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A Path Analysis of the Effects of Self-Confidence and Habits of Mind on Students' Learning Activeness and Mathematical Communication Skills

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Abstract. Learning activeness and mathematical communication skills are core competencies that students must develop in mathematics learning. The development of these competencies is related to and influenced by students' internal factors, namely self-confidence and habits of mind. Sixty-five eleventh-grade students at SMAN 1 Sampara from two classes were selected using a cluster random sampling technique based on the Slovin formula. The instruments used were a questionnaire to measure self-confidence, habits of mind, and learning activity, and a test to measure mathematical communication skills. Data analysis was conducted using path analysis techniques to determine the direct and indirect effects between variables. The results showed that self-confidence (60%), habits of mind (67.69%), learning activity (64.62%), and mathematical communication skills (63.08%) were in the moderate category. Self-confidence and habits of mind have been shown to have a positive and significant influence on students' learning activities. However, no direct or indirect influence of self-confidence, habits of mind, and learning activity on students' mathematical communication skills was found. In conclusion, although self-confidence and thinking habits can increase students' active participation in the learning process, they are not enough to improve their ability to communicate mathematical ideas effectively.

Keyword: habits of mind; learning activeness; mathematical communication skills; self-confidence

INTRODUCTION

Mathematics is a fundamental discipline that serves as the foundation for the advancement of science and modern civilization, while also developing human critical and analytical thinking skills(Lamote, 2017). In mathematics learning, deep conceptual understanding can be achieved when students actively participate and are directly involved in the learning process. Therefore, a comprehensive understanding of mathematical material requires an optimal level of engagement in learning. Learning engagement is defined as a learning process that demands active student involvement, thus shaping more effective academic behavior (Kanza, dkk., 2020). Furthermore, Prasetyo & Abduh (2021) Describe learning engagement as a systematic effort by students to actualize their potential through various learning activities, both offline and online, to achieve educational goals.

School mathematics is often perceived as difficult, and many students have even been reported to be concerned about assessment-driven mathematics learning environments (Jenßen et al., 2023; Jiang et al., 2025; Li & Schoenfeld, 2019; Yuan et al., 2022). This situation has also prompted various research findings indicating that student learning engagement, particularly in mathematics, remains relatively low. This low engagement, as expressed by Fadjrin (2017)This is reflected in minimal student participation in asking questions, a lack of engagement in solving practice problems, and low initiative to solve problems in front of the class. Given that without student engagement, the learning process will not achieve optimal results, increasing student learning engagement also greatly requires the development of effective communication skills, known in mathematics as mathematical communication skills.

Mathematical communication skills are defined as students' competence in expressing mathematical ideas through various forms of mathematical language representation, including written expressions, visualizations, tables, graphs, and diagrams (Triana et al., 2019; Wardono et al., 2020). Furthermore, these skills include the ability to construct mathematical models and represent mathematical thinking using a language they master (Ahdhianto et al., 2019; Suhenda & Munandar, 2023). Mastery of mathematical communication skills plays a crucial role in learning, as it not only serves as an indicator of students' understanding of mathematical concepts but also serves as a means to train mathematical, analytical, logical, and systematic thinking patterns (Lubis et al., 2023; Öztaş & Güçlü, 2023; Sari et al., 2025).

However, the reality on the ground shows that students' mathematical communication skills remain relatively low. One indicator is their inability to articulate mathematical ideas or concepts using language they understand effectively (Hendriana, 2018). This low level of ability indicates challenges in transforming abstract mathematical understanding into coherent and structured communication. Therefore, strengthening mathematical communication skills requires serious attention in efforts to improve students' mathematical literacy.

Observations indicate that students tend to be passive when faced with material they don't understand and are reluctant to ask questions of either the teacher or classmates when they encounter difficulties. Furthermore, students often face challenges in analyzing or exploring complex mathematical problems. These difficulties often trigger frustration when they fail to find a solution, resulting in decreased self-confidence and a fear of making mistakes when solving problems. These findings align with research by Nurfalihah. (2023), which states that the decline in student learning activity is caused by a lack of self-confidence and a feeling of embarrassment about asking questions even though they haven't mastered the material. Furthermore, students are also unable to respond spontaneously to teacher questions.

Further observations revealed that students still have difficulty expressing mathematical ideas independently in their own language. They also proved less skilled in representing concepts in various forms of mathematical expression, such as graphs, notation, or precise mathematical sentences. These limitations, including the inability to explore alternative solutions to problems, further exacerbated feelings of self-doubt, leading students to avoid active participation, such as speaking in front of the class, engaging in discussion, or asking questions about mathematical concepts. This is reinforced by research by Ramdani, dkk. (2021), which concluded that students' weak mathematical communication skills are influenced by psychological barriers, particularly feelings of inferiority or lack of self-confidence. Thus, it can be concluded that self-confidence is a key factor influencing both students' learning engagement and mathematical communication skills.

Self-confidence is a psychological construct that shapes students' understanding and perception of their capabilities, encompassing aspects of self-belief, optimism, objectivity, responsibility, and rational and realistic thinking (Yulianto, dkk., 2020). This confidence fosters an optimistic attitude in facing various learning situations. Conversely, students with low self-confidence tend to have difficulty expressing ideas and avoid active participation in discussion forums due to concerns about negative evaluation (Ramdani, dkk., 2021). In mathematics, students with high self-confidence demonstrate greater engagement in academic interactions and more active participation during learning.

Besides self-confidence, habits of mind are a critical factor in the learning process (Yuzalia, dkk., 2021). This concept refers to the cognitive characteristics possessed by individuals in responding to and solving problems, encompassing the integration of intelligence, attitudes, skills, and knowledge (Dwirahayu, dkk., 2017). Habits of mind include the ability to recognize uncertainty in problems, construct mathematical meaning, and have the courage and humility to revise thinking and learn from mistakes (Prasad, 2020). Variations in habits of mind among students contribute to academic achievement and significantly influence learning success, including in mathematics.

Several previous studies, such as those by Robiah & Nuraeni (2023), Ilmi, dkk. (2022), Yanti, dkk. (2020), Rahmah, dkk. (2022), Pramesty & Suratno (2021), dan Firdawati & Hidayat (2018)have explored the relationship between self-confidence, habits of mind, and related variables and learning engagement and mathematical communication skills. These findings indicate the importance of these two constructs, although in practice, students' mathematics learning engagement remains low, reflected in suboptimal mathematical communication skills. Therefore, this study aims to analyze the influence of self-confidence and habits of mind on learning engagement and mathematical communication skills. The research results are expected to serve as a reference for educators in creating an interactive learning environment and supporting the development of students' mathematical competencies.

METHOD

This research was conducted during the odd semester of the 2024/2025 academic year using primary data obtained through a survey of 11th-grade students at SMAN 1 Sampara. Sample selection was carried out using a cluster random sampling technique, with each class acting as a cluster. Of the six available classes, two classes were selected as research samples, with the following details:

Table 1. Number of Samples

Population	Class	Total
190	XI.1	33
	XI.3	32
Total		65

Data collection was conducted using questionnaires, including instruments for self-confidence (KD), habits of mind (HoM), learning activity (KB), and mathematical communication ability (KKM). The collected data were then analyzed descriptively and inferentially. Inferential analysis was carried out using path analysis, beginning with a data feasibility check. Next, a path diagram model was constructed based on a relevant theoretical framework. The final stage involved testing the path coefficients between variables using t-tests and evaluating the model's significance with a goodness-of-fit test. The results of the analysis were then interpreted to identify the influence of each variable in the model.

FINDINGS

Description of Research Variables

Descriptive statistics that describe the characteristics of the research data, including the average, variance, and standard deviation of the four variables studied, can be seen in Table 2 below:

Table 2. Description of Research Variable Data

	SC	HoM	LA	MCS
Variance	59,97	82,34	50,35	4,12
Minimum	45,75	62,88	71,14	7,02
Maximum	79	101	68	11
Standard Deviation	49	65	31	0
Mean	6,76	7,93	8,43	2,65

SC: Self-Confidence
HoM: Habits of Mind
LA: Learning Activeness
MCS: Mathematical Communication Skills

Descriptive statistics in Table 2 show an overview of the research data. In the self-confidence variable, an average of 59.97 was obtained with a score range between 49 (minimum) and 79 (maximum). The standard deviation of 6.76 indicates that, although there is variation in respondents' self-confidence levels, the data distribution is relatively homogeneous and not far from the mean. In contrast to the previous variable, habits of mind recorded the highest average (82.34) among the variables, with a maximum score of 101 and a minimum of 65. The standard deviation of 7.93 indicates moderate variation and confirms that students' reflective and critical thinking skills are generally at a high level. Meanwhile, the learning activity showed an average of 50.35, with a score range of 31 to 68. The largest standard deviation (8.43) among all variables indicates a significant disparity in the level of learning activity among the research subjects. In contrast, mathematical communication ability recorded the lowest average (4.12), with a maximum score of 11 and a minimum of 0. The standard deviation of 2.65 reflects moderate variation, although overall this ability is still considered low in the sample studied. This analysis highlights the heterogeneity of the data distribution and provides an empirical basis for further interpretation in the research context.

The results of the analysis of the percentage of student self-confidence are presented in Figure 1 below:

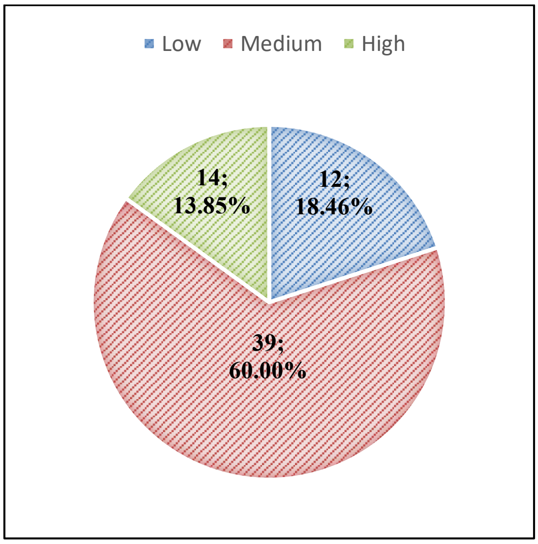

Figure 1. Percentage of Students' Self-Confidence

Figure 1 illustrates the distribution of self-confidence levels among eleventh-grade students at SMAN 1 Sampara, with 12 students categorized as low, 39 as medium, and 14 as high. Based on these data, 60% of students have a moderate level of self-confidence, indicating a dominant trend in this category.

The results of the analysis of the percentage of students' habits of mind are presented in Figure 2 below:

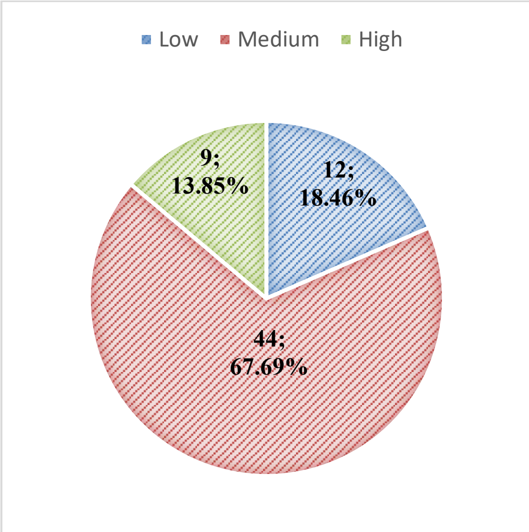

Figure 2. Percentage of Students' Habits of Mind

Figure 2 displays the results of the habits-of-mind categorization, with 12 students classified as low, 44 as medium, and 9 as high. With a percentage of 67.69%, the majority of students have habits of mind in the medium category, indicating a fairly developed pattern of thinking among the respondents.

The results of the analysis of the percentage of student learning activity are presented in Figure 3 below:

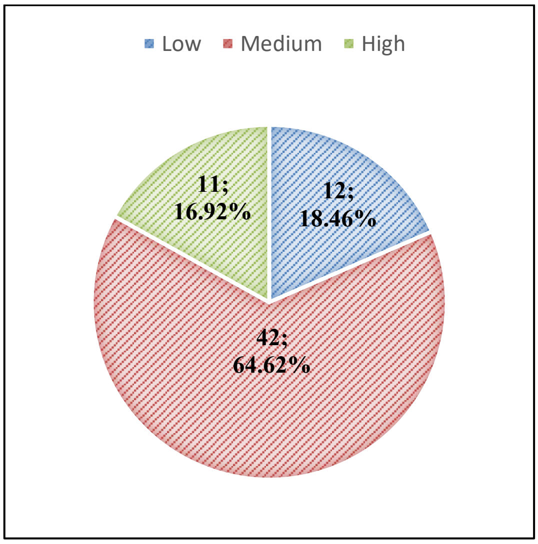

Figure 3. Percentage of Student Learning Activity

Figure 3 shows the distribution of learning engagement, with 12 students in the low category, 42 in the medium category, and 11 in the high category. The analysis shows that 64.62% of students fall into the medium category, indicating that their overall learning engagement is intermediate.

The results of the analysis of students' mathematical communication skills are presented in Figure 4 below:

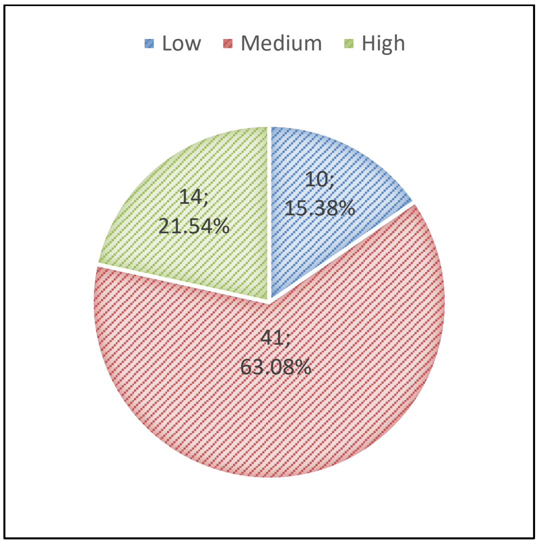

Figure 4. Percentage of Students' Mathematical Communication Skills

Figure 4 presents data on mathematical communication skills, with 10 students in the low category, 41 students in the medium category, and 14 students in the high category. The 63.08% confirms that students' mathematical communication skills are mostly at the medium level, reflecting a stable trend in achievement in this area.

Path Diagram

Based on the theories underlying the relationship between variables, a path diagram can be drawn as in Figure 5 below.

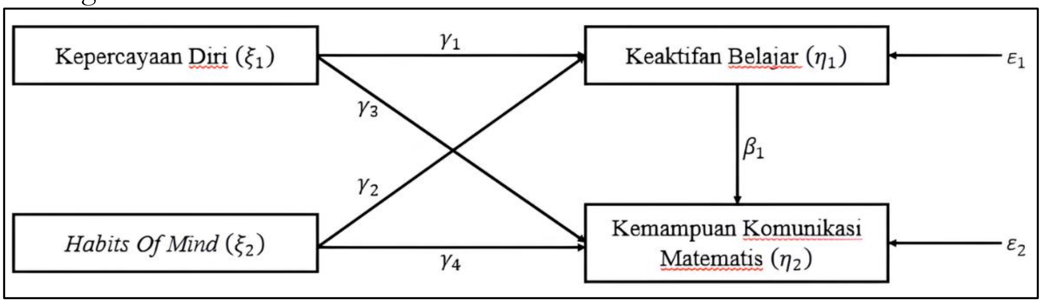

Figure 5. Path Diagram

From Figure 5 above, the model specifications in the equation can be written as follows (Patih, 2016):

$$\eta_1 = \gamma_1\xi_1 + \gamma_2\xi_2 + \varepsilon_1 \quad (1)$$
$$\eta_2 = \gamma_3\xi_1 + \gamma_4\xi_2 + \beta_1\eta_1 + \varepsilon_2 \quad (2)$$

Where γ_i is the parameter coefficient that connects the endogenous variable with the exogenous variable on the i^{th} Path. β_i is the parameter coefficient that connects the endogenous variable with the exogenous variable on the i^{th} path.

Path Analysis Parameter Estimation

The influence model between endogenous and exogenous variables is presented in Figure 6 below:

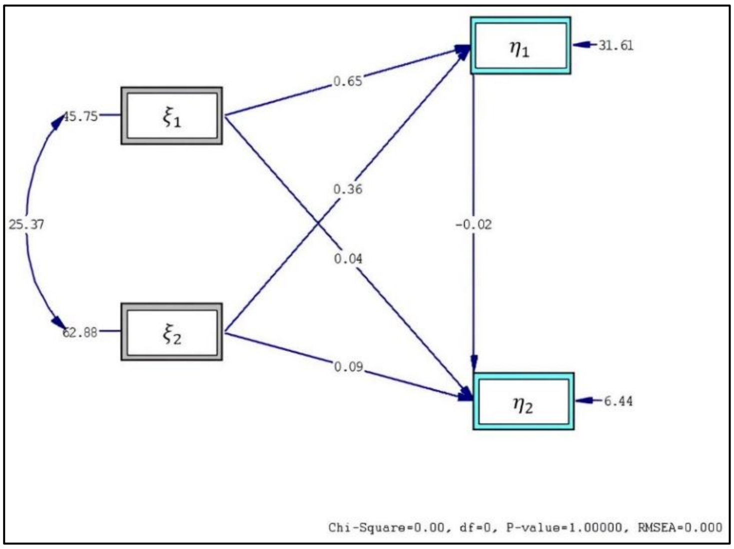

Figure 6. Path Diagram Parameter Estimation Results

Based on Figure 6 and the analysis of equations (1) and (2), the path coefficient estimation results, along with an evaluation of the R^2 value, which measures the proportion of endogenous variable variability explained by exogenous variables, are presented in detail in Table 3.

Table 3. Path Coefficient and R^2

Effects	Path Coefficient	t	t_{table}	Decision	R-Square
SC → LA	0,65	5,48*	1,96	Significant	55,6%
HoM → LA	0,36	3,56*	1,96	Significant	
SC → MCS	0,04	0,60	1,96	Not Significant	8,25%
HoM → MCS	0,09	1,83	1,96	Not Significant	
LA → MCS	-0,02	-0,42	1,96	Not Significant	

Note: * Significant at α=5%

Based on Table 3, only two relationships are significant at the α = 5% level: the influence of Self-Confidence on Student Learning Activeness and the influence of Habits of Mind on Learning Activeness. Furthermore, the variables Self-Confidence and Habits of Mind together account for 55.6% of the variation in Learning Activeness. Meanwhile, the combination of Self-Confidence, Habits of Mind, and Learning Activeness explains only 8.25% of the variation in Mathematical Communication Ability, indicating the model's limited predictive power for these variables. This finding indicates that although some relationships are significant, other factors outside the model may play an important role in shaping Mathematical Communication Ability. The structural model of Figure 6 can be written as follows:

$$\text{LA} = 0{,}65\text{SC}^* + 0{,}36\text{HoM}^*$$
$$\text{MCS} = 0{,}04\text{SC} + 0{,}09\text{HoM} - 0{,}02\text{LA}$$

Note: * Significant at α=5%

Direct Effect, Indirect Effect, and Total Effect of Path Analysis

The following are the results of the estimation and testing of the direct and indirect influence of each variable.

Table 4. Direct Effect, Indirect Effect, and Total Effect of Each Variable

	Effects					
	Direct	P-Value	Indirect (Through LA)	Sobel Test	Total	t

SC → LA	0,65	0,00	-	-	0,65	5,57
HoM → LA	0,36	0,00	-	-	0,36	3,61
SC → MCS	0,04	0,55	-0,02	-0,42	0,02	0,45
HoM → MCS	0,09	0,07	-0,01	-0,42	0,08	1,85
LA → MCS	-0,02	0,67	-	-	-0,02	-0,43

Based on the data analysis in Table 4, the self-confidence variable shows the most significant direct effect on learning activity, with a coefficient of 0.65 and a p-value of 0.00. On the other hand, the largest direct effect on mathematical communication ability is shown by the habits of mind variable. However, the magnitude is relatively small (0.09), and the p-value is 0.07, which is not statistically significant. Furthermore, the results of the path analysis revealed that the indirect effect of self-confidence on mathematical communication ability, mediated by learning activity, is negative (-0.02), as supported by the Sobel test (- 0.42). A similar pattern is observed in the indirect effect of habits of mind through learning activity, with an estimated effect of -0.01 and an identical Sobel test value (-0.42). In the context of the total effect, self-confidence again occupies a dominant position in learning activity (0.65), with a significant t = 5.57. In contrast, the weakest effect was observed in the relationship between learning activity and mathematical communication ability, which was not only small (coefficient =-0.02) but also statistically insignificant, with a t_count of -0.43. This finding indicates variations in the strength and significance of the influence between variables in the studied model.

Evaluation of Goodness of Fit (GoF) Criteria

The total amount of data variability explained by the overall model can be calculated as follows:

$$\begin{aligned} R_m^2 &= 1 - R^2_{LA(HoM,SC)} \times R^2_{MCS(LA,HoM,SC)} \\ &= 1 - (0{,}56)(0{,}08) \\ &= 0{,}96 \end{aligned}$$

The calculation results show that the developed path analysis model explains 96% of the phenomena or cases studied, with the remaining 4% attributable to other variables not yet incorporated into the model. To validate the model's overall performance, a Goodness-of-Fit (GoF) test was conducted. This test aims to measure the extent to which the constructed model can represent empirical reality, while also identifying potential limitations that may arise due to the exclusion of external variables (Maydeu-olivares & Forero, 2010).

Table 5. Goodness of Fit Test

Degrees of Freedom for (C1)-(C2)	0
Maximum Likelihood Ratio Chi-square (C1)	0,0 (P = 1,0000)
Browne's (1984) ADF Chi-square (C2_NT)	0,0 (P = 1,0000)

Based on Table 5, the chi-square test yielded a chi-square value of 0.0 with a significance level of P=1.0000, indicating that the model as a whole explains the case of learning activity and mathematical communication skills well (Model Fit).

DISCUSSION

The Direct Influence of Self-Confidence on Learning Activity

The research findings confirm the direct influence of self-confidence on students' learning engagement. This finding aligns with the research of Ruyani & Sudiansyah (2024), which revealed that students with high levels of self-confidence demonstrate more active participation in the learning process. This is reflected in their courage to ask questions and intensive engagement in discussions, thus strengthening their motivation and perseverance in overcoming academic challenges. Further support comes from research by Pramesty & Suratno (2021), which found a positive correlation between self-confidence and learning engagement. Individuals who have strong beliefs in their abilities tend to be more motivated to explore what interests them. Achieving this level of confidence not only strengthens self-confidence but also encourages more dynamic participation in classroom activities. Furthermore, Nurfalihah (2023) found that students with high levels of self-confidence tend to demonstrate greater engagement in learning, including the courage to ask questions, offer critical responses, and actively participate in academic discussions.

The Direct Influence of Habits of Mind on Learning Activity

This study confirms the positive influence of habits of mind on student learning engagement. This finding aligns with the study by Ruyani & Sudiansyah (2024) which states that habits of mind play a significant role in increasing students' active participation in learning. Habits of mind, as a framework for critical and reflective thinking, facilitate students' development of deeper engagement in the learning process. Students with well-formed habits of mind are more likely to participate actively, including by being open to asking questions, engaging in discussions, and participating in various learning activities. Furthermore, the significant influence of habits of mind on learning engagement can be understood through their ability to encourage students' cognitive and emotional engagement during learning (Dwirahayu, dkk., 2017). Students with strong habits of mind tend to be more proactive in class discussions, asking questions to deepen conceptual understanding, and seeking solutions to learning problems. Thus, habits of mind create an active learning dynamic, where students do not merely passively receive information but also play an active role in knowledge construction (Aringga, dkk., 2019). This reinforces the importance of developing habits of mind as a key driver of learning effectiveness.

The Direct Influence of Self-Confidence on Mathematical Communication Ability

Research findings indicate that self-confidence does not directly influence mathematical communication skills. This is in line with the results of a study by Indrawati & Hartati (2019) which concluded there was no significant relationship between the two variables. Increasing self-confidence can be achieved through various means, including courage, knowledge mastery, effective communication skills, and speaking practice, all of which are influenced by both internal and external factors. However, in addition to self-confidence, several other factors shape mathematical communication skills, including conceptual understanding, learning approaches, and the learning environment.

Research by Iman & Lukas (2024) revealed that a deep understanding of mathematical concepts and the ability to construct arguments logically and systematically contribute significantly to mathematical communication skills. This means that even if students have high self-confidence, their inability to understand basic mathematical concepts will limit their ability to communicate mathematical ideas effectively. Furthermore, the learning methods implemented by educators also play a significant role. Afifah, dkk. (2020) Found that the Problem-Based Learning (PBL) model integrated with technology significantly improved students' mathematical communication skills.

Furthermore, a conducive learning environment is another determining factor in developing this ability. A study by Soleha & Ihsanudin (2024) confirmed that a collaborative and student-focused learning environment encourages improved mathematical communication skills. Therefore, it can be concluded that self-confidence alone is insufficient to support successful mathematical communication without strong conceptual understanding, appropriate learning strategies, and a supportive learning environment.

The Direct Influence of Habits of Mind on Mathematical Communication Ability

Research results indicate that habits of mind do not directly affect students' mathematical communication skills; however, this finding is not fully supported by current empirical evidence. As an illustration, studies conducted by Ilmi, dkk. (2022) and Astuti & Yuliani (2024) Revealed a positive correlation between habits of mind and mathematical communication competence. However, the lack of a significant effect of habits of mind on these abilities may be explained by the complexity of mathematical communication, which entails a range of specialized skills. According to Suryawati, dkk. (2023)These skills include a deep understanding of mathematical concepts, the capacity to construct logical arguments, and the accurate application of mathematical notation. Furthermore, Saputri & Faiziyah, (2023) emphasized that mastery of mathematical communication requires structured practice oriented towards the use of technical language and symbolic representation. For example, students with critical habits of mind may excel at assessing the validity of arguments but still struggle to express mathematical ideas clearly if they lack training in formal reasoning. Thus, although habits of mind do not have a statistically significant effect, this finding indicates that mathematical communication skills are more dependent on habituation and direct experience focused on mathematical aspects.

The Direct Influence of Learning Activity on Mathematical Communication Ability

Active learning does not directly influence students' mathematical communication skills. Students' active learning does not directly influence their mathematical communication skills. This ability relies more on in-depth conceptual understanding and focused practice in aspects of mathematical communication. General learning activities, such as participating in discussions or frequently answering questions, do not automatically improve students' ability to convey mathematical ideas clearly and in a structured manner. Conversely, mastery of mathematical communication requires a deep understanding of mathematical concepts and the ability to relate them to effective communication contexts. Therefore, active learning that only prioritizes the quantity of interaction, without being supported by reinforcement of appropriate communication concepts and strategies, is insufficient to develop this competency (Dalimunthe, dkk., 2024). His finding aligns with research by Hikmah, dkk. (2019), which shows that student active learning is not always an indicator of their mathematical communication skills. For example, some students actively participate in discussions, ask questions, or respond to friends' opinions, but when tested in depth through tests or interviews, they are unable to solve math problems correctly. This strengthens the argument that general learning activities, such as completing assignments or interacting in class, do not directly contribute to the development of mathematical communication unless accompanied by exercises that explicitly involve aspects of formal communication.

Therefore, a task-based learning approach designed to deepen conceptual understanding while simultaneously training mathematical communication skills is important (Husna, dkk., 2016). Through this strategy, active learning can be directed more effectively to support the development of mathematical communication skills, thereby achieving more optimal results.

The Indirect Effect of Self-Confidence on Mathematical Communication Ability Through Learning Activeness

The results of the study indicate that self-confidence does not have an indirect effect on mathematical communication skills mediated by learning engagement. Although self-confidence is recognized as a key factor in the learning process, its influence is insufficient to improve mathematical communication skills when examined through the lens of learning engagement. This finding is consistent with a study by Indrawati & Hartati (2019), which concluded that mathematical communication skills are more influenced by deep conceptual understanding and mastery of mathematical technical skills than by self-confidence alone. Although self-confidence can encourage student participation in learning, it does not necessarily guarantee their ability to communicate mathematical ideas effectively.

Furthermore, high levels of learning engagement do not necessarily correlate positively with improved mathematical communication skills (Hikmah, dkk., 2019). The quality of interactions and learning methodology are also determining factors. Without implementing strategies specifically designed to develop mathematical communication skills, the impact of learning engagement is limited. Furthermore, contextual factors, such as the types of learning activities implemented, can influence these outcomes. If learning activities do not provide opportunities for students to practice mathematical communication directly, then students' learning engagement will not significantly contribute to mastery of these skills.

The Indirect Effect of Habits of Mind on Mathematical Communication Skills Through Learning Activity

While habits of mind play a role in supporting students in solving mathematical problems, their influence on mathematical communication skills is indirect. Habits of mind do not explicitly improve students' capacity to convey mathematical ideas orally or in writing. Instead, mathematical communication skills depend more on a deep understanding of the material and mastery of communication skills in a mathematical context (Afifah, dkk., 2020). On the other hand, learning engagement, although often associated with improved academic achievement, does not directly influence mathematical communication skills. High levels of learning engagement, while positively impacting academic grades, do not necessarily translate into improved communication skills. External factors, such as teachers' teaching methods, are more dominant in shaping learning engagement, while their impact on mathematical communication remains limited (Halimah & Rahmi, 2020).

Therefore, efforts to improve mathematical communication skills must focus on two main aspects: strengthening conceptual understanding of mathematics and developing structured communication skills. Habits of mind and active learning, although useful in supporting the learning process, cannot be relied upon as direct determinants in improving mathematical communication skills (Firdawati & Hidayat, 2018). Thus, the learning approach needs to place greater emphasis on in-depth material and systematic communication training to achieve the expected results optimally.

CONCLUSION

The results showed that the majority of eleventh-grade students at SMAN 1 Sampara were at a moderate level in terms of self-confidence, habits of mind, learning engagement, and mathematical communication skills. Further analysis revealed that self-confidence and habits of mind significantly influenced learning engagement, with increases in any of these variables positively impacting engagement. However, this finding did not apply to mathematical communication skills, which showed no significant correlation with the three variables. This means that although self-confidence, habits of mind, and learning engagement are interrelated, they do not directly or indirectly influence students' mathematical communication skills. Thus, it can be concluded that factors that encourage learning engagement do not necessarily improve mathematical communication skills, indicating that other dimensions need to be explored to understand the determinants of these abilities more holistically.

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