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STUDENTS' MATHEMATICAL COMMUNICATION INSTRUMENTS: A GENDER PERSPECTIVE IN MATHEMATICS LEARNING

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Abstract

Evaluating students' mathematical communication ability is crucial for understanding their ability to convey mathematical ideas logically, precisely, and in a structured manner. A good evaluation instrument is the primary tool for measuring this aspect objectively and purposefully. This research is motivated by the low mathematical literacy achievement of Indonesian students in the 2018 PISA survey, which indicates weak mathematical communication ability. This study aims to analyze students' mathematical communication ability from a gender perspective. This study used a quantitative method with a survey design. The survey type used was a cross-sectional survey design. The results showed that female students had higher average scores than male students, but the ANOVA test produced a significance value of 0.062 (> 0.05), indicating no significant difference. This finding shows that mathematical communication ability is more influenced by individual factors. The implication is that teachers need to use adaptive learning approaches and evaluation instruments that address individual student needs.

Keywords: *instrument*, *mathematical communication ability, mathematical literacy*

1. INTRODUCTION

Mathematical communication is an essential component in mathematics learning because it allows students to convey ideas, explain solution procedures, use symbols appropriately, and represent concepts coherently and logically [1]–[4]. Based on the 2018 PISA survey, Indonesia ranked 72nd out of 77 countries in mathematical ability [5], [6]. This reflects the weak mastery of basic skills, including aspects of mathematical communication, which require special attention as a strategic issue in improving the quality of national education.

Communication is also the foundation for building scientific understanding, especially in science and mathematics learning [7]–[9]. Effective interactions between students and educators have been shown to improve in-depth conceptual understanding. Conversely, limited communication often results in difficulties in understanding the material. In addition, gender factors also influence students' communication patterns. Research by [10] shows differences in tendencies between male and female students in learning styles, communication strategies, and the expression of mathematical ideas. Therefore, studies on mathematical communication from a gender perspective are important to support a more inclusive learning process and be responsive to individual needs.

Although mathematical communication is a crucial aspect of learning, assessment instruments specifically designed to measure communication ability, particularly those that consider gender differences, are still limited. Yet, evaluation in mathematics learning cannot be separated from students' ability to communicate their mathematical ideas. Effective evaluation must meet the principles of integration, coherence, active participation, pedagogical value, and accountability [11]. In addition to measuring final results, evaluation also serves as a tool to assess the

effectiveness of the learning process as a whole, from planning to follow-up.

Previous research has shown that students still experience difficulties in solving problems that measure mathematical communication ability [12]. One cause is inaccuracy in the selection of evaluation instruments. Educators are still found to be unable to distinguish between good, poor, and unsuitable questions [13]. Furthermore, the practice of instrument quality testing by mathematics educators has also not been optimal due to various technical and non-technical obstacles (Setiyawan & Wijayanti, 2020). However, a good test instrument must be able to produce accurate and representative assessment data [14]. The ideal instrument is one that has high validity and reliability, supported by analysis of the level of difficulty and discriminatory power (Argianti & Retnawati, 2020). These four components are key elements in developing test items that can measure students' abilities accurately and objectively.

Based on these problems, this study aims to develop and implement a mathematical communication assessment instrument in mathematics learning by considering a gender perspective. This study uses a quantitative descriptive approach regarding indicators from [1], namely: (1) written communication in one's language, (2) visual representation or images, and (3) mathematical expression through symbols. The novelty of this study lies in the integration between the development of the instrument as a form of strengthening soft skills and the analysis of gender differences as an important variable in increasing the effectiveness of learning. The presence of this instrument is expected to support a fairer, adaptive evaluation process, and in accordance with the actual needs of students in the class.

2. RESEARCH METHODS

The population of this study was all students of class X MIPA at MA Pesawaran. The number of samples used was 101 students, consisting of 3 classes, namely class X MIPA 1, X MIPA 2, and X MIPA 3. The sample was selected using a cluster random sampling technique. This study used a quantitative method with a survey design Table 1. Research Procedure Flow

Instrumen Modification	:	Reviewing the existing instrument and adding, removing, or modifying items based on relevant theories and findings from the preliminary study.
Instrumen Validation	:	This stage ensures that the instrument is both valid and reliable before being used for data collection. There are two types of validity assessed: Empirical Validity, which is tested through field trials and statistical analyses (e.g., item-total correlation and construct validity testing using CFA/EFA), and Expert Validity, which is evaluated by experts who are highly competent in their respective fields."
Data Collection	:	Determining the population and research sample, distributing questionnaires, or conducting observations according to the research methodology.
Data Analisis	:	Processing and analyzing data to answer the research questions and test the hypotheses.

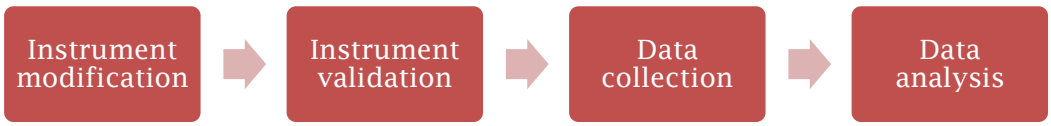


Figure 1. Research Procedures

3. RESULTS AND DISCUSSION

The test instrument was designed to evaluate the quality of the measurement tool developed by the researcher, which is expected to serve as an alternative reference in education, particularly in mathematics learning. The quality of a test instrument is determined by the quality of each item. According to [15], quantitative analysis was conducted through instrument trials on groups of students with similar characteristics to the primary target audience. Theoretical validity was tested by experts, while empirical validity was tested using Pearson's Product-Moment. Pearson's Product-Moment is a correlation index appropriate when data represent an interval or ratio scale; this index considers each pair of scores and produces a coefficient between 0.00 and 1.00 [16].

A test is considered valid if it produces accurate and relevant information to achieve specific measurement objectives. Validity is generally divided into two types: theoretical validity and empirical validity. Theoretical validity encompasses empirical validity and expert validity. Empirical validity is achieved when the instrument has been proven feasible through field trials and statistical analysis. The results of empirical validity are shown in Table 1.

Table 1. Validity Test

Item	Significance value	Information
item_1	0.134	Invalid
item_2	0.136	Invalid
item_3	0.063	Invalid
item_4	0.058	Invalid
item_5	0.147	Invalid
item_6	0.027	Valid
item_7	0.040	Valid
item_8	0.027	Valid
item_9	0.016	Valid
item_10	0.017	Valid
item_11	0.003	Valid
item_12	0.031	Valid
item_13	0.010	Valid
item_14	0.023	Valid
item_15	0.043	Valid
item_16	0.008	Valid
item_17	0.001	Valid
item_18	0.027	Valid

The results of the validity test are shown at a significance value of <0.05, so the item can be declared valid. Based on Table 1, there are 18 multiple-choice questions tested, 13 items (72%) are declared valid, while 5 items (28%) need to be revised or discarded because they do not meet the validity criteria. The instrument is generally quite suitable for use in measuring students' mathematical communication skills, but it is recommended to evaluate and correct the 5 invalid items before the instrument is used fully.

This test was conducted to determine whether the instrument was reliable. This study used Cronbach's alpha to calculate the reliability of incorrectly scored items compared to those that were incorrectly scored. Cronbach's alpha is the internal consistency coefficient or reliability for instruments that require only one test administration [16].

Table 2. Reliability Test

Item	Cronbach's Alpha if Item Deleted
item_6	0.638
item_7	0.627
item_8	0.620
item_9	0.637
item_10	0.647
item_11	0.649
item_12	0.617
item_13	0.643
item_14	0.598
item_15	0.630
item_16	0.654
item_17	0.642
item_18	0.638

In the reliability testing, items 1–5 were not included because they had been identified as invalid during the previous empirical validity testing. The reliability analysis only involved items that had met the validity criteria to ensure that the calculation of the instrument's reliability was based solely on question items that accurately measure the intended construct. The reliability test results are demonstrated by consistent Cronbach's Alpha values of 0.653 > 0.6. The validity and reliability test results can be used for further testing. A one-way ANOVA test was conducted to determine and assess differences in the test results between the three groups.

In this context, the gender factor is one of the variables analyzed through the main effect to compare the average between male and female students. The results show that females obtained higher scores, indicating a relatively better level of emotional intelligence compared to males. This finding is in line with previous literature stating that females tend to be more emotionally expressive than males [17]. Therefore, the data were classified by gender to identify significant differences in variance and support the analysis of mathematical communication ability from an affective and cognitive perspective, as seen in Figure 2.

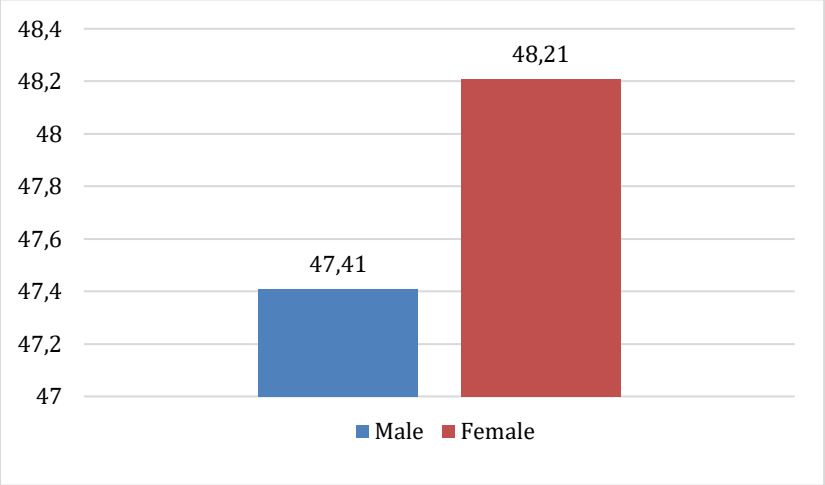


Figure 2. Average Mathematical Communication Ability

Figure 2 represents a comparison of the average mathematical communication ability between male and female students. The graph shows that female students have an average score of 48.21 and male students have an average of 47.41. This data indicates that female students tend to have better mathematical communication ability than male students. This difference can be attributed to the tendency of female students to be more active in group discussions, more verbally expressive, and more open in expressing opinions and receiving input [18], [19]

However, the statistical test results showed a significance value of 0.062 (> 0.05), which means there is no statistically significant difference between genders in determining students' mathematical communication ability. This means that although female students have a higher average score, the difference is not significant enough to conclude that there is a real effect of gender on mathematical communication ability. This finding indicates that students' mathematical communication ability is individual and not entirely influenced by gender factors.

Communication skills are an important indicator that students need to have to achieve success in their studies, where students' mathematical communication skills can organize mathematical thinking both in writing and orally [20]. This trend is in line with

previous results that stated that female students are more verbally active and more participatory in collaborative learning activities [10]. Therefore, an adaptive and inclusive learning approach is essential so that every student has an equal opportunity to develop mathematical communication ability, regardless of gender factors.

Students need to have good mathematical communication skills in learning mathematics [21]. Mathematical communication skills will be crucial in the future. Mathematics is a unique language, using tables, words, symbols, and graphs to help students develop communication skills. Students will be more effective and confident in applying mathematical knowledge if they are trained to investigate and explain problems, and to convey their results both in writing and orally, including in constructing arguments [22].

4. CONCLUSION AND SUGGESTIONS

The findings of this study reveal that neither class nor gender exerts a statistically significant influence on students' mathematical communication ability. This conclusion is supported by the results of a one-way ANOVA, which produced a significance value of 0.062 (> 0.05). indicating no significant differences between groups based on gender. This finding reinforces the view that mathematical communication ability is more influenced by students' character and potential, as well as a supportive learning environment, than by factors such as gender. Mathematical communication ability is important in the learning process because it can help students understand mathematical concepts, increase engagement in discussions, and strengthen understanding through explanations and argumentation.

However, this study has several limitations. The limited number of participants and the homogeneity of the schools may affect the representativeness of the data. Furthermore, the use of

multiple-choice test instruments did not fully capture students' mathematical communication skills comprehensively, particularly in the aspect of conveying ideas verbally and in writing.

Therefore, further research is recommended to involve more participants from schools with diverse backgrounds and to employ various test formats, including essay questions and collaborative assignments. In addition, it is important to examine the role of learning motivation, teacher teaching style, and classroom atmosphere in supporting the optimal development of students' mathematical communication ability.

REFRENCES

[1] NCTM, *Principles and Standards For School Mathematics*. Reston:VA, 2000.

[2] W. Tate, "Mathematics communication: Creating opportunities to learn," *Teach. Child. Math.*, vol. 1, no. 6, pp. 344–369, 2020, doi: 10.5951/tcm.1.6.0344.

[3] D. Hardianti *et al.*, "Analysis of mathematical communication instruments on the material of flat side space," *5Th Int. Conf. Innov. Des. Anal. Dev. Pract. Aerosp. Automot. Eng. I-Dad'22*, vol. 2766, no. October 2021, p. 020045, 2023, doi: 10.1063/5.0141522.

[4] F. Lestari; *et al.*, "Mathematical communication in blended learning," *AIP Conf. Proc.*, vol. 3142, no. 1, pp. 020064-1–0200647, 2025, doi: https://doi.org/10.1063/5.0262599.

[5] O.E.C.D., "PISA 2018 results." 2019.

[6] M. H. Setiawan *et al.*, "Kemampuan Numerasi Siswa Menyelesaikan Soal Hots Pada Materi Posisi Garis Terhadap Lingkaran," *Hipotenusa J. Res. Math. Educ.*, vol. 6, no. 2, 2023.

[7] R. Dumila and D. Hardianti, "Peningkatan Kemampuan Komunikasi Matematis Siswa Dalam Menggunakan Video Pembelajaran," *Hipotenusa*, vol. 4, no. 2, pp. 87–101, 2021.

[8] P. Y. Lafiani, I. Bony, and O. Elfa, "Kemampuan komunikasi

sains siswa dalam mendiskusikan hasil kegiatan suatu masalah atau peristiwa pada pembelajaran biologi di SMA Negeri 3 Tanjungpinang," *Student Online J.*, vol. 3, no. 1, pp. 547–552, 2022.

[9] I. Rusydi, L. Masruroh, and M. K. Azzaen, "Pengaruh bimbingan kelompok terhadap peningkatan keterampilan komunikasi interpersonal siswa kelas VIII di SMP Negeri 2 Indramayu tahun ajaran 2021/2022," *Islam. Guid. Couns. Journals*, vol. 3, no. 2, pp. 41–51, 2022.

[10] Kamid, "Mathematical communication skills based on cognitive styles and gender," *Int. J. Eval. Res. Educ.*, vol. 9, no. 4, pp. 847–856, 2020, doi: 10.11591/ijere.v9i4.20497.

[11] K. Nurohmah, L. R. Nurjamin, and A. Hamzah, "Navigating the merdeka curriculum: english transformational teachers' challenges with project-based learning," *English Educ. Appl. Linguist. J.*, vol. 7, no. 2, pp. 68–78, 2024, doi: 10.31980/eeal.v7i2.1761.

[12] T. Wahyudi, Noerhasmalina, D. Desmayanasari, and F. Lestari, "Collaborative Learning on Mathematical Critical Thinking Skills," *Hipotenusa J. Res. Math. Educ.*, vol. 5, no. 1, pp. 32–45, 2022.

[13] S. N. Maulidah *et al.*, "Analisis Peran Guru dalam Pembelajaran Abad 21 pada Siswa Sekolah Dasar di Kurikulum Merdeka," *Pop. J. Penelit. Mhs.*, vol. 3, no. 2, pp. 31–42, 2024, doi: 10.58192/populer.v3i2.2116.

[14] D. Desmayanasari, D. Hardianti, F. Lestari, T. Agnesa, and P. S. Balkist, "Designing mathematical creative thinking skill instrument," *YOUNG Sch. Symp. Sci. Math. Educ. Environ.*, vol. 2595, no. 1, p. 060008, 2023, [Online]. Available: https://pubs.aip.org/aip/acp/article-abstract/2595/1/060008/2890699/Designing-mathematical-

creative-thinking-skill.

[15] D. Kartika, Sriyono, and N. Ngazizah, "Pengembangan instrumen untuk mengukur kemampuan komunikasi sains siswa SMA," *Radiasi*, vol. 8, no. 1, pp. 28–32, 2016.

[16] J. R. Fraenkel, N. E. Wallen, and H. H. Hyun, *How to Design and Evaluate Research in Education*, 8th ed. New York: McGraw-Hill, 2012.

[17] S. Baron-Cohen, *The Essential Difference: Men, Women and the Extreme Men Brain*. Londra: Allen Lane, 2003.

[18] H. Hariyanto, S. Yamtinah, S. Sukarmin, S. Saputro, and L. Mahardiani, "The analysis of student's verbal communication skills by gender in the middle school in South Tangerang," *Int. Conf. Sci. Appl. Sci. [Conference]. AIP Conf. Proc*, vol. 2202, no. 1, p. 20064, 2019, doi: 10.1063/1.5141677.

[19] A. Qazi *et al.*, "Gender diferences in information and communication technology use & skills: a systematic review and meta-analysis," *Educ. Inf. Technol.*, vol. 27, no. 3, pp. 4225–4258, 2022, doi: 10.1007/s10639-021-10775-x.

[20] P. Muhtarom, A. D., and Y. H. Murtianto, "Profile of prospective teachers' mathematical communication ability reviewed from adversity quotient," *J. Math. Educ.*, vol. 10, no. 1, pp. 93–108, 2021, doi: 10.22460/infinity.v10i1.p93-108.

[21] Y. D. Kristiani, D. Juandi, and R. I. I. Putri, "Students' mathematical communication skills on straight-line equation using PMRI and collaborative learning," *J. Pendidik. Mat.*, vol. 18, no. 2, pp. 163–180, 2024, doi: 10.22342/jpm.v18i2.pp163-180.

[22] D. H. Tong, B. P. Uyen, and N. V. A. Quoc, "The improvement of 10th students' mathematical communication skills through learning ellipse topics," *Heliyon*, vol. 7, no. 11, 2021.