically with peers. Based on the syntax of the PBL model, the learning model focuses on learner activity and contextual problems to be given to learners. So that learners' understanding of the material provided becomes more optimal and results in the development of learners' mathematical communication ability.

Mathematical Communication: SAVI, PBL, and Direct Learning Model

Based on the calculation of the ANOVA one-way test, it was obtained that $F_{\text{obs}}=8.391>3.101=F_{\text{critic}}$. Because the value F_{obs} is included in the critical area, it is H_0 rejected. This means there are differences in the level of effectiveness of mathematical communication ability between learners who obtain the SAVI learning, PBL, and direct learning models in class VIII number pattern material.

Based on the post-ANOVA follow-up test, a decision was obtained that experimental class 1 and experimental 2, it was obtained that the test decision were H_0 accepted. This means that SAVI learning and PBL models are both effective in improving learners' mathematical communication ability. The SAVI learning and PBL models are learning models that both focus on student activities during the learning process. Both have cooperative elements where learners discuss and exchange ideas in solving given contextual problems with other learners. This is in accordance with the constructivism theory stated by Vygotsky (in Pohan, 2020), which means the learning process will be efficient and effective if learners learn cooperatively with peers in a supportive atmosphere and environment, under the supervision of someone more capable.

Then in experimental class 2 and control, it was obtained that the test decision was H_0 rejected. This means that there is a difference between PBL and direct learning model against mathematical communication ability. In this study, The average score of experimental class 2 is 82.53, while in the control class, the average is 73.53. Based on these averages, it is concluded that the PBL model is more effective than the direct learning model for learners' mathematical communication ability. Learning in experimental class 2 with the PBL model is carried out in groups and started with contextual problems so that learners construct their own knowledge. This is in line with Ausubel's meaningful learning theory which utilizes contextual problems, guiding learners to use their own way of solving these problems until they find a concept. So that learning mathematics is more meaningful.

Then in experimental class 1 and control, it was obtained that the test decision was H_0 rejected. This means that there are differences in the effectiveness of the SAVI learning model and the direct learning model on mathematical communication ability. The average value of experimental class 1 was 79.93, while the average control class is 73.53. Based on these averages, it can be concluded that the SAVI learning model is more effective than the direct learning model against the mathematical communication ability of learners. The learning process in experimental class 1 with the SAVI learning model is carried out in groups and given practice questions related to contextual problems, so that learners actively discuss solving a given problem, and presented them in front of others. Learners who are not presenting also actively listen to their friends during the presentation and actively ask questions if there are things they still don't understand. This is in accordance with the theory of learning according to Piaget, where learners are encouraged to actively participate in building understanding based on experience and interactions that occur.

Learning in control classes, learners tend to passively listen to what the teacher explains. The teacher becomes the center during the learning process by providing material concepts and providing examples of questions and their solutions. Learners have a chance to be active when the teacher gives questions in a textbook or blackboard to work on. Occasionally teacher gives an opportunity for learners to write the results of their answers on the blackboard.

CONCLUSION

Based on the discussion above, it can be concluded that: (1) The results of the mathematical communication ability test of students who obtained the SAVI learning model have reached completion. (2) The results of the mathematical communication ability test of students who obtained the PBL model have reached completion. (3) There is a difference between the results of the student's mathematical communication ability test between students who obtained the

SAVI learning, PBL model, and the direct learning model. The third hypothesis is outlined as follows. (a) The SAVI learning and PBL models are equally effective against students' mathematical communication skills. (b) The PBL model is more effective than the direct learning model of students' mathematical communication skills. (c) The SAVI learning model is more effective than the direct learning model of students' mathematical communication skills.

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