

Mathematical Communication Ability of Prospective Teacher Students Seen from Initial Mathematical Ability Through *Maple*-Assisted *E-Learning*

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Abstract

Mathematical communication ability are a crucial standard in mathematics learning for prospective teachers. However, preliminary studies indicate that most student teachers still experience difficulty expressing mathematical ideas verbally, in writing, or visually. This study aims to analyze the effect of e-learning-based instruction using the Maple application on the Mathematical communication ability of student teachers, based on their Initial Mathematical Ability (IMA). The research method used was a quasi-experimental one-group pretest-posttest design. The sample consisted of 61 third-semester Mathematics Education students from the Faculty of Teacher Training and Education, Pasundan University, divided into three categories of IMA (high, medium, and low). The research instrument was a Mathematical communication ability test, and data analysis used the Wilcoxon, Kruskal-Wallis, and Mann-Whitney tests. The results showed a significant difference in students' Mathematical communication ability before and after learning through Maple-assisted e-learning. Overall, students' communication skills improved after the treatment compared to before. According to the IMA, there was a significant difference in communication ability between the high and low-achieving groups, as well as the medium and low-achieving groups, while the difference between the high and medium groups was not significant. Therefore, the use of symbolic computation applications such as Maple is worth considering as an alternative learning innovation to facilitate pre-service teachers in developing better mathematical communication ability.

Keywords: mathematical communication, e-learning, Maple, initial mathematical ability

1. Introduction

Mathematical communication ability were added by NCTM as one of the process standards in mathematics learning that received special attention. Mathematical communication ability is also one of the essential competencies that students and learners must possess in mathematics education. The National Council of Teachers of Mathematics (NCTM, 2000) affirms that mathematical communication not only helps learner's express ideas, thoughts, and reasoning, but also serves to build deeper conceptual understanding. Through communication, participants educate can explain settlement problem, giving argument logical, and interpret mathematical ideas Good in a way oral, written, and visual

The low level of mathematical communication ability is also consistent with previous research findings. Research conducted by Utami & Warmi (2021) shows that part big student difficulty in compiling mathematical representation in written form and symbol, as well as not enough capable explain solution with coherent language. Meanwhile that, research by Wahyudin (2019) found that students still tend to be passive when asked to explain their mathematical thinking process, and this impacts their critical thinking and problem-solving skills.

In addition, research relevant by Rani & Nugraha (2020) also revealed that low communication mathematical is affected by the lack of the opportunity given to lecturer /teacher for discuss, ask questions, and present mathematical ideas in class. In fact, mathematical skills communication is one of the important aspects in form prospective professional teachers, because they later must capably convey draft mathematics to students in a clear and effective way.

With thus, the low mathematical communication ability student prospective teachers are problems that need to be addressed and get attention serious. This is important Because communication Not only support achievement competence mathematics, but also contributes to improvement quality learning, development skills 21st century, as well as readiness student in face challenge profession in the future. Jihad (2008, p. 168) revealed that indicators of Mathematical communication ability include students' abilities: (1) Connecting real objects, images, and diagrams into mathematical ideas; (2) Explaining mathematical ideas, situations, and relationships orally or in writing with real objects, images, graphs, and algebra; (3) Expressing everyday events in mathematical language or symbols; (4) Listening, discussing, and writing about mathematics; (5) Reading with understanding or written mathematical presentations; (6) Making conjectures, constructing arguments, formulating definitions and generalizations; (7) Explaining and asking questions about the mathematics that has been studied. In making the instrument, the seven indicators can be described in writing (written texts) through drawings and mathematical expressions. To measure all aspects of mathematical communication better, learning innovations are needed that can improve Mathematical communication ability through appropriate strategies, models, and learning media.

Data submitted by the Director General of Teachers and Education Personnel (GTK) as reported in the Daily "Pikiran Rakyat" (23 May 2016) states that , " Based on the results of the Teacher Competency Test (UKG) conducted at the end of 2015, the average score was 53.02, out of the Ministry of Education and Culture's target of 55. The competencies tested were Professional and Pedagogical competencies. Based on these data, improvements are still needed from the teacher side in Indonesia as a whole . "

One of the goals to be achieved in mathematics learning in general and in FKIP Unpas in particular is to provide the widest possible opportunities and chances to prospective mathematics teacher students to improve, develop and integrate their communication skills both orally and in writing; *speaking or talking* in using ideas, outlook and experience; *writing* in modeling in the form of mathematical expressions , *drawing* in modeling mathematics in the form of images, and presenting what has been learned. This is in line with the opinion of Tong (2021), " design learning that emphasizes activity representation (writing , drawing , diagram, reading) graphs) and discussion mathematical can increase ability student in communicating mathematical ideas Good in a way written both visual and visual."

Researchers as teachers of calculus courses found the fact that students who study calculus said that the course is a difficult course , requires a high level of reasoning, is difficult to understand, and is difficult to communicate because calculus material is material that contains deep concepts.

In reality, calculus, which includes Limits, Differentials, and Integrals, is essential and serves as a prerequisite for several subsequent courses, such as Linear Algebra, Vector Analysis, Real Analysis, Mathematical Statistics, Differential Equations, and perhaps several other courses from other study program curricula. Therefore, efforts are needed to ensure that calculus scores increase annually and satisfy both students, lecturers, and related institutions.

The results of Rahmawati's research (2025) on the integral calculus course which is a basic course, which includes basic knowledge and operations of numbers and symbols, as well as function graphs to find the area under the curve or the volume of rotating objects. However, most students still get less results in the course according to the integral calculus grade data in the previous year, namely that 37.5% got an A, 25% got a B, 18.75% got a C and 12.5% got an E.

However, the reality shows that students' mathematical communication ability is still classified as low. Based on studies introduction conducted on students prospective teachers in one of the college high in Bandung, data obtained that only around 26.8% of students capable understand, interpret, and evaluate mathematical ideas both verbally and in other visual forms (Written texts,) , 7.7% capable students express mathematical ideas orally, in writing, and demonstrate them and describe them visually (drawing), and 20.3% of students were able to use mathematical terms, notations and structures to present ideas, describe relationships and situation models (Mathematical expression) .

In a pandemic situation, the competencies that are prioritized and must be pursued, in addition to mathematical calculation skills, are also the ability to keep up with ICT developments. Anggraena (2021) stated, "Based on the PISA 2021 framework, mathematical literacy, which initially focused on basic calculation skills, must be redefined to take into account rapid technological advances."

In line with the development of innovation in the field of technology, learning through computers can be accessed via the internet. The use of *e-learning* is one of the competencies of educators in implementing ICT , and as an effort to overcome technical problems in learning (learning media), as well as an effort to answer substantial problems in learning

(teaching resources). In the learning process, it is possible for students to develop themselves to be able to learn independently without the limitations of distance and time so that they can grow and develop independence after learning repeatedly through *e-learning*, both cognitive and affective competencies and the growth of creativity of educational *stakeholders*.

We often face complex and lengthy computations in searching for mathematical solutions conventionally, one ultimately lacks the time to analyze or interpret the solutions obtained. This Maple application is capable of performing mathematical computations easily and quickly without requiring mastery of a specific computer programming language.

Maple is a Computer Algebra System (CAS)-based mathematics software capable of performing symbolic and numerical calculations, as well as visualizing mathematical concepts in graphical and animated forms (Monagan et al., 2015). Through Maple, students can model problems, explore solution steps, and present results with clear visualizations. This can strengthen mathematical communication.

This study was conducted with the aim of analyzing students' Mathematical communication ability and learning independence. The specific objectives are as follows: (1) To analyze the differences in Mathematical communication ability of prospective mathematics teachers before and after receiving instruction through Maple-assisted e-learning; (2) To analyze the Mathematical communication ability of prospective mathematics teachers who receive Maple-assisted e-learning based on Initial Mathematical Ability (IMA: high, medium, low).

Based on the above explanation, systematic research and efforts are needed to improve the skills of prospective mathematics teachers in higher education, enhancing students' communication skills, thus gradually improving their students' mathematical abilities in the future. In connection with the national implementation of the Merdeka Belajar Kampus Merdeka curriculum, which encourages the use of ICT, research on the impact of *Maple* -assisted *e-learning* on communication skills needs to be conducted immediately and continuously.

2. Methodology

The researcher used an experimental research method in this study. According to Sugiyono (2017, pp. 11-12) "The experimental research method is a research method used to find the effect of a particular *treatment* or treatment." In this study, the experiment used was a quasi-experimental type, namely "research that approaches a real experiment where it is impossible to control or manipulate all relevant variables. The reason for using this quasi-experimental method is because in reality the circumstances or situations do not allow the use of a control class in this study. Because of this situation, the researcher chose a quasi-experiment, namely using only one class.

The research design used is *One-Group-Pretest-Posttest* Arikunto (2010, p. 124) said that, "*one group pretest-posttest design* is a research activity that provides an initial test (*pretest*) before being given treatment, after being given treatment, then giving a final test (*posttest*)". All subjects were given a *pretest* (O1). Next, they were given treatment: treatment X is *Maple* -assisted *e-learning*. After completing the learning process, each group was given a *posttest* (O2).

To see more deeply the influence of the use of *Maple* -assisted *e-learning* on the Mathematical communication ability and *self-regulated learning* of prospective mathematics teachers, this study involved students' initial mathematical abilities (high, medium and low) using the Weiner Model.

The population in this study was all students of the Mathematics Education Study Program, Faculty of Teacher Training and Education, Pasundan University (Unpas) in Bandung City, West Java Province. The researcher took two classes as samples in this study, namely Class A and B, from the same level, namely semester 3. However, both classes were given the same treatment, so there was no control class.

3. Research Results

Analysis of Mathematical Communication Ability

The analysis carried out was a comparative test of the Mathematical communication ability of prospective teacher students before and after being given e-learning treatment assisted by the Maple application, because the data was not normally distributed, so the parametric statistical test analysis used was the Wilcoxon Test.

Table 1. *Wilcoxon Test of Pretest-Posttest Data of Mathematical Communication Ability*

Test Statistics ^a	
Communication Pretest - Communication Posttest	
Z	-6.808 ^b
Asymp. Sig. (2-tailed)	.000

Wilcoxon Test analysis, the significance value = $0.000 < 0.05$ so that H_a is accepted, namely there is a significant difference between the Mathematical communication ability of prospective teacher students before and after being given learning with e-learning assisted by the maple application. In this case, the Mathematical communication ability of prospective teacher students after receiving learning with e-learning assisted by the maple application better than before

receiving the learning. The next analysis then compared the three groups: high, average, and poor. Because the data were not normally distributed, the next analysis used non-parametric statistics, namely the Kruskal-Wallis test.

Table 2. Kruskal-Wallis analysis One Path Posttest Ability Data Mathematical Communication Based on IMA

		Ranks	
	THURSDAY	N	Mean Rank
Post-Communication	Tall	12	38.63
	Currently	37	32.00
	Low	12	20.29
	Total	61	
Test Statistics a,b			
		Communication Skills	
Chi-Square		7,188	
Df		2	
Asymp. Sig.		.027	
a. Kruskal Wallis Test			
b. Grouping Variable: IMA			

Based on the one-way ANOVA analysis, the significance value = $0.027 < 0.05$ so that H_a is accepted, namely there is a significant difference in Mathematical communication ability between the high, average, and low groups of prospective teacher students who received learning with e-learning assisted by the Maple application. To determine the comparison between the two groups, a two-way ANOVA analysis was conducted. The following are the results of the two-way ANOVA analysis.

Table 3. Mann Whitney Analysis of Comparison of Posttest Data of Mathematical Communication Ability Based on IMA (Excellent-Average)

		Ranks		
	THURSDAY	N	Mean Rank	Sum of Ranks
Posttest	High	12	29.17	350.00
	Currently	37	23.65	875.00
	Total	49		
Test Statistics a				
				Posttest
Mann-Whitney University				172,000
Wilcoxon W				875,000
Z				-1.215
Asymp. Sig. (2-tailed)				.224
a. Grouping Variable: IMA				

The sig value = 0.334 is greater than 0.05. This means that H_a is rejected and H_0 is accepted, so there is no significant difference in Mathematical communication ability between students in the high and average groups. The mean rank of the high group is greater than the average group, but it is not significant and only applies to students in that cohort.

Table 4. Mann Whitney Analysis of Posttest Data Comparison of Mathematical Communication Ability Based on IMA (High-Low)

		Ranks		
	THURSDAY	N	Mean Rank	Sum of Ranks
Posttest	High	12	15.96	191.50
	Low	12	9.04	108.50
	Total	24		

Test Statistics ^b		Posttest
Mann-Whitney University		30,500
Wilcoxon W		108,500
Z		-2,449
Asymp. Sig. (2-tailed)		.014
Exact Sig. [2*(1-tailed Sig.)]		.014 ^a
a. Not corrected for ties.		
b. Grouping Variable: IMA		

The sig value = 0.014 is less than 0.05. This means that H₀ is rejected and H_a is accepted, so there is a significant difference in Mathematical communication ability between students in the high group and the low group. *The mean rank* of the high group > low group, meaning that the Mathematical communication ability of the high group are better than those of the low group.

Table 5. Mann Whitney Analysis of Posttest Data Comparison of Mathematical Communication Ability Based on IMA (Medium-Low)

		Ranks		
	THURSDAY	N	Mean Rank	Sum of Ranks
Posttest	Currently	37	27.35	1012.00
	Low	12	17.75	213.00
	Total	49		

Test Statistics ^a		Posttest
Mann-Whitney University		135,000
Wilcoxon W		213,000
Z		-2.111
Asymp. Sig. (2-tailed)		.035
a. Grouping Variable: IMA		

The sig value = 0.035 is less than 0.05. This means that H₀ is rejected and H_a is accepted, so there is a significant difference in Mathematical communication ability between students in the medium group and the low group. The mean rank of the medium group > low group, meaning that the Mathematical communication ability of the medium group are better than the low group.

4. Discussion

Students' Mathematical communication ability

Based on the analysis of communication ability, it can be concluded that there is a significant difference in the Mathematical communication ability of prospective teachers before and after learning with Maple-assisted e-learning. In case This mathematical communication ability student prospective teachers after get learning with e-learning assisted Maple application better than before get learning This explains that students who receive learning with e-learning assisted Maple application can help students in achieving ability communication better mathematical skills after learning takes place , this can be seen from results students' work in answering test questions mathematical communication ability. The following is an example of a mathematical communication problem.

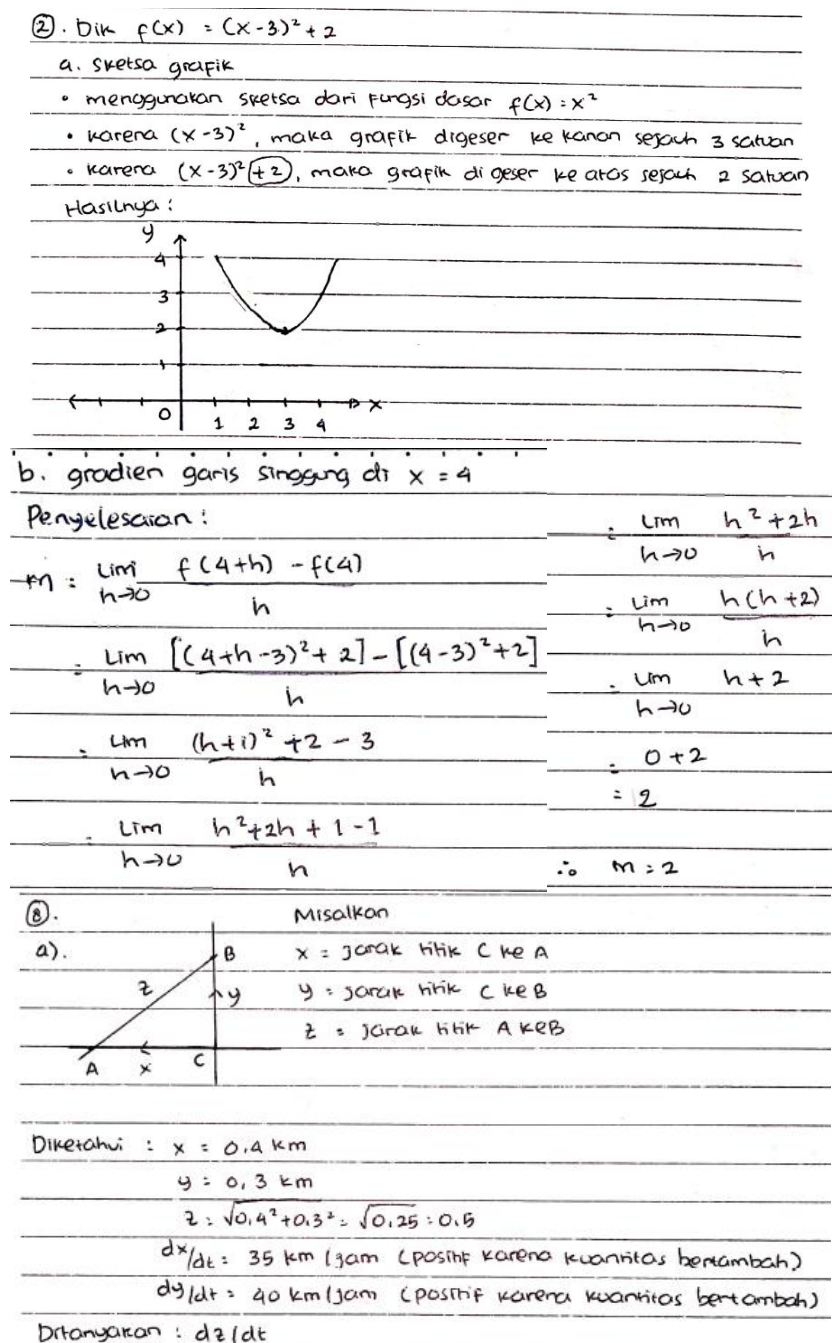


Figure 1. Problem Solving Posttest Communication Mathematical Drawing (top), Written Text (middle), Mathematical Expression (down)

On this question, during the pretest, some students were unable to answer it. Answer the question, including by the student concerned who is in the picture This indicates that before the learning treatment, students had difficulty writing down ideas, expressing mathematical concepts, and drawing solutions—showing poor communication ability. However, after being given learning treatment, students were able to answer the question well, correctly, even right. Like the example image completion of one of the students. This indicates after the learning treatment, students were able to write down their ideas, express mathematical concepts, and create drawings. This indicates that students had better communication skills compared to before the learning treatment.

Then if you look at it from Initial Mathematics Ability (IMA), available significant difference mathematical communication ability between student prospective group teachers high, medium, and poor who obtained learning with e-learning assisted Maple application. From the results analyst comparison between the two groups obtained results namely: (1) No there is significant difference mathematical communication ability between student group high and group medium. Mean rank group high > group medium, only just No significant and only valid for student force That only; (2) There are significant difference mathematical communication ability between student group high and low groups. Mean rank group high > low group, meaning mathematical communication ability group high better than low group; (3) There are significant difference mathematical communication ability between student group medium and low groups. Mean

rank group medium > low group, meaning mathematical communication ability group currently better than low group. This is in accordance with Azmi's research (2017) which stated that, "the average test end ability communication for high, medium and low groups respectively of 12.36, 9.57, and 7.75, which means that the mathematical communication ability high group is greater than the low group and the medium group is bigger than the low group".

Student activities to Learning assisted e-learning Maple application

In online learning, there are competencies that must be improved, namely competence use of ICT, so that impact on quality good education. Based on the results of a student questionnaire on online learning conducted by Hamdani (2020), one of them the questionnaire statement reads, "Content The lectures I received were varied, such as text, animation, sound, video, motion graphics, infographics, and others." From this statement, only 6.9% of students answered strongly agree. This means to answer the student's hopes, the researcher try providing learning with e-learning assistance from the Maple application, because from the maple application there is animation mathematical like movement The formation of motion graphics and other calculations that make it more interesting. The following is an example of using Maple to create graphs during learning.

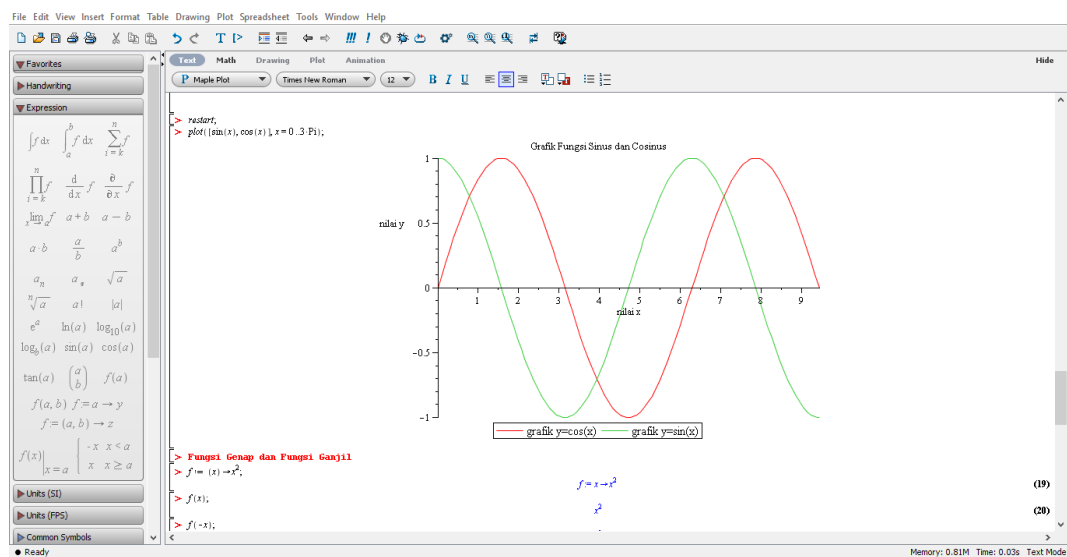


Figure 2. Display Using Maple in Creating Graphics

Besides generating visual outputs as shown in the figure, Maple is also capable of validating student answers—something that was previously done manually. This is one example of Maple's computational process.

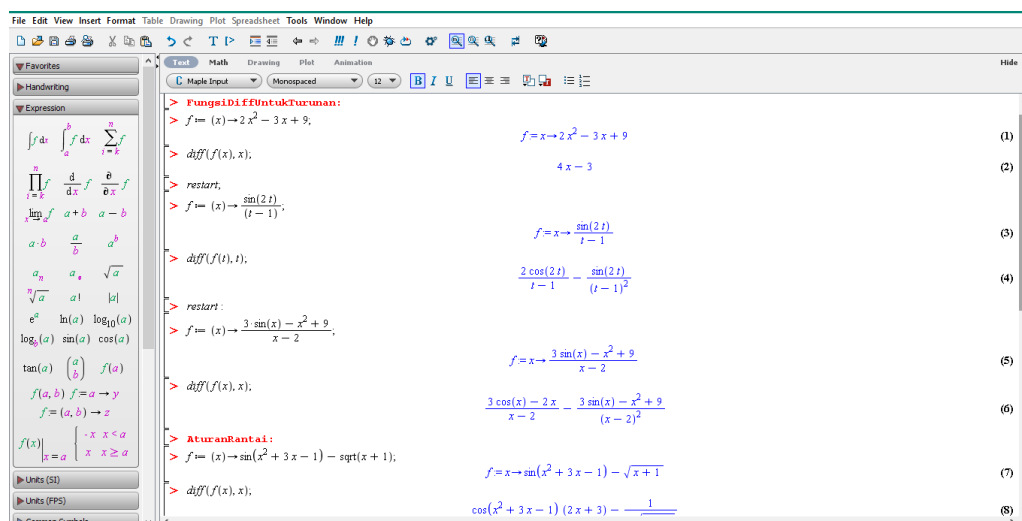
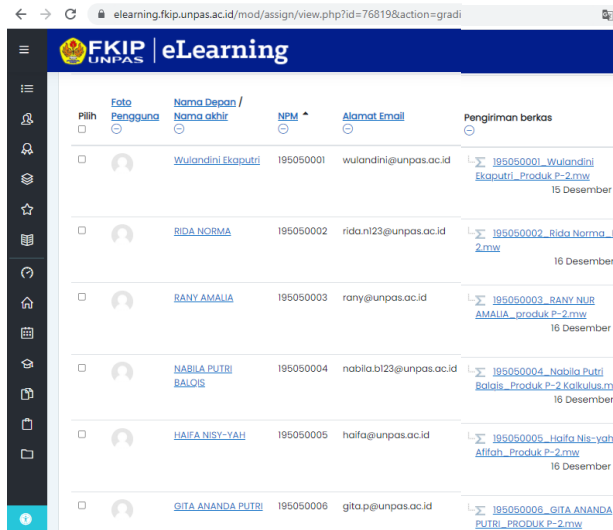


Figure 3. Display Use of Maple in Solving Problems Differential Calculus

Based on observations, student activities in Maple-assisted e-learning showed that this approach created conditions where students learned more actively. According to Sriyono (Gumiarti, 2014) that, "one of methods For increase quality education is with activate student in learning. During learning seen student activities in Study high, so that they Want to Work hard in finish assigned tasks, though Not yet reach maximum results. Lestari, Jupri, & Nurlaelah (2024) in a systematic literature review showed that ICT plays a significant role in enhancing interaction and communication in

mathematics learning. Darmanova et al. (2025) emphasized that the use of CAS such as Maple improves mathematical visualization and communication skills. Opesemowo (2025) highlighted that AI-based applications and CAS (Maple Calculator, Microsoft Math Solver, etc.) provide significant opportunities for students to develop mathematical communication. Thus, the use of digital technology and CAS not only serves to accelerate calculations but also creates a more collaborative and creative learning space. Students can explore various mathematical representations both visually and symbolically, so that their communication skills develop more comprehensively and contextually according to the needs of the 21st century. The following is an example of a student who has completed an assignment with Maple and uploaded it to e- learning.



Pilih	Foto Pengguna	Nama Depan / Nama akhir	NPM	Alamat Email	Pengiriman berkas
☐		Wulandini Ekaputri	195050001	wulandini@unpas.ac.id	195050001_Wulandini Ekaputri_Produk P-2.mw 15 Desember
☐		RIDA NORMA	195050002	rida.n123@unpas.ac.id	195050002_Rida Norma_f 2.mw 16 Desember
☐		BANY AMALIA	195050003	ramy@unpas.ac.id	195050003_BANY NUR AMALIA_Produk P-2.mw 16 Desember
☐		NABILA PUTRI BALOG	195050004	nabila.b123@unpas.ac.id	195050004_Nabila Putri Balog_Produk P-2 Kalkulus.m 16 Desember
☐		HAIFA NISY-YAH	195050005	haifa@unpas.ac.id	195050005_Haifa Nis-yah Affah_Produk P-2.mw 16 Desember
☐		GITA ANANDA PUTRI	195050006	gita.pg@unpas.ac.id	195050006_GITA ANANDA PUTRI_PRODUK P-2.mw 16 Desember

Figure 4. Maple Assignment Collection Display in e- learning

In learning with the Maple application, all students were enthusiastic. They listened attentively to the lecturer and were actively involved in the practicum. Many participated from beginning to end because they did not want to be left behind. Some students who were usually passive became active, frequently asking questions and trying additional calculations. Here is an example of a catch screen from learning with the Maple application.

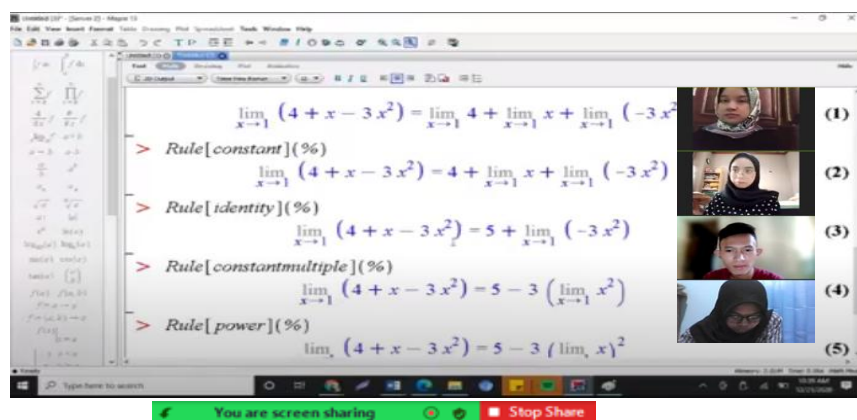


Figure 5. Maple Application Learning View

Juandi et al. (2025) demonstrated that learning mathematics with interactive software (including Maple) makes students more active and improves learning outcomes. Setialaksana et al. (2025) emphasized that e-learning support can reduce math anxiety and improve students' performance in mathematical communication. These findings demonstrate that learning technology functions not only as an aid but also as a psychological factor that can foster students' confidence in understanding and conveying mathematical concepts. With an interactive learning environment free from excessive pressure, students are encouraged to participate more actively, discuss, and express their mathematical ideas more clearly.

4. Conclusion

Based on results data processing and findings obtained in study This obtained a number of conclusions as following: (1) There is difference mathematical communication ability student prospective mathematics teacher before and after get learning through *e-learning* assisted *maple*. The mathematical communication ability of prospective teachers after learning with Maple-assisted e-learning was significantly better than before the treatment; (2) There is difference

mathematical communication ability student prospective mathematics teachers who obtained learning through *e-learning* assisted *maple* between students high, medium, and low. Group high > group medium, only just No significant and only valid for student force That only. Group high > low group significantly, and medium group > low group significantly.

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