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Mathematical Communication Skills in Terms of Cognitive Style

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Abstract. The goal of this study is to help students improve their mathematical communication abilities, which are shown in indicators based on cognitive style. up to 30 students may participate in learning mathematics logic in class X SMAIQu Al-Bahjah Center. The methodology is qualitative. Through the use of surveys, exams, interviews, and documentation, data were gathered. Techniques for data analysis include data gathering, data reduction, data display, and data verification. Based on the questionnaire's answers, the subjects were divided into three categories or levels of cognitive style: low, medium, and high. Each survey had two participants. According to the study's findings, students' mathematical communication abilities include indicators for formulating mathematical concepts and strategies, expressing themselves verbally and in writing, visualizing mathematical concepts, understanding, interpreting, and evaluating mathematical material ideas verbally and in writing, as well. Use terminology, mathematical notation, and structures to show ideas and explain connections between mathematical concepts in various visual formats.

Key words: mathematical communication skills; cognitive style

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INTRODUCTION

An international research study of trends, directions, and advancements in mathematics and science is called the Trend in International Mathematics and Science Study (TIMSS). The International Association for the Evaluation of Educational Achievement carried out this study (IEA). The primary goal of TIMSS is to enhance the process of teaching and learning mathematics and science by collecting information on student accomplishments in connection to various forms of curriculum, teaching methods, and educational settings (Mullis et al., 2016). Knowledge, application, and reasoning are three components of the cognitive process domain that are evaluated by TIMSS. Information, in particular, influences knowledge, and in daily life, information can be gathered from data and observations of the world around us and disseminated through communication.

The Latin word communis, which means "to communicate," is the origin of the word. To make the same thing is called communicate, communication, or community. In plain English, communication can take place if the sender and the recipient of the message are comparable. As a result, communication is reliant on mutual understanding. Communication is a means of knowledge and experience sharing. Human communication frequently takes the form of speech, writing, gestures, and broadcasting. Interactive communication, transactive communication, purposeful communication, and purposeless communication are all forms of communication. Others can comprehend a person's or group of people's attitudes and sentiments through communication. But effective communication depends on the recipient's ability to understand the message being given (Hastasari et al., 2022).

Notification, dialogue, idea sharing, and relationships are all examples of communication (Utami, 2021). The act of conveying messages from one party to another using symbol and other methods so that both parties understand one another is referred to as communication (Nurrokhim et al., 2019). One of the activities that frequently take place in daily life is communication. Communication can take place between two or more individuals and has a variety of situations and purposes (Zahri, 2019). Ideas will become the subject of communication for discussion, advancement, revolution, and reflection (Rustam, 2017; Werdiningsih et al., 2018; Utami, 2021). Communication demonstrates how students convey ideas and reflect others on their grasp of mathematics (Veva et al., 2018; Zahri, 2019). Students learn communication skills through practicing them with others. This helps them convince others to accept their ideas and develop a mutual understanding (Hamlin et al., 2019). In (Asikin, 2021), the role of communication in mathematics learning is described as follows: (1) being able to explore mathematical ideas from various

perspectives, encouraging student thinking, and increasing the ability to see connections from various mathematical pathways; (2) being able to be used to reflect and measure students' mathematical understanding; (3) being able to encourage students to combine and organize mathematical ideas; and (4) being able to improve the construction of mathematical knowledge, social skills, and understanding. The purpose of communication is to create meaning, present ideas, and share ideas. Students will learn to clarify and persuade others of their thoughts when communicating (Yulian, 2018). Through excellent communication, students can solve problems quickly and also explain mathematical ideas and techniques to peers, teachers, or others (Rakhman, 2019).

Mathematical Communication Skill

Mathematical communication is the term for communication in mathematics learning (Utami, 2021). The four standards of mathematical communication skills in (Pujiastuti *et al.*, 2017) are as follows: (1) regulate and strengthen mathematical thinking through communication; (2) communicate mathematical thinking coherently and clearly to peers, teachers, and others; (3) analyze and evaluate other people's mathematical ideas and strategies; and (4) use mathematical language to present mathematical ideas correctly. There are three standards for mathematical communication abilities in (S. H. Nasution, 2020): (1) students can communicate themselves verbally, in writing, and visually; (2) students can comprehend, interpret, and evaluate mathematical ideas verbally, in writing, or other visual forms, and (3) Students can convey ideas and explain how one mathematical topic relates to another using terminology, mathematical notation, and structure. There are three standards for mathematical communication skills according to (Kosko & miyazaki, 2012): (1) expressing oneself verbally, in writing, and visually; (2) understanding, interpreting, and evaluating mathematical ideas verbally, in writing, and other visual forms; and (3) using terms, mathematical notation, and their structures to present ideas and describe connections between mathematical concepts.

Cognitive Style

When making decisions or organizing information based on their observations, people use their cognitive style (Wang et al., 2022). The various ideas all imply that there are consistent individual variances in how information and experiences are structured and processed which might be referred to as cognition styles (Baldacchino et al., 2022). How a person observes, thinks, learns, solves issues, and interacts with others is characterized by his cognitive style (Mohammadi & Amjadiparvar, 2022). Two cognitive style dimensions—analysis and intuition—make up the whole (Wu, 2022). The dimensions are listed as (1) analytical, deductive, strict, restricted, convergent, formal, and critical, and (2) synthetic, inductive, expansive, unconstrained, divergent, informal, diffuse, and creative (Mohammadi & Amjadiparvar, 2022). Analytical and non-analytical, according to (Anshu et al., 2022).

METHODS

Research of this kind is qualitative. The objective is to develop a framework that describes cognitive style-based indicators of mathematics communication skills. This study went through several steps, including problem formulation, application of theoretical studies, data gathering, data analysis, conclusion-making, and validation. The participants were 30 students from SMA Al-Bahjah Pusat who were studying mathematical logic in the odd semester of 2022–2023. Understanding mathematical statements and their negation or negation, figuring out how true a compound statement or a quantified statement is, and generating a statement that is comparable to a given compound statement or quantified statement are some of the subjects covered. Instruments used for data collecting include cognitive style assessments, interviews, documentation, and testing of mathematics communication skills. Students were divided into three categories or levels, namely low, medium, and high, based on the results of the cognitive style questionnaire. Table 1 displays categories of cognitive style.

Table 1. Categories of Cognitive Style

Formula	Category
$M_i + 0.5SD_i < X \leq M_i + 1.5SD_i$	High
$M_i - 0.5SD_i < X \leq M_i + 0.5SD_i$	Medium
$M_i - 1.5SD_i < X \leq M_i - 0.5SD_i$	Low

Note:
x: Cognitive style questionnaire scores
X_{max}: Maximum Score
X_{min}: Minimum Score
M_i: Ideal average score with $M_i = \frac{1}{2}(X_{max} + X_{min})$
SD_i: Ideal Standard Deviation with $SD_i = \frac{1}{6}(X_{max} - X_{min})$.

Two students from each category were chosen as respondents from the cognitive style questionnaire results. Purposive sampling was the method employed for the sample of responders. Indicators of mathematical communication skills are used to organize the test questions. The indicators utilized in the study are described in Table 2 below.

Table 2: Indicator of Mathematical Communication Ability

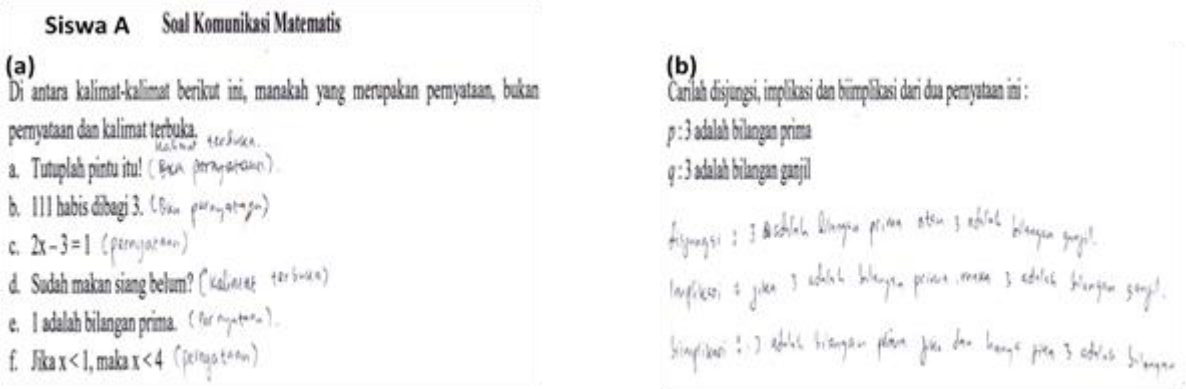
Indicator	Description
develop mathematical ideas and techniques.	Create as many instructional resources as you can.
both verbally and in writing, as well as depict mathematical ideas.	Encourage every pupil
comprehend, interpret, and assess mathematical concepts in spoken, written, and other visual formats.	provide students with feedback
Use language, mathematical notation, and their frameworks to communicate ideas and highlight connections between different mathematical ideas.	integrating all indicators to produce a sound idea

Responses to the test were examined for signs of mathematical communication abilities. Data reduction, data presentation, and conclusion drawing are tasks in data analysis. To make conclusions and adapt them to the research topic, this activity entails summarizing the data already collected, choosing the data thought necessary, and structuring the data. The condensed data pertains to the cognitive style of mathematical communication abilities. Additionally, the data is displayed by outlining the research findings about the capacity for mathematical communication and describing it in detail using images, descriptions, and tables. The final stage of analysis is about to end. The initial findings are still preliminary and subject to change at any time. Idea validation comes next. triangulation-based verification exam. The task at this point is to combine the data as a comparison or measurement to assess the data's validity (Sugiyono, 2015). Additionally, data analysis is based on assessments of mathematical communication and reinforcement via in-depth interviews.

RESULTS AND DISCUSSION

A cognitive style questionnaire is administered to all participants in the study who are students. The cognitive style is used to arrange this questionnaire. Three of the 30 students that completed the cognitive style questionnaire fell into the low group, four into the medium category, and 23 into the high category. For the cognitive style category, two respondents from each group were collected. The mathematical communication process was examined using indicators based on the respondents' responses. In the low category, formulating mathematical ideas and techniques comes first in the writing. be able to comprehend mathematical propositions and their refutation. Respondents in the interviews stated that they are accustomed to putting down knowledge that stimulates problem-solving and does not rehash reading questions. As a result, it demonstrates some aspects of developing mathematical concepts and techniques. The subject put down their explanations for the statements and denials in response to the statement and denial questions. The written requirements include a mathematical logic requirement. In interviews, respondents claimed that they found it easiest to work on statement and negation questions since they were quick to recall and complete. This demonstrates how the indications create mathematical ideas and methods. The respondent demonstrates that the

assertion and the denial are the exact opposite in the following question. The approach adopted is the definition of affirmations and negations. There are no barriers in the writing of the answers, and there are no scribbles on the answers. This demonstrates that self-expression has a component. The subject did not record any additional methods utilized to demonstrate the problem from the statement and denial questions. Respondents claimed that they were unable to generate additional thoughts because they lacked relevant studies, were unsure of which ideas to employ, and read less. The indications of knowledge and mathematical terms/structure were not met by the respondents. The written responses, according to interview participants, were not changed and offered no conclusions after considering all of the questions. There is no evaluation implied by this.

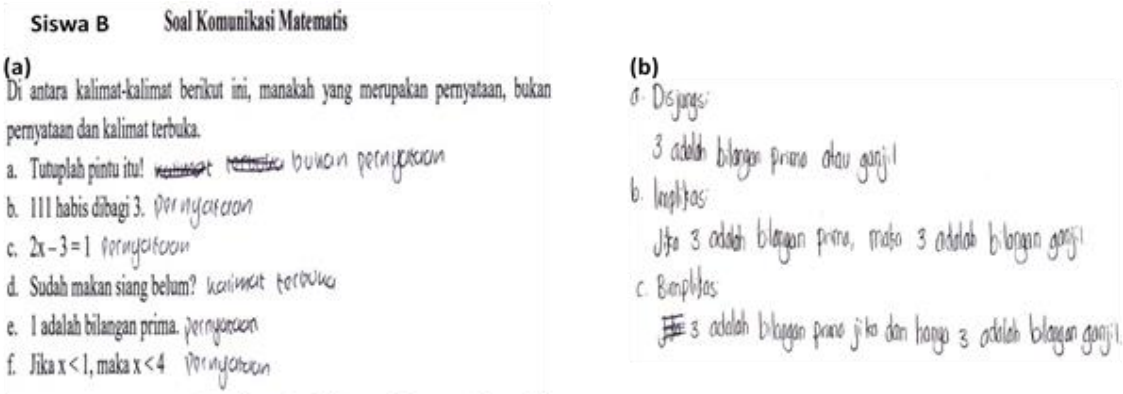


Gambar 1 : (a) Jawaban pada soal pertama, (b) Jawaban pada soal kedua

When the researcher asks the student why he does not understand what a statement, not a statement, and open sentence are, the student responds that he does not understand any of the questions that have been given. As a result, the student was unable to provide a proper response to the first question because he was unable to identify the question. When the researcher inquires as to the students' method of problem-solving, all the inquiries must be answered truthfully. However, when the researcher asked the students to explain why their solution was appropriate, they simply remained silent and grinned. Students do not yet understand the concepts of mathematical reasoning, according to this.

Students are competent enough to provide thoughtful responses to the second question when they are unable to distinguish between the questions, thus the answers are written entirely following the questions, only adding or, if then, and if and only if. The researcher inquired about the student's approach to the questions based on their responses, and the students responded that they tried to provide as many answers as they could. Whether or if the information was accurate, the most essential thing was that it was filled out. I smiled as I gave up. The pupils said that the answer was just one or two words added to get all the answers when the researcher inquired once again as to why it appeared that the solution was precisely the same as the issue.

It demonstrates that students in this instance do not comprehend how to use the properties of mathematical reasoning. The students responded that they were quite confident in their responses and knew about their talents, which could only be done up to this point when the researcher questioned how the students' attitudes were working on the problems. The students responded that there was no initiative to question friends or others because they were preoccupied with their separate jobs when the researcher inquired about it again. Additionally, it might be said that student A has a positive view of herself.

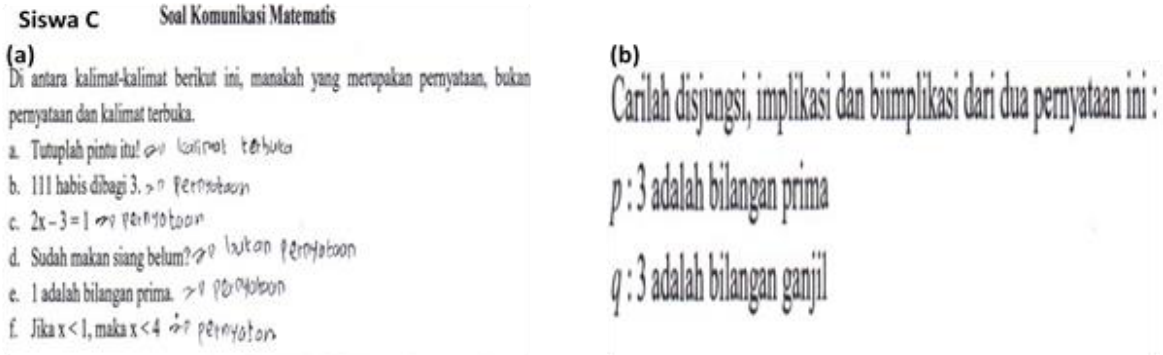


Gambar 2 : (a) Jawaban pada soal pertama, (b) Jawaban pada soal kedua

Students were unable to properly respond to the first question because they were unable to recognize the issue. However, when the researcher asks why they do not understand what a statement, a not-a-statement, and an open sentence are, the students respond in their language when they are instructed to do so. When the researcher inquired about the student's approach to the problem, the student replied that he was unfamiliar with using mathematical logic. The student also added that when the students first encountered the issue, it was similar to one they would encounter in daily life, so the questions were based on their memory of the issue. Because of this, pupils still do not understand mathematical reasoning, and the procedure involves a variety of other subject areas.

The pupils were competent enough to accurately answer the two questions, but they still had some reservations about their responses, which led to instances where the identical writing appeared in more than one sentence and had to be crossed out. The researcher inquired about the student's approach to the questions based on their responses, and the students responded, "I answered according to the questions given with the accurate answer as much as possible." The pupils said that the answer was simply one or two words added to reach the right answer when the researcher asked why it appeared that the solution was precisely the same as the query.

It demonstrates that students in this instance do not comprehend how to use the properties of mathematical reasoning. When the researcher inquired about the students' work attitudes, the students responded that they felt less secure in their responses and that some had to be crossed out since they raised problems in their minds. When the researcher re-asked if there had been any initiative to ask friends or others, the student replied in the affirmative since he did not accept the researcher's response. Thus, it might be said that student B has a poor view of himself.



Gambar 3 : (a) Jawaban pada soal pertama, (b) Jawaban pada soal kedua

Students can adequately describe the contextual issue in their response to the first question. When the researcher inquired about the kids' approach to the issue, the pupils responded in their native tongue. When the researcher questioned the students about whence such an answer originated, the pupils responded with their ideas.

The students skipped providing an answer to the second question because they were

preoccupied with the first one and ran out of time. The kids responded that it wasn't necessarily the friend who said that the answer was accurate and the time had run out even if the friend did not have time to copy when the researcher asked the students why they didn't ask their friends how to answer or the answer. With their responses, students feel better. This demonstrates that pupils respect their good self-concept.

CONCLUSION

Based on the findings and discussion above, it is clear that while the majority of students can describe contextual issues, some students struggled to express and explain their ideas about mathematical concepts and situations. This was likely due to their lack of a thorough understanding of the subject matter. Students' understanding of mathematics will affect their level of mathematical communication skills and can be influenced by cognitive style because it affects the realization of several indicators that relate to students' understanding of themselves. Some students have the understanding to connect prior knowledge to solve given contextual problems, but some students connect the material with other disciplines in the wrong way.

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