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ANALYSIS OF STUDENTS' MATHEMATICAL COMMUNICATION ABILITY BASED ON SELF-CONFIDENCE AND COGNITIVE STYLE

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Abstract

Self-confidence and cognitive style are important variables that influence the behavior of students in the academic field, the continued development of academic abilities, how learning is carried out, and how they interact in classroom activities. Learning activities will be expected more effective because all of the learning steps going to be attractive and get to reach the learning achievements if students have good self-confidence. So, all of these things are related to mathematical communication ability. The data on students' mathematical communication ability scores that were influenced by two factors, the level of self-confidence and different cognitive styles, were analyzed by the experimental design carried out in this research was a 3x2 Completely Randomized Factorial Design. The observation data were analyzed statistically with the F-test at a significance level of 5%. From the test of between-subjects effects, the output data was on the ANOVA table. We can get the conclusion that there was factors interaction which can be seen by *p-value (Sig.)* $< \alpha = 0.05$, which means rejected H_0. There was an effect of interaction between self-confidence with cognitive style significantly to mathematical communication ability.

Keywords: mathematical communication, self-confidence, cognitive style

1. Introduction

Mathematical communication ability is one of the mathematical competencies that is basically had by students in mathematics learning. This is according to the main content of mathematics subjects for primary and secondary education level which contain descriptions and provisions regarding the objectives of mathematics subjects in schools, one of the purposes is for students can be able to get and develop mathematical communication ability, which can be identified by the ability to translate an idea using pouring it into forms, symbols, or media in order to clarify a problem or situation (Maulyda et al., 2022). Because mathematics and communication are two things that complement each other and can't be separated. Communication ability is needed to learn and understand the aims and objectives of the subjects in mathematics and its correlation to daily life, and learning mathematics is the way for students to practice thinking abilities, especially in mathematical communication ability (Chasanah & Usodo, 2020).

Mathematical communication ability is the ability that functions to express mathematical ideas in both written and verbal (Lestari & Yudhanegara, 2017). Students' mathematical communication ability can be developed through the learning process at school, in by mathematical learning process. This happens because all of the elements of mathematics are the science of logic which is able to develop students' thinking abilities. Thus, mathematics has an important role in the development of mathematical communication ability (Hodiyanto, 2017). Based on the observation results, some students don't make a good enough effort to understand the material when learning mathematics, and easily give up on completing assignments given by the teacher because of their low level of mathematical communication ability (Farman & Samsiah, 2023).

Mathematical communication is a way to exchange ideas and clarify students' understanding. Through mathematical communication, ideas become objects that are reflected on to be improved, discussed, and probably modified. The communication process helps establish the meaning and certainty of an idea or concept and makes it something common (Tong et al., 2021). There are various ways to improve students' mathematical communication ability, among others, teachers encourage students to be able to think logically by giving mathematical problems and relating them to daily activities, and then students can ask some questions regarding the details of the problem with the purpose that students can understand it meaningful. The objectives of the learning material are being carried out so that from any information obtained, students are expected to be able to provide answers with independent completion steps. Students can also improve their mathematical communication ability by learning to analyze something based on steps that follow existing theorems that have been studied previously by themselves. Developing mathematical communication ability requires learning that can accommodate thinking processes, reasoning processes, critical attitudes, and asking some questions (Azmi et al., 2021).

Mathematical communication abilities between one student and another are definitely different. This diversity of abilities is influenced by various factors. Self-confidence is the main thing that a student must have in learning education, as well as in daily life. Students who have good self-confidence will try hard to carry out learning activities and have a sense of optimism to achieve something as expected. Have a high sense of responsibility, and be rational and realistic in solving problems individually. This can be an incentive and make the students' learning process easier. With confidence and self-confidence in ability, a confident attitude toward learning will arise (Dewi et al., 2021).

The indicators of mathematical communication ability that can be used to measure in a study are divided into three dimensions, such as; 1) written text, including making models of situations or problems in writing form, making models of situations or problems in visual form, making questions about the mathematics that has been studied. 2) drawing, measured by reflecting real objects or images into mathematical ideas, 3) mathematical expression, measured by expressing mathematical concepts by stating a problem in language or mathematical symbols (Gordah & Astuti, 2013).

Good communication ability is proportional to self-confidence level. A higher self-confidence level by someone makes for better communication ability. Because self-confidence makes someone able to boldly express some ideas from within their mind these can be conveyed to someone else. There is a positive relationship between self-confidence and students' mathematics learning outcomes and a positive relationship between mathematics learning outcomes and mathematical communication ability too (Erayani et al., 2022).

Students' mathematical communication ability will be good if the students have good self-confidence. This is because students have a

positive view of themselves and their abilities so students don't feel afraid because of making some mistakes or are anxious when solving problems regarding mathematical communication. When students have good self-confidence, they will be braver in expressing their opinions and will be encouraged to improve their achievements (Lar & Maulina, 2021). Mathematical communication ability and self-confidence can be grown through the learning process, of course with the participation of teachers as facilitators and motivators for students (Noviyana et al., 2019).

The other factor that influences mathematical communication ability can be seen from the differences in characteristics of each individual. Differences in characteristics between students who persist in how to organize and manage information and experiences are known as cognitive styles (Slameto, 2015). Mathematical communication ability is definitely related to the cognitive style that exists within someone else. This is because cognitive style influences the information-collecting process in students' minds so there will be differences in students' delivery of mathematical ideas in each cognitive style. Every individual has a different cognitive style (Malaya et al., 2021).

Cognitive styles describe individual differences based on two models. One model comprises four basic cognitive modes derived from the intersection of a wholist-analytic dimension and a verbalizer-imager dimension (Riding & Rayner, 2013). This model synthesizes the research and literature produced in the field of cognitive styles and solves the problem researchers have faced when labeling cognitive styles phenomena. The second model also synthesizes a large body of literature on learning styles. Two models of cognitive styles are known as reflective and impulsive cognitive styles (Fan, 2020).

Cognitive style is a new idea in the study of developmental and educational psychology. This idea is developed by research on how individuals receive and organize information from the surrounding environment. Teachers are obligated to understand the relationship between the creativity resulting from each of these cognitive styles. Reflective and impulsive cognitive styles are cognitive styles that indicate tempo or speed in thinking. So, the creative and critical thinking ideas that children produce depend on their cognitive style (Rahmatina et al., 2014). The creative and critical thinking ideas are two of the basic to improve communication ability, either verbal and written (Qin, 2021). One of the differences between the characteristics of reflective and impulsive cognitive styles is, that impulsive students tend not to go through the stages of planning a solution, do only a few calculations, and are reluctant to re-examine solutions that have been found (Fadiana, 2016).

Students' self-confidence and cognitive style are important variable that influences the behavior of students in the academic field, the continued development of academic abilities, how learning is carried out, and how they interact in classroom activities. Learning activities will be expected more effective because all of the learning steps going to be attractive and get to reach learning achievements if students have good self-confidence (Rachmayani, 2014). The activity between teachers and students also shows different approaches in receiving or providing interaction activity according to cognitive styles themselves (Fulantelli et al., 2023). So, all of these things are related to mathematical communication ability.

2. Method

Research Methods

This research purposes will determine students' mathematical communication abilities which were influenced by two factors, there were the level of self-confidence and the different cognitive styles of students. The categories of self-confidence factors used in this research were divided into low, medium, and high categories. Meanwhile, the categories of cognitive style factors used in this research were reflective cognitive style and impulsive cognitive style.

The instruments of measurement in this research were test instruments for mathematical communication ability was on test and non-instruments for self-confidence and cognitive style on the questionnaire. The criteria of the validity and reliability test for all the instruments that had been tested obtained a validity and reliability coefficient in the high classification, so the research instruments were considered valid and reliable so that the instruments could be used as a research measurement (Hidayat, 2021). The method used to determine each category in these two factors was filling out a questionnaire by students, self-confidence and cognitive style.

The questionnaire on self-confidence consisted of 27 questions about self-confidence that show the characteristics of each category of self-confidence, which was adapted from other research (Faturohman et al., 2022). Meanwhile, the questionnaire on cognitive style consisted of 40 questions about cognitive style that show the

characteristics of each category of cognitive style was adapted from other research (Umah, 2020). Then the students were categorized by their own self-confidence and cognitive style.

Every question in the questionnaire on self-confidence refers to a Likert scale or a summated rating scale where answers had a value from 1 to 5. Every question in the questionnaire of cognitive style refers to a Likert scale or summated rating scale where answers had a value from 1 to 4. All of the questions in the questionnaire on self-confidence consisted of positive questions only. Meanwhile, all of the questions in the questionnaire on cognitive style consisted of positive questions only.

The experimental design used was a completely randomized design with two factors, there was self-confidence and cognitive style. The observation data were analyzed statistically with the F-test at a significance level of 5%. If there were significant differences between the factor interaction, a multiple-range test was carried out using Duncan's Multiple Range Test method (Cavalloro, 2021).

Equation Model

This research used the equation model of experimental design as follows (Dean et al., 2015).

$$Y_{ijk} = \mu + \alpha_i + \beta_j + (\alpha\beta)_{ij} + \varepsilon_{ijk}$$

for $i = 1,2,3$; $j = 1,2$; $k = 1,2,3,4$

Notes:

Y_{ijk}	:	observation results for the average value of mathematical communication ability for each factor
μ	:	the middle value of the results of mathematical communication ability
α_i	:	the effect of self-confidence
β_j	:	the effect of cognitive style
$(\alpha\beta)_{ij}$	:	the interaction effect between self-confidence with cognitive style
ε_{ijk}	:	test error for each factor

3. Results and Discussion

3.1 Results

Data on students' mathematical communication ability scores was influenced by two factors, there was the level of self-confidence and different cognitive styles. The experimental design carried out in this research was a 3x2 Completely Randomized Factorial Design. The observation data were analyzed statistically with the F-test at a significance level of 5%. The results were on the ANOVA table to see the significant value by both factor and factor interaction.

The following is data on students' mathematical communication ability obtained in research and discussion. The population was the senior high school students in first grade. Sample data was obtained from 126 students in 4 classes and then the average scores for each class were determined for each category in the factor interaction so that the data used was mathematical communication ability scores from the 4 classes represented each category in the factor interaction. The table below describes the number of students in each category of each factor.

Table 1. Number of Students

Self-confidence	Cognitive style	N				Total
		1	2	3	4	
Low	**Reflective**	5	6	4	2	17
	Impulsive	5	7	3	9	24
Medium	**Reflective**	6	5	8	4	23
	Impulsive	6	5	7	3	21
High	**Reflective**	5	6	6	8	25
	Impulsive	3	3	4	6	16

Notes:
Percentage of students based on category

Self-confidence:	Low	32.54%
	Medium	34.92%
	High	32.54%
Cognitive style:	Reflective	51.59%
	Impulsive	48.41%

The data on Table 1 shows that there was no significant difference between the number of students in each category of both factors. So, all of the research subjects were from the normal population and could be used for the research. After the number of students from each category was known by the questionnaire answered. The next step was giving the mathematical communication ability test to all students to get the scores.

After all the scores were obtained, then were calculated to get the average scores from each category. The data of the mathematical communication ability scores test that were obtained by the average score of students from each class was described in Table 2.

Table 2. Mathematical Communication Ability Scores

A	B	Score				Total
		1	2	3	4	
1	1	8.62	9.77	12.38	10.21	40.98
	2	11.33	13.57	13.74	11.34	49.98
2	1	13.53	15.97	13.78	14.77	58.05
	2	12.01	11.74	13.27	14.25	51.27
3	1	12.89	13.63	14.66	15.49	56.67
	2	15.73	14.22	15.08	16.15	61.18

Notes:
A (Self-confidence) B (Cognitive Style)
1 = Low 1 = Reflective
2 = Medium 2 = Impulsive
3 = High

Mathematical communication ability scores on Table 2 were measured with a test instrument that had been fulfilled in a validity and reliability test, consisting of 6 descriptive questions with a minimum total score of 0 and a maximum score of 18. The average scores of each category in each class show that there were no significant differences.

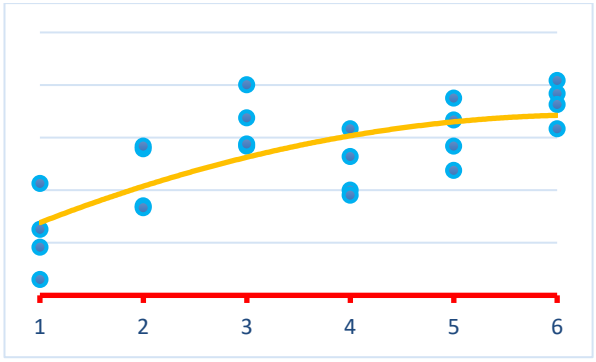

Figure 1. Scatterplot of Test Results

All of the data from Table 2 were used for calculation in this research. The calculation was done using the IBM SPSS Statistics 27 program. The data were analyzed to get the output results in the Type III Sum of Squares analysis of variance (ANOVA) table. The main effect was used for each factor, and the interaction effect was used between both. Output data was measured to know how significant effect of both factors and the interaction from both of them. The results are described in Table 3.

Table 3. Tests of Between-Subjects Effects

Dependent Variable: Mathematical Communication Ability Scores Data

Source	*Type III Sum of Squares*	*df*	*Mean Square*	*F*	*Sig.*
Corrected Model	65.461[a]	5	13.092	9.095	0.001
Intercept	4233.133	1	4233.133	2940.685	0.001
A	47.175	2	23.587	16.386	**0.001**
B	1.961	1	1.961	1.362	**0.258**
AB	16.326	2	8.163	5.671	**0.012**
Error	25.911	18	1.440		
Total	4324.505	24			
Corrected Total	91.372	23			

a. R Squared = 0.716 (Adjusted R Squared = 0.638)

The hypothesis that would be tested truly was mathematical communication ability is significantly affected by self-confidence, cognitive style, and both of their interaction. The significant value from the table above means how significant the main effect of each factor, is and the interaction effect between both factors. So, we could get the results. For A (self-confidence), *p-value (Sig.)* $< \alpha = 0.05$, which means rejected H_0. There was **an effect of self-confidence significantly** on mathematical communication ability. For B (cognitive style), *p-value (Sig.)* $> \alpha = 0.05$, which means accepted H_0. There was **no effect of cognitive style significantly** on mathematical communication ability. For AB (factors interaction), *p-value (Sig.)* $< \alpha = 0.05$, which means rejected H_0. There was **an effect of interaction between self-confidence with cognitive style significantly** to mathematical communication ability.

Because there is an interaction effect of self-confidence and cognitive style on students' mathematical communication ability scores, it is necessary to carry out further tests to find out which factors interaction has the best results in terms of producing students' mathematical communication ability scores (Leppink, 2019). In this research, further test calculations were carried out using Duncan's Multiple Range Test for the factor interaction between self-confidence factors and cognitive style factors.

The results of further test calculations using Duncan's Multiple Range Test for the factors interaction between self-confidence factors and cognitive style factors. Duncan's Multiple Range Test as advanced test calculations used the IBM SPSS Statistics 27 program. Duncan's Multiple

Range Test aimed to find out how significant the differences produced by each factor interaction were in the results obtained (Cavalloro, 2021).

Table 4. Duncan's Multiple Range Test

Factor Interaction	*N*	*Subset*			
		1	2	3	4
$(AB)_{11}$	4	10.295			
$(AB)_{12}$	4		12.492		
$(AB)_{22}$	4		12.852	12.852	
$(AB)_{21}$	4		14.147	14.147	14.147
$(AB)_{31}$	4			14.542	14.542
$(AB)_{32}$	4				15.355
Sig.		1.000	0.080	0.074	0.194

Means for groups in homogeneous subsets are displayed.
Based on observed means.
The error term is Mean Square (Error) = 1.440.
a. Uses Harmonic Mean Sample Size = 4.000.
b. Alpha = 0.05.

The critical value is the value that shows the difference in the effect of each factors interaction in a study (Lehmann & Romano, 2022). The critical values by subset were 1.000, 0.080, 0.074, and 0.194, which means that only factors interaction in the first subset had a significant difference with factors interaction in other subsets. The data above was the interpretation results of continued tests carried out using Duncan's Multiple Range Test for the factors interaction between self-confidence factors and cognitive style factors.

Factors interaction $(AB)_{11}$ was significantly different from the others. Factors interactions $(AB)_{12}$, $(AB)_{22}$, and $(AB)_{21}$ were not significantly different. Factors interactions $(AB)_{22}$, $(AB)_{21}$, and $(AB)_{31}$ were not significantly different. Factors interaction $(AB)_{32}$ gave the best result for the score of mathematical communication ability, but there was no significant difference between $(AB)_{21}$ and $(AB)_{31}$.

3.2 Discussion

Based on the results obtained from the output data of the ANOVA table and Duncan's Multiple Range Test, it can be interpreted that:

a. Students with mathematical communication ability scores from high self-confidence were significantly different from those of students with low and medium self-confidence.
b. Students with mathematical communication ability scores between a reflective cognitive style and an impulsive cognitive style weren't significantly different from each other, no category was more dominant.
c. Students with mathematical communication ability scores from a high self-confidence and an impulsive cognitive style have the highest average score, but only students with low self-confidence and a reflective cognitive style were significantly different compared to students with the other factors interaction.

The results obtained from the output data of the ANOVA table (Table 3) and Duncan's Multiple Range Test (Table 4) were supported by the statement that good communication ability is proportional to self-confidence level.

A higher self-confidence level by someone makes for better communication ability. Self-Confidence is a crucial part of communication skills because that can give enthusiasm, brave, and stimulation to the learners (Maftuna, 2020). Because that if the learners have high self-confidence, they will achieve the best performance in communication skill fluently. High self-confidence can be positively correlated with verbal performance. Therefore, the student who has higher self-confidence than the other students can communicate well (Kansil et al., 2022).

Meanwhile, cognitive style didn't give positive results because either reflective or impulsive cognitive style has its advantages and disadvantages (Viator et al., 2020), and has differences in characteristics between students who persist in how to organize and manage information and experiences. Reflective and impulsive are two personality tendencies of human beings and a pair of learning styles in the category of cognition. The two cognitive styles have their own advantages. Reflective cognitive style promotes language accuracy, while impulsive style facilitates fluency. In contrast, students with impulsive cognitive style speak enthusiastically and dare to express their views and opinions in class. In addition, impulsive students show the characteristics of learning in a small increase, and it often ups and downs. While, to reflective one, learning stages are increased by a large amount and the stable period is longer (Chen, 2021).

However, the interaction between both factors gave various results which means that either students' self-confidence or cognitive style are important variables that have a positive effect on students' mathematical communication ability.

4. Conclusion

From the data obtained and analyzed on students' mathematical communication ability, the conclusions obtained from this research are: There

was a significant effect of self-confidence on students' mathematical communication ability scores. There was no significant effect of cognitive styles on students' mathematical communication ability scores. There is a significant effect from factors interaction effect of self-confidence with cognitive styles on students' mathematical communication ability scores, with students' high self-confidence and impulsive cognitive styles above average giving the best results on students' mathematical communication ability scores.

The conclusions of this research is, mathematical communication ability was significantly affected by self-confidence and not significantly affected by cognitive style, but factors interaction effect of self-confidence with cognitive styles have a significant effect on students' mathematical communication ability.

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