



Improving Mathematical Argumentation Ability and Sociomathematical Norms Using Missouri Mathematics Project on Trigonometric Ratios

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ABSTRACT

In quality mathematics learning, there must be interaction between learners and educators. The interaction referred to in this study covers mathematical argumentation and sociomathematical norms. Mathematical argumentation ability: pay attention to signs, notations, and symbols from mathematics and how to negotiate to understand mathematical ideas. This study aims to analyze the improvement of mathematical argumentation ability and sociomathematical norms using the Missouri Mathematics Project on trigonometric ratios material. This research approach is quantitative. At the same time, the method used is a quasi-experiment with a non-equivalent control group design. The sample in this study was 51 learners. Data were analyzed by Two-Way ANOVA test with the conclusions: 1) The improvement of mathematical argumentation ability using the Missouri Mathematics Project learning model is better than the problem-based learning model; 2) There are differences in mathematical argumentation ability based on aspects of sociomathematical norms (high, medium and low); 3) There is no interaction between learning model and sociomathematical norms on mathematical argumentation ability.

Keywords: Trigonometric Ratios, Missouri Mathematics Project, Mathematical Argumentation, Sociomathematical Norms.

ABSTRAK

Pada pembelajaran matematika yang berkualitas harus terdapat interaksi antar peserta didik maupun pendidik. Interaksi yang dimaksud pada penelitian ini melingkupi argumentasi matematis dan sosiomathematical norms. Kemampuan berargumentasi matematis memperhatikan tanda, notasi, simbol dari matematika serta cara bernegosiasi untuk memahami ide-ide matematika. Penelitian ini bertujuan untuk menganalisis peningkatan kemampuan argumentasi matematis dan sosiomathematical norms menggunakan Missouri Mathematics Project pada materi perbandingan trigonometri. Pendekatan penelitian ini adalah pendekatan kuantitatif. Sedangkan metode yang digunakan adalah quasi eksperimen dengan desain kelompok kontrol nonekuivalen. Sampel pada penelitian ini sebanyak 51 peserta didik. Data dianalisis dengan uji Two-Way ANOVA dengan kesimpulan pada penelitian ini yaitu: 1) Peningkatan kemampuan argumentasi matematis yang menggunakan model pembelajaran Missouri Mathematics Project lebih baik dibandingkan dengan model pembelajaran problem based learning; 2) Terdapat perbedaan kemampuan argumentasi matematis didasarkan pada aspek sosiomathematical norms (tinggi, sedang dan rendah); 3) Tidak terdapat interaksi antara model pembelajaran dengan sosiomathematical norms pada kemampuan argumentasi matematis.

Kata Kunci: Perbandingan Trigonometry, Missouri Mathematics Project, Argumentasi Mathematics, Sociomathematical Norms.



INTRODUCTION

Mathematics is the logical study of form, arrangement, numbers, and other conceptions of relationships that are numerous and divided into three branches: algebra, analysis, and geometry (Susanah, 2021). Mathematics is the science of logic concerning form, structure, magnitude, and concepts related to one another with many concepts (Bailly & Longo, 2011). Mathematics equips learners with all mathematical understanding to apply mathematics to overcome challenges in their daily lives (Harahap & Lubis, 2019; Kenedi et al., 2019). These provisions are related to the mathematical argumentation ability and high sociomathematical norms, such as being adept at socializing with mathematical language. Mathematics has a problem with different solutions, depending on when the issue is answered, where the problem is responded to, who answers it, and which side is included in mathematics (Solikhin, 2020).

In mathematical learning, a discussion will practice learners' mathematical argumentation and sociomathematical norms when mathematics learning (Maarif, Widodo et al., 2024; Widodo et al., 2019). One of the skills that learners must acquire and master during mathematics learning is mathematical argumentation (De Lange, 2004). The ability of a learner to communicate in their language without ignoring established mathematical agreements, such as signs, notations, symbols, and symbols in mathematics, regarding a mathematical concept or principle is known as mathematical argumentation ability (Resmi & Rusdi., 2021). Mathematical argumentation is one of the abilities that can construct learners' thinking, so it needs to be developed in the learning process (Cardetti & LeMay, 2019; Yackel & Cobb, 1996). A series of mathematical sentences intended to express a fact can be referred to as an argument, while an argument developed mathematically and logically is known as argumentation (Novaes, 2021). In mathematical proof, argumentation is very important because mathematical argumentation between learners can make it easier for them to get evidence of the truth of the solution to mathematical problems and is essential for academic success in mathematics (Soekisno, 2015). Argumentation is a method by which one can logically address any issue, disagreement or question and find its solution (Charwat et al., 2015). An argument is a claim (solution) supported by several premises (guarantees), supporting data, and refuting objections (Novaes, 2021).

Sociomathematical norms can make learners interact and negotiate to understand mathematical ideas (Rizkiyanto, 2013). Sociomathematical norms are "the understanding of what kind of argumentation is mathematically acceptable". In contrast, social norms are "the understanding and awareness that learners have of the appropriate way to communicate solutions and ways of thinking." In other words, manners are associated with social norms (Yackel & Cobb, 1996). Agreement, freedom, consistency, universality and decisiveness are some of the norms or values found in mathematics. Normative behaviours more closely related to mathematics are known as sociomathematical norms (Kadir, 2008). Social and psychological dimensions are two general categories included in sociomathematical norms. These norms are broken down into the social dimension, which provides for social norms within the classroom, sociomathematical norms themselves, and classroom mathematical practices; and the psychological dimension, which includes conceptions of mathematics, beliefs about mathematics and its role in education, and beliefs

about mathematics and values (Yackel & Cobb, 1996). Since these two dimensions are closely related, sociomathematical norms are essential to establish in mathematics education. In addition, according to Chaviaris & Kafoussi (2010), learners' perceptions of collaborative mathematics learning activities are influenced by sociomathematical norms. By collaborating, learners will solve math problems together.

The problem for learners in learning mathematics is low argumentation skills. Learners' argumentation abilities are in a low category, with an average argumentation score of less than 50% (Syerliana et al., 2018). Meanwhile, mathematical argumentation is critical for learners to explain concepts logically and choose the best action when solving mathematical problems (Wulandari et al., 2016). The problem arises because of the low sociomathematical norms of learners, which means that learners do not have ideas they can develop into mathematical sentences or argumentation (Widodo et al., 2019).

Educators can use many mathematical models, including the Missouri Mathematics Project. Researchers use this learning model because it is famous for many independent and group exercises, so it will stimulate learners to discuss between learners and educators. The Missouri Mathematics Project learning model was created to assist educators in efficiently utilizing practice to help learners achieve extraordinary progress (Hidayah & Aulia, 2015). Good, Grouws, and Emmeier at the University of Missouri in the mid-1970s and early 1980s conducted a learning experiment that became the foundation for the Missouri Mathematics Project learning model (Rahman & Nasryah, 2020). A lesson plan that serves as a guideline for classroom teaching is called a learning model (Latifah & Madio, 2014). The Missouri Mathematics Project learning model is one of the structured models. (Jannah et al., 2013) They have explained that the Missouri Mathematics Project learning model trains learners to work together through cooperative work steps. In group work, to complete the learner worksheet, learners can help each other solve problems and share ideas. This study was conducted to improve educators' mathematical argumentation ability and sociomathematical norms using the Missouri Mathematics Project. Mathematical argumentation ability and sociomathematical norms must be researched further so that educators in Indonesia pay more attention to existing educational problems and create a better generation of learners.

There has been a lot of research related to the MMP learning model. As did Latifah & Madio (2014) used the Missouri Mathematics Project to improve students' mathematical problem-solving abilities. This study is different from the Missouri Mathematics Project, which used the Missouri Mathematics Project to improve students' mathematical argumentation and sociomathematical norms. Furthermore, Budiono et al. (2018) concluded that students' mathematical argumentation skills could be effectively enhanced by predicting observations explaining based on learners' worksheets. In this study, researchers will examine the improvement of students' mathematical argumentation using the Missouri Mathematics Project, not with prediction observe explain-based learners' worksheets. In previous research conducted by Widodo & Purnami (2018), it was found that sociomathematical norms can be developed through Team Accelerated Instruction. Likewise, in the study conducted by Maarif, Subagyo et al. (2024), which is related to the development of sociomathematical norm measuring instruments, it was obtained that the sociomathematical norm

instrument obtained a reliability index of 0.99 and a Pearson reliability of 0.86. It can be concluded that no one has used the Missouri Mathematics Project to improve mathematical argumentation skills and sociomathematical norms, so this study aims to analyze the improvement of mathematical argumentation skills and sociomathematical norms using the Missouri Mathematics Project on trigonometric ratio material.

Based on the explanation above, the hypotheses of this study are: (1) The improvement of mathematical argumentation ability using the Missouri Mathematics Project learning model is better than the problem-based learning model; (2) There are differences in mathematical argumentation ability based on aspects of sociomathematical norms (high, medium and low); (3) There is an interaction between learning model and sociomathematical norms on mathematical argumentation ability. This research is hoped to inspire further researchers to pay more attention to the state of education in Indonesia to create quality human resources.

METHOD

This research approach is quantitative. This research includes one dependent variable, an independent variable, and a categorical variable. At the same time, the method used is a quasi-experiment. Researchers use quasi-experimental methods so that learners feel like they are not being given an experiment. A Nonequivalent Posttest-Only Control Group Design is the design underlying this study. This design is divided into treated or experimental and untreated classes, namely control classes. The two classes were given different treatments. They begin by providing pretests to both classes and then giving treatment, using the Missouri Mathematics Project learning model for the experimental class and the problem-based learning model for the control class.

Participant

The source of this research is learners in grades X-3 and X-5 at one of the schools in East Jakarta, SMAN 93 Jakarta, for the 2023/2024 learning year. One way of selecting samples with random is cluster random sampling. Clusters or classes from the population (7 classes), namely the entire X grade, are randomly taken as many as two classes. Before this study, the researcher was familiar with the learners at SMAN 93 Jakarta, where X-3 and X-5 had the characteristics of classes dominated by less active learners. With consideration and shortening the time, the researcher set X-3 as the experiment class and X-5 as the control class. The sample size can be calculated by percentage if the population (number of subjects) is large, such as 10%, 15%, 20%, 25%, or higher (Danuri & Maisaroh, 2019). The sample size in this study was 26 learners for the experimental class and 25 for the control class—a total of 51 out of 252 learners (20% of the population). The following information regarding the research sources of this study is in Table 1.

Table 1. Learner Data

Learner Age Category	Experimental Class			Control Class		
	M	F	Total	M	F	Total
15-16	6	14	20	9	9	18
17-18	4	2	6	4	3	7
Total	10	16	26	13	12	25

Data Gathering Instruments

This study will use test instruments to collect data on learners' mathematical argumentation ability. Written assessments or descriptions will be used as a test instrument, reinforced with oral descriptions to measure learners' mathematical argumentation ability. The description test is prepared considering that the introductory competencies class X is connected to the aspects measured for the mathematical argumentation ability of learners. The indicators of mathematical argumentation ability are naming, transformation, and supporting ideas (Ufairah, 2022). Naming is the ability to convey a conclusion or argument based on facts and previous research so that it can be convincing. Transformation reasoning, based on a conclusion previously determined with facts and previous research, is also expected to provide reasons so that the conclusion is proper. Supporting ideas for this indicator will be strengthened with further evidence.

In the mathematical argumentation ability instrument, seven questions are validated by experts and statistically shown in the collecting data section. Each question contains three indicators at once, so there will be three questions: (1) what formula do you use to solve the problem of mathematics above? (Naming), (2) what is your reason for using this formula? (Transformation Reasoning), and (3) from the formula used to prove its correctness again! (Supporting Ideas)

Sociomathematical norms of learners are tested at the beginning of the meeting in the form of a questionnaire with a Likert scale. Sociomathematical norms, according to (Yackel & Cobb, 1996), consist of 6 indicators: explanation of mathematics, experience in mathematics, mathematical communication, mathematical difference, mathematical insight, and mathematics effectiveness. The reason for mathematics is learners can accept, understand, and use mathematics to justify arguments. Experience in mathematics means learners actively, attentively, and efficiently contribute to mathematics learning. Mathematical Communication is when learners can ask, understand, listen, and comprehend essential communication in the classroom. Mathematical Difference is when learners recognize, evaluate, and distinguish conceptual similarities and differences from various solutions. Mathematical insight is during the activity. Learners can discuss different topics related to mathematics. Mathematics Effectiveness is when learners can identify and clarify the best or most straightforward solution to the problem.

Meanwhile, there are 23 instruments of sociomathematical norms after being validated by experts and statistically shown in the collecting data section. Each indicator contains 2-5 items, will be given examples of items from several indicators below:

1. "I can explain the solution to math problems to my friends" (Explanation of Mathematics)
2. "I do not contribute during math learning" (Experience of Mathematics)
3. "I can answer questions from educators correctly" (Mathematical Communication)
4. "I only use the solutions taught by the educator" (Mathematical Difference)
5. "I find it difficult to discuss because I don't understand the material" (Mathematical Insight)
6. "I was able to determine the best solution to use" (Mathematics Effectiveness)

Procedure

The data of this study came from the assessment of mathematical argumentation ability tested with normalized gain and sociomathematical norms, which were interpreted into three categories according to Al Adawiyah (2022). The criteria of the three categories are listed in Table 2.

Table 2. Sociomathematical Norms Score Category

Category	Criteria
High	$X > M + 1SD$
Medium	$M - 1SD \leq X < M + 1SD$
Low	$X < M - 1SD$

The samples used to collect research data were classes X-3, the experimental class, and X-5, the control class. Both classes will receive trigonometric ratios material with different learning models, Missouri Mathematics Project for the experimental class and Problem-Based Learning for the control class. Table 3 describes the sub-materials on trigonometric ratios material for four meetings.

Table 3. Details of Learning Materials

Meeting	Subject Matter	Sub Material
1	Angle	Angle Measures and Basic Concepts of Angles
2	Trigonometric Ratios	Trigonometric Ratios of Right Triangles
3	Related Angles	Related Angles and Special Angles
4	Application of Trigonometric Ratios	Trigonometric Ratios in Daily Life

The experimental class used the Missouri Mathematics Project model, which consists of 5 syntaxes, according to Jannah et al. (2013). The activities in each syntax are presented in Table 4.

Table 4. Syntax of Missouri Mathematics Project Model

Syntax	Activity
Review	Educators and learners recapitulate the previous learning outcomes.
Development	The educator explains previously taught math concepts and offers bright ideas.
Cooperative Working	Learners make groups to work on the learners' worksheets that have been provided.
Independent Work	Learners are given individual practice questions.
Assignments	Learners are given homework with the meeting material.

Meanwhile, the control class used the problem-based learning model, which consists of 5 syntaxes, according to Suginem (2021) and Budiarti (2021). The activities in each syntax are presented in Table 5.

Table 5. Syntax of Problem-Based Learning Model

Syntax	Activity
Orient learners to the problem	The educator discusses the learning goals, explains them, and encourages the class to solve problems together.
Organizing learners in learning	The educator assists learners in defining and planning problem-related learning assignments.
Assisting individual and group investigations	Learners are encouraged by their educators to perform experiments, get pertinent data, and look for answers and explanations.

Syntax	Activity
Developing and presenting work	In addition to helping learners interact with others, the instructor helps them plan and prepare suitable results, such as reports, video recordings, and models.
Analyzing and evaluating the problem-solving process	The educator supports learners in reflecting on their research and their methods.

Collecting Data

In the first stage, researchers validated the instrument with two experts, mathematics educators and lecturers. Then, the test determines whether the instrument is suitable for research. This test uses Winstep Rasch ver 5.1.4 software with Cronbach's Alpha approach. The criteria for the validity test are the value of MNSQ between 0.5 – 1.5 and the value of ZSTD between -2.0 – +2.0. The validity test in this study will be presented in Table 6.

Table 6. Validity Test Results

Variable	Item	MNSQ	ZSTD	Conclusion
Mathematical Argumentation	1	1.32	0.71	Valid
	2	1.09	0.37	Valid
	3	2.2	1.43	Invalid
	4	0.79	-0.14	Valid
	5	1.97	1.79	Invalid
	6	1.44	1.24	Valid
	7	0.96	-0.1	Valid
	8	0.82	-0.92	Valid
	9	0.82	-0.83	Valid
Sosiomathematical Norms	1	0.75	-1.66	Valid
	2	0.76	-1.67	Valid
	3	0.88	-0.78	Valid
	4	1.67	3.84	Invalid
	5	0.81	-1.28	Valid
	6	0.97	-0.15	Valid
	7	1.05	0.38	Valid
	8	0.84	-1.01	Valid
	9	0.99	0	Valid
	10	0.76	-1.64	Valid
	11	0.8	-1.32	Valid
	12	1.13	0.82	Valid
	13	1.47	2.87	Invalid
	14	0.82	-1.22	Valid
	15	1.04	0.33	Valid
	16	1.12	0.8	Valid
17	0.75	-1.69	Valid	
18	0.85	-0.92	Valid	
19	0.84	-1.06	Valid	
20	0.81	-1.43	Valid	
21	0.92	-0.49	Valid	
22	2.55	6.88	Invalid	
23	1.04	0.33	Valid	
24	1.25	1.5	Valid	
25	0.85	-1.09	Valid	

After testing the instrument data's validity, the reliability test is next. This study for mathematical argumentation has a sufficiently reliable category, namely sig. 0.5, while

sociomathematical norms have a high-reliability category, which is sig. 0.84. According to Putri et al. (2023), the reliability test has an index shown in Table 7.

Table 7. Reliability Category

Reliability Index	Reliability Category
0.80 – 1.00	Very High
0.60 – 0.80	High
0.40 – 0.60	Intermediate
0.20 – 0.40	Low
0.00 – 0.20	Very Low

Data Analysis

In processing this data, researchers used SPSS 25.0. As previously explained, sociomathematical norms will be categorized into three, while mathematical argumentation will first be tested for normalized gain using SPSS 25.0. After getting the normalized gain, we continued with normality and homogeneity tests. The normality test is used to determine whether the research sample has a normal distribution, and researchers use the Kolmogorov-Smirnov test to determine whether the data is normal or not. While the homogeneity test is used to determine whether or not the value of the variance in the population under study is the same, the Levene Statistic method is used to carry out this homogeneity test.

The research hypothesis was tested using a Two-Way ANOVA test to test the improvement of mathematical argumentation ability of the experimental class better than the control class, test the difference in mathematical argumentation ability based on sociomathematical norms, as well as the interaction between learning models with sociomathematical norms on mathematical argumentation ability.

RESULT AND DISCUSSION

Result

Data tested with two-way ANOVA presents results obtained from this study. The results and discussion section will explain the hypothesis that has been determined. A statistical description of learners' mathematical argumentation categorized by sociomathematical norms using the Missouri Mathematics Project and problem-based learning models can be seen in Table 8.

Table 8. Data Statistical Description

Sosiomathematical Norms Category	N	Class	Mean	Std. Deviation
High	5	Experiment	0.5160	0.25245
	6	Control	0.2033	0.18184
Medium	18	Experiment	0.4939	0.29203
	14	Control	0.1193	0.26946
Low	3	Experiment	0.6333	0.00577
	5	Control	0.2500	0.07714
Total	26	Experiment	0.5142	0.26494
	25	Control	0.1656	0.22428

Before the Two-Way ANOVA test, the data had been proven to be normally distributed, and the data variance was homogeneous. The Kolmogorov-Smirnov test results in the experimental class

were sig. = 0.054, while in the control class, it is sig. = 0.060, it can be concluded that sig. > 0.05, and the data is normally distributed. In the Levene Statistic test, data that simultaneously covers the experimental and control classes is sig. = 0.140, so the data has the same or homogeneous data variance. After the data is proven to be normally distributed and homogeneous variance, then the Two-Way ANOVA test will be presented in Table 9.

Table 9. Results of the Two-Way ANOVA Test

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Model	1.116	1	1.116	17.698	0.000
Sociomathematical Norms	0.117	1	0.058	0.926	0.404
Model* Sociomathematical Norms	0.009	2	0.004	0.069	0.933

It can be seen that the significance of the model is sig. = 0.000 where sig. < 0.05 so that there is a difference between the treatment between the experimental class and the control class. Then, back in Table 8, the experimental class is better than the control class, and it can be concluded again that improving mathematical argumentation ability using the Missouri Mathematics Project learning model is better than the problem-based learning model.

Table 10. Tukey HSD Test

(I)	(J)	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
High	Medium	0.0155	0.08777	0.983	-0.1973	0.2282
	Low	-0.483	0.11669	0.910	-0.3311	0.2345
Medium	High	-0.0155	0.08777	0.983	-0.2282	0.1973
	Low	-0.0638	0.09927	0.798	-0.3043	0.1768
Low	High	0.0483	0.11669	0.910	-0.2345	0.3311
	Medium	0.0638	0.09927	0.798	-0.1768	0.3043

In the source column of the sociomathematical norms section with sig. = 0.404 and significant < 0.05, so the research hypothesis about differences in mathematical argumentation ability based on aspects of sociomathematical norms (high, medium and low) is accepted. However, Table 9 also shows the interaction analysis between the model and sociomathematical norms with sig. = 0.933 where sig. > 0.05, the research hypothesis about the interaction between learning models and sociomathematical norms on mathematical argumentation ability is rejected. Table 10 will further present the differences in sociomathematical norms group categories with the Tukey HSD test.

The conclusion has been explained that improving mathematical argumentation ability using the Missouri Mathematics Project learning model is better than the problem-based learning model.

Discussion

Effectiveness of the Missouri Mathematical Project Learning Model

Table 8 shows that the experimental class is better than the control class. The experimental class was given a different treatment from that of the control class. The treatment in the experimental class used the Missouri Mathematics Project learning model. Thus, this learning model can improve

learners' mathematical argumentation. Examples of students' mathematical argumentation ability are shown in Figures 1 and 2.

<p>2. Jika α adalah sudut lancip dan nilai $\cot \alpha = x$. Maka nilai $(\sin \alpha + \cos \alpha)^2 = \dots$</p> <p>a. Formula apa yang anda gunakan untuk permasalahan matematika di atas (Naming)</p> <p style="text-align: center;">(2)</p> <div style="border: 1px solid black; padding: 5px; margin: 5px;"> <p>Perbandingan sisi dari identik trigonometri</p> </div> <p>b. Apa alasan anda menggunakan formula tersebut? (Transformation Reasoning)</p> <div style="border: 1px solid black; padding: 5px; margin: 5px;"> <p>agar lebih mudah memahaminya</p> </div>	<p>2. If α is acute angle and value of $\cot \alpha$ is x. Find $(\sin \alpha + \cos \alpha)^2 = \dots$</p> <p>a. What formula do you use to solve this problem of mathematic above? (Naming)</p> <div style="border: 1px solid black; padding: 5px; margin: 5px;"> <p>Side ratios of trigonometric identities</p> </div> <p>b. <u>Whats</u> is your reason for using this formula? (Transformation Reasoning)</p> <div style="border: 1px solid black; padding: 5px; margin: 5px;"> <p>To make it easier to understand</p> </div>
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Figure 1. Learner Worksheet from Control Class

The result of Trisanti & Nusantara (2022) successfully improved students' mathematical argumentation skills by using a learning model that can encourage students to be active. The learning model, with much discussion, is suitable for enhancing students' mathematical argumentation skills.

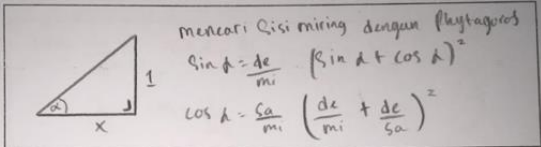
<p>2. Jika α adalah sudut lancip dan nilai $\cot \alpha = x$. Maka nilai $(\sin \alpha + \cos \alpha)^2 = \dots$</p> <p>a. Formula apa yang anda gunakan untuk permasalahan matematika di atas (Naming)</p> <div style="border: 1px solid black; padding: 5px; margin: 5px;">  </div> <p>b. Apa alasan anda menggunakan formula tersebut? (Transformation Reasoning)</p> <div style="border: 1px solid black; padding: 5px; margin: 5px;"> <p>karena sudah ketemu sisi samping & depan maka kita hrs cari nilai sisi miring menggunakan Pythagoras, & mencari nilai $(\sin \alpha + \cos \alpha)^2$ nya (5)</p> </div>	<p>2. If α is acute angle and value of $\cot \alpha$ is x. Find $(\sin \alpha + \cos \alpha)^2 = \dots$</p> <p>a. What formula do you use to solve this problem of mathematic above? (Naming)</p> <div style="border: 1px solid black; padding: 5px; margin: 5px;"> <p>Find hypotenuse use <u>pythagoras</u></p> $\sin \alpha = \frac{y}{r}$ $\cos \alpha = \frac{x}{r}$ </div> <p>b. <u>Whats</u> is your reason for using this formula? (Transformation Reasoning)</p> <div style="border: 1px solid black; padding: 5px; margin: 5px;"> <p>Because we have found the side and front side, then we have to find the value of the hypotenuse using <u>pythagoras</u> and find the $(\sin \alpha + \cos \alpha)^2$ value.</p> </div>
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Figure 2. Learner Worksheet from Experiment Class

The literature study results show that the Missouri Mathematics Project learning model has several advantages and disadvantages. The advantages include: 1) Can provide a large amount of material because it does not require a long time. This means that the use of time can be controlled quite tightly. 2) Lots of practice so that learners can quickly master various questions. The disadvantages include (1) It does not put learners in an active role and (2) Because they listen more, learners may get bored more quickly (Nurjannah et al., 2019).

In this study, researchers ask questions when providing material to stimulate learners to be active. And provide a forum for learners to ask questions about each sub-material. In line with Rahman & Nasryah (2020), the disadvantages can be overcome by (1) Providing opportunities for learners to ask questions about concepts they find confusing or difficult to understand, especially in

trigonometric ratios material that requires proof and in-depth understanding of concepts, (2) Increasing the number of practice questions so learners can work on various questions efficiently. Educators can use the cooperative working and independent working sections to provide exercises of various forms to familiarize learners with other problem types and (3) Provide direction to learners still having difficulties, such as re-explaining the sub-material that the learner questions or the educator himself asking about the understanding of the sub-material.

In this study, experimental and control class learners were each dominant in actively asking questions about trigonometric ratios material. However, the control class had more difficulty when they had to understand the material independently—in line with Yulianti & Gunawan (2019), who mentioned that learners' understanding is lacking by using a problem-based learning model. For further research, educators should first introduce the learning flow of problem-based learning so that learners can adapt to the new learning model.

Differences in mathematical argumentation ability based on biomathematical norms

The results of this study are shown in Figures 1 and 2, where there are differences in students' mathematical argumentation skills. On the worksheet of students from the control class is an incorrect answer. It is hoped that students can use the right reasons for these math problems. According to Lee (2015), learners must rationally express their views using formal mathematical terminology.

The first implication of sociomathematical norms refers to the indicators of sociomathematical norms, the attitudes that students have, which will be a process in bringing up ideas to develop mathematical argumentation in mathematics learning. They were second, based on the syntax of the Missouri Mathematics Project learning model, in which students are trained in their mathematical argumentation skills with affective elements, namely sociomathematical norms. Shows that sociomathematical norms can accommodate or shape students' mathematical argumentation skills. So, students with high, medium and low sociomathematical norms also differ in the results. In the future, implement the Missouri Mathematics Project to improve mathematical argumentation skills. Besides that, it is also essential to have the wrong affective attitude, namely sociomathematical norms with high, medium, and low categories.

Interaction of the Missouri Mathematical Project Learning model on sosiomathematical norms. In this study, it can be seen in the table that sig. There is no interaction between Missouri's Mathematical Project Learning model and sociomathematical norms. This means applying this learning model is more effective for sociomathematical norms from high, medium, and low categories. If sig. If there is an interaction, then this learning model is only effective in some categories of sociomathematical norms.

CONCLUSION

This research achieves the aims with results from hypotheses that: 1) The improvement of mathematical argumentation ability using the Missouri Mathematics Project learning model is better than the problem-based learning model; 2) There are differences in mathematical argumentation ability based on aspects of sociomathematical norms (high, medium and low); 3) There is no

interaction between learning model and sociomathematical norms on mathematical argumentation ability.

Based on the learners' worksheet findings, they understand the best solution and why they use it. Therefore, the Missouri Mathematics Project model is highly recommended for use so that learners better understand the material with a lot of practice. The experimental class is better than the control class. Specialized in trigonometric ratios material is suitable for research on mathematical argumentation ability because the material contains the abstract proof. By knowing the category of sociomathematical norms of learners, educators can divide heterogeneous groups with learners with a high level of sociomathematical norms equally divided in each group. With heterogeneous groups, there will be more quality discussions between learners.

REFERENCES

- Al Adawiyah, K. (2022). *Pengaruh dukungan sosial terhadap kejenuhan belajar mahasiswa di kota Bandung selama pembelajaran jarak jauh yang dimediasi oleh self regulated learning*. Bandung: Universitas Pendidikan Indonesia).
- Bailly, F., & Longo, G. (2011). *Mathematics and the natural sciences: the physical singularity of life* (Vol. 7). Imperial College Press.
- Budiarti, N. T. (2021). Literature study of PBL (Problem Based Learning) learning models on students' science problem solving. *Social, Humanities, and Education Studies (SHEs): Conference Series*, 4(5), 82–87. <https://doi.org/10.20961/shes.v4i5.65963>
- Budiono, S. S., & Dahlan, S. (2018). Pengembangan LKPD berbasis POE pada konsep kesebangunan untuk meningkatkan kemampuan argumentasi matematika siswa. *Jurnal Pendidikan Matematika Universitas Lampung*, 9(2). Retrieved from <https://jurnal.fkip.unila.ac.id/index.php/MTK/article/view/15595>
- Cardetti, F., & LeMay, S. (2019). Argumentation: Building students' capacity for reasoning essential to learning mathematics and sciences. *PRIMUS*, 29(8), 775-798. <https://doi.org/10.1080/10511970.2018.1482581>
- Charwat, G., Dvořák, W., Gaggl, S. A., Wallner, J. P., & Woltran, S. (2015). Methods for solving reasoning problems in abstract argumentation—a survey. *Artificial intelligence*, 220, 28-63. <https://doi.org/10.1016/j.artint.2014.11.008>
- Chaviaris, P., & Kafoussi, S. (2010). Developing students' collaboration in a mathematics classroom through dramatic activities. *International Electronic Journal of Mathematics Education*, 5(2), 91-110. <https://doi.org/10.29333/iejme/252>
- Danuri, & Maisaroh, S. (2019). *Metodologi penelitian*. Yogyakarta: Samudra Biru.
- De Lange, J. (2004). Mathematical literacy for living from OECD-PISA perspective. *Tsukuba Journal of Educational Study in Mathematics*, 12.
- Solikhin, F. (2020). Efforts to Improve Mathematics learning achievement through the make a match learning model in class III students of SDN Brebeg 01 jeruklegi. *Social, Humanities, and Education Studies (SHEs): Conference Series*, 3(3), 378–383. <https://doi.org/10.20961/shes.v3i3.45811>
- Harahap, H. M., & Lubis, R. (2019). Efektivitas pendekatan pembelajaran matematika realistik (PMR) terhadap kemampuan pemecahan masalah matematis siswa SMP Negeri 7. *Jurnal MathEdu (Mathematic Education Journal)*, 2(2), 105–113. Retrieved from <https://journal.ipts.ac.id/index.php/MathEdu/article/view/1016>
- Hidayah, A., & Aulia, I. (2015). Penerapan model pembelajaran Missouri Mathematics Project (MMP) terhadap kemampuan pemecahan masalah siswa di SMP. *EDU-MAT: Jurnal Pendidikan Matematika*, 3(1), 49–58. <https://doi.org/10.20527/edumat.v3i1.629>
- Jannah, M., Triyanto, T., & Ekana Ch, H. (2013). Penerapan Model Missouri Mathematic Project (MMP) untuk Meningkatkan Pemahaman dan Sikap Positif Siswa Pada Materi Fungsi (Penelitian dilakukan di kelas XI. 11 SMK Negeri 1 Karanganyar Tahun Ajaran 2012/2013. *Jurnal Pendidikan Matematika SoLuSi (Tersohor Luas dan Berisi)*, 1(1). Retrieved from <https://core.ac.uk/download/pdf/12347851.pdf>

- Kadir. (2008). Mengembangkan norma sosiomatematik (Sociomathematical Norms) dengan memanfaatkan potensi lokal dalam pembelajaran matematika. *Phytagoras*, 4(1), 74–85. <http://dx.doi.org/10.21831/pg.v4i1.689>
- Kenedi, A. K., Helsa, Y., Ariani, Y., Zainil, M., & Hendri, S. (2019). Mathematical connection of elementary school students to solve mathematical problems. *Journal on Mathematics Education*, 10(1), 69-80. <http://dx.doi.org/10.22342/jme.10.1.5416.69-80>
- Latifah, D., & Madio, S. S. (2014). Meningkatkan kemampuan pemecahan masalah matematis siswa melalui model pembelajaran Missouri Mathematics Project (MMP). *Mosharafa: Jurnal Pendidikan Matematika*, 3(3), 159–168. <https://doi.org/10.31980/mosharafa.v3i3.320>
- Lee, T. N. (2015). Developing a theoretical framework to assess taiwanese primary students' geometric argumentation. *Mathematics Education in the Margins (Proceedings of the 38th Annual Conference of the Mathematics Education Research Group of Australasia)*, 365–372. Retrieved from <https://eric.ed.gov/?id=ED572487>
- Maarif, S., Soebagyo, J., Pradipta, T. R., & Widodo, S. A. (2024). A Psychometric Validation of the Sociomathematical Norm Scale for Senior High School Students in Mathematics Learning. *European Journal of Educational Research*, 13(issue-2-april-2024), 541-556. <https://doi.org/10.12973/eu-jer.13.2.541>
- Maarif, S., Widodo, S. A., & Hidayat, W. (2024). *Norma Sosiomatematis: Landasan Teoretis dan Praktis Penelitian*. Deepublish.
- Novaes, D. C. (2021). *Argument and argumentation*. Retrieved from <https://plato.stanford.edu/entries/argument/?ref=our-brew>
- Nurjannah, N., Djadir, D., & Dassa, A. (2019). Kemampuan pemecahan masalah matematika siswa yang diajar dengan menerapkan Missouri Mathematics Project. *Issues in Mathematics Education (IMED)*, 1(2), 91–100. Retrieved from <https://ojs.unm.ac.id/imed/article/view/9463>
- Putri, N. A., Fakhruddin, Z., & Fauza, N. (2023). Validitas dan reliabilitas butir soal berbasis kemampuan berpikir kritis. *Jurnal Pendidikan Fisika*, 12(1). <https://doi.org/10.24114/jpf.v12i1.42833>
- Rahman, A. A., & Nasryah, C. E. (2020). Efektivitas model pembelajaran missouri mathematics project untuk meningkatkan hasil belajar siswa SMA. *Mosharafa: Jurnal Pendidikan Matematika*, 9(2), 335–346. <https://doi.org/10.31980/mosharafa.v9i2.650>
- Resmi, D. C., & Rusdi, M. (2021). Desain LKPD pada materi sistem persamaan linear tiga variabel berbasis generative learning untuk meningkatkan kemampuan argumentasi matematika siswa SMA. *Jurnal Cendekia: Jurnal Pendidikan Matematika*, 5(2), 1854-1868. <https://doi.org/10.31004/cendekia.v5i2.685>
- Rizkianto, I. (2013). Norma sosiomatematik dalam kelas matematika. *Prosiding Seminar Nasional Matematika Dan Pendidikan Matematika*, 978–979.
- Soekisno, R. B. A. (2015). Pembelajaran berbasis masalah untuk meningkatkan kemampuan argumentasi matematis mahasiswa. *Infinity Journal*, 4(2), 120. <https://doi.org/10.22460/infinity.v4i2.77>
- Suginem. (2021). Penerapan model Problem Based Learning (PBL) untuk meningkatkan keaktifan dan hasil belajar siswa. *Jurnal Ilmiah Pendidikan*, 3(1), 33–36. <https://doi.org/10.37058/metaedukasi.v3i1.3254>
- Susanah. (2021). Matematika dan pendidikan matematika. *Universitas Terbuka*, 2–44.
- Syerliana, L., Muslim, & Setiawan, W. (2018). Argumentation skill profile using “toulmin argumentation pattern” analysis of high school student at subang on topic hydrostatic pressure. *Journal of Physics: Conference Series*, 1013(1). <https://doi.org/10.1088/1742-6596/1013/1/012031>
- Trisanti, L. B., & Nusantara, T. (2022). The influence of infusion learning strategy on students' mathematical argumentation skill. *International Journal of Instruction*, 15(2), 277–292. <https://doi.org/10.29333/iji.2022.15216a>
- Ufairah, E. H. (2022). Analisis kemampuan argumentasi matematis siswa pada materi bangun ruang sisi datar ditinjau dari kemampuan awal matematika. *Jakarta: FITK UIN Syarif Hidayatullah Jakarta*.
- Widodo, S. A., & Dahlan, J. A. (2019, October). Can sociomathematical norms be developed with learning media?. In *Journal of Physics: Conference Series* (Vol. 1315, No. 1, p. 012005). IOP Publishing. <https://doi.org/10.1088/1742-6596/1315/1/012005>
- Widodo, S. A., & Purnami, A. S. (2018). Mengembangkan norma sosiomatematik dengan team accelerated instruction. *NUMERICAL: Jurnal Matematika Dan Pendidikan Matematika*, 2(1), 29. <https://doi.org/10.25217/numerical.v2i1.238>

- Wulandari, W., Darmawijoyo, & Hartono, Y. (2016). Pengaruh pendekatan pemodelan matematika terhadap kemampuan argumentasi siswa kelas VIII SMP Negeri 15 Palembang. *Jurnal Pendidikan Matematika Sriwijaya*, 10(1), 114–126. <http://dx.doi.org/10.22342/jpm.10.1.3292.114-126>
- Yackel, E., & Cobb, P. (1996). Sociomathematical norms, argumentation, and autonomy in mathematics. *Journal for research in mathematics education*, 27(4), 458-477. <https://doi.org/10.5951/jresmetheduc.27.4.0458>
- Yulianti, E., & Gunawan, I. (2019). Problem Based Learning (PBL) learning model: the effect on understanding of concept and critical thinking. *Indonesian Journal of Science and Mathematics Education*, 02(3), 399–408. <https://doi.org/10.11606/issn.2176-7262.v47i3p301-307>