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Ability to Construct Geogebra-Assisted Proofs in View of Gender Differences

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ABSTRACT

Kemampuan mahasiswa Pendidikan Matematika di Unimor untuk membuktikan pernyataan matematika relatif rendah. Kemampuan mengkonstruksi bukti dalam pembelajaran konsep limit fungsi sangat penting untuk materi kalkulus lanjut. Tujuan penelitian ini untuk menganalisis kemampuan mahasiswa laki-laki dan perempuan dalam menyusun bukti setelah diajarkan menggunakan GeoGebra sebagai media pembelajaran. Kesimpulan penelitian menunjukkan bahwa mahasiswa perempuan memiliki kemampuan menyusun bukti yang lebih unggul dari mahasiswa laki-laki. Mahasiswa perempuan unggul dalam mengorganisasi fakta, memanipulasi fakta, dan mengurutkan langkah-langkah pembuktian.

The ability of Mathematics Education students at Unimor to prove mathematical statements is relatively low. The ability to construct proofs in learning the concept of function limits is very important for advanced calculus material. The purpose of this study is to analyze the ability of male and female students in constructing proofs after being taught using GeoGebra as a learning medium. The research findings show that female students have superior proof construction abilities compared to male students. Female students excel in organizing facts, manipulating facts, and sequencing proof steps.

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INTRODUCTION

The ability to compile mathematical evidence is one of the important that must be possessed by students, especially those who study in the fields of mathematics and scienceabilities (Frentika et al., 2020). In mathematics, mathematical proof not only serves to ensure the truth of a statement, but als becomes the basis for building a logical and systematic thinking structure (Susanto, 2011). By understanding and being able to construct proofs, students can develop critical thinking, analytical, an reasoning skills that are essential in solving various complex problems (Septiati, 2021a). Evidence i mathematics is a logical argument used to prove the truth of a mathematical statement by referring t previously recognized principles, axioms, or theorems (Santosa, 2013). Mathematical proof aims to ensure that a statement is universally true and free from ambiguity, by following strict logical reasonin rules (Dewi & Dasari, 2023). Logical means ensuring that each step in an argument or proof can be accounted for and follows valid reasoning patterns (Suhendri, 2011). Mathematical proof ability includes skills in compiling evidence and verifying the truth of the evidence (Sundawan, 2018).

In the academic world, mathematical proof is the main tool to connect theory and application (Suandito, 2017). Students often face situations where they not only need to understand concepts,

but also need to be able to formally explain the reasons behind the applicability of a concept through the proof process. This strengthens the understanding of concepts in depth, so that students do not just memorize formulas or procedures, but really understand the logical basis of the material studied.

Based on the author's observations when teaching the concept of function limit, the ability of students of the Mathematics Education Study Program at Timor University to construct mathematical proofs is still relatively low. This is shown in the work of students who do not use the definition of limit in proving the limit value of a function. Students use standardized formulas, are fooled by previous learning experiences by calculating limits with theorems about limits, many students have difficulty understanding basic logic, choosing the right method of proof, or compiling valid mathematical arguments. This challenge is often due to the lack of emphasis on proof-based learning at the high school level, so students are not familiar with this process when they enter college. In addition, the low ability to construct proofs is characterized by the average ability of students in the ability to construct proofs of limit functions being 34 out of a range of 0 to 100.

The ability to construct mathematical proofs is also important to equip students with relevant skills in the modern era. In fields such as information technology, data science or artificial intelligence, evidence-based arguments are often required to ensure the reliability of the models or algorithms developed. Thus, learning that focuses on developing these abilities not only strengthens students' mathematical understanding, but also prepares them to contribute significantly in future professional fields.

The ability to construct evidence allows a person to design, compile, and convey valid and logical mathematical arguments to prove the truth of a statement or theorem (A'idah, 2022). This ability includes a number of important aspects related to logic, concept understanding, and skills in organizing ideas systematically to build valid evidence. The aspects in the ability to construct evidence are Understanding Mathematical Concepts, Logical and Deductive Reasoning, Choosing the Right Proof Method, Creativity in Arranging Proof Steps, Using Appropriate Mathematical Tools and Techniques, Ability to Check and Critique Evidence.

The process of constructing evidence begins with determining the statement to be proven, namely understanding the statement or theorem to be proven. This statement must be clear and unequivocal, Gathering Information Known axioms, definitions, or existing theorems that are relevant for the proof, Choosing a Proof Strategy in the form of determining the proof method to be used based on the characteristics of the statement (Suwanti & Fayeldi, 2018). This method can be direct proof, induction, or contradiction, depending on the situation, Developing logical Proof Steps to reach the desired conclusion. Each step should be based on valid mathematical principles, such as previous definitions, axioms, or theorems, Conclude and State the Proof, Verification and Refinement to ensure that each step is correct. If there are errors, the proof needs to be corrected or modified.

According to Septiati (2022) the ability to compile mathematical evidence can be assessed based on several indicators, namely: 1) identify information contained in a statement, 2) determine the conclusions that can be drawn from the statement, 3) show the relationship between data and between data and conclusions through an explanation, 4) propose hypotheses related to the concepts basic that connect data with conclusions (conjecture), and 5) critically evaluate the rules for drawing conclusions based on facts available or obtained (inference)method.

Standard methods of proof in mathematics include proof direct and indirect proof and proof using mathematical induction. This process is based on two main principles: (1) the system of axioms and premises used must be clearly stated, and (2) all steps of the proof need to include deductive explanations. Based on the perspective of cognitive development, there are four stages of proof representation: checking the validity of arguments using aids or props (enactive proofvisual proo*f*), verifying the truth through visualization such as tables or graphs or images (visual proof), testing by manipulating algebraic symbols (symbolic proof), and compiling standard proofs involving deductive reasoning (formal proof)) (Listiyaningsih, 2022). This shows that before getting to the stage symbolic proof learning media is needed at the stagesenactive proof and visual proof.

Learning media includes various tools, materials, or sources that are used to convey information, communicate messages, or facilitate the learning process between teachers and students (Harsiwi & Arini, 2020). This media helps students acquire and understand knowledge in an easier, more interesting,

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and effective way. Learning media can be physical (such as books, whiteboards, or props), digital (such as software or learning applications), or even social (such as group discussions or project-based learning).

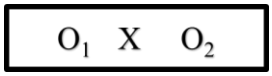
Functions of Learning Media (Hasan et al., 2021) including 1) Facilitate Understanding: Media helps simplify complex information and make it easier to understand, especially if it involves abstract concepts, 2) Increase Student Interest and Motivation: media Good and diverse can attract students' attention and increase their motivation to learn, 3) Increase Interactivity: By using interactive media, such as software or apps, students can be more actively involved in the learning process, 4) Support Experiential Learning: Media such as simulations or experimental videos allow students to learn through hands-on experience, 5) Facilitate Distance Learning: Technology-based learning media allows students to learn outside the classroom, anytime and anywhere.

Types of Learning Media (Fendiyanto et al., 2023) consists of 1) Visual Media: Media that rely on images, graphics, or videos to convey information. Examples: pictures, maps, diagrams, movies, animations, 2) Auditory Media: Media that involves sound or sound to convey messages. Examples: audio recordings, podcasts, educational music. 3) Audio-Visual Media: Media that combines sound and images to convey information simultaneously. Examples: educational films, learning videos, multimedia presentations. 4) Print Media: Media in the form of printed text or images. Examples: textbooks, student worksheets, posters, brochures. 5) Digital/Interactive Media: Technology-based media that allows direct interaction with the user. Examples: learning apps, computer simulations, learning software, educational websites. 6) Social Media and Collaboration-Based Learning: Media used to support discussion and collaboration between students. Examples: online forums, social media groups, educational blogs.

Benefits of Learning Media (Fajriadi et al., 2022) including 1) Improve Concept Understanding: Media allows students to see, hear, or even interact with learning materials, which makes it easier for them to understand the material, 2) Encouraging Creativity: The use of varied media can stimulate students' creativity in exploring and processing information, 3) Increase Engagement: Interesting and interactive media can encourage students' participation in the learning process, making them more focused and enthusiastic, 4) Facilitate Independent Learning: With digital learning media, students can obtain materials flexibly without being bound by time and place, supporting a more independent learning process. Gender differences are one of the factors that affect the ability to construct evidence. based on the results of research byproof is (Sutiarso, 2019) shows that women are superior in fluency and flexibility, while men are superior in originality, further research by (Erawati & Purwati, 2020) shows that that the there are variations in ability between female and male studentsproof ability students male students, with female students showing superior female superior compared to results aof nd the results of research (Sholihah et al., 2021) states that female superior to students' proof ability is male . They tend to be more careful in solving problems and utilize more symbolic abilities in providing answersstudents. The results of research (Park et al, 2015) show that the abstract thinking ability of male adolescents is superior to women and the results of research He & Wang (2021) show that male students have have superior spatial mathematical abilities than women. while research (Purwanto et al., 2019) shows that in the process of solving problems, male students a tendency to use drawing sketches to help understanding, while female students usually do not make sketches. They only provide known information and questions that must be answered from the problem.

METHODS

A with a pre-experimental research method (quasi-experiment) that adopted a One Group Pretest-Posttest designquantitative approach was applied in this study .



(Sugiyono, 2013)

O_1 : Pretest
O_2 : Final Test (Posttest)
The population of this study were third semester students of the Mathematics Education Study Program at Timor University and the sample was students in this population who chose Calculus I class B even

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semester of the 2023/2024 Academic Year. technique The sampling used is technique *simple random sampling*, namely each student has the same opportunity to choose the Calculus I class B course.
The data collection technique used in this study is the Mathematical Proof Construction Ability Test and observation to observe the learning process using Geogebra while the data analysis technique used is as follows,

1. The prerequisites are test . data normality and equality test
   These two prerequisite tests were carried out before conducting a similarity test of the average basic mathematical abilities of male and female students from the pretest data, and a comparative test of the ability to construct evidence of male and female students.
2. Test of equality of
   The equality test mean aims to ensure that the mean ability to construct evidence of male and female students before being treated must be the same.
   Hypothesis:
   H_0: $\mu_1 = \mu_2$ (the mean of basic math skills of female students is equal to that of male students)
   H_1: $\mu_1 \neq \mu_2$ (the mean basic math skills of female students are not equal to those of male students)
   The formula used in this test is the independent sample t test.

$$t = \frac{\overline{x_1} - \overline{x_2}}{\sqrt{\frac{s_1^2}{n_1} + \frac{s_2^2}{n_2}}}$$

   $\overline{x_1}$= mean Ability to construct evidence of male students
   $\overline{x_2}$= mean Ability to construct evidence of female students
   s_1^2=variance (square of standard deviation) of male students
   s_2^2=variance (square of standard deviation) of female students
   n_1=number of male students
   n_2=number of female students

3. Comparative test
   The Comparison Test aims to compare the mean ability to construct evidence of male and female students after being given the same treatment. The formula used is the same as the equality test mean but differs in formulating hypotheses and statistical hypothesis acceptance criteria.
   H_0: $\mu_1 \leq \mu_2$ (the mean basic math skills of female students are not students superior to those of male)
   H_1: $\mu_1 > \mu_2$ (the mean basic math skills of female students are studentssuperior to those of male)
   H_0 is rejected if $t_{count} > t_{table(n1+n2-2)}$ with 95% significance level.

RESULTS AND DISCUSSION

Before the study was conducted, the researcher applied the mean mean of equality test to ensure that the basic mathematics ability of male students was the same as that of female students. The normality test of the basic ability data is shown in Table 1.

Table 1. Test of Normalization Pretest Data

	Kolmogorov-Smirnov		
	Statistic	df	Sig.
Ability_basic	0.107643	41	0.2

Based on the results of the Kolmogorov-Smirnov test, the basic ability data is normally distributed, characterized by a sig value of 0.2>0.05 so that it can be continued to the similarity testmean . The results of the similarity test mean look like Table 2

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Table 2: Test for equality of means of Pretest data

		Levene's Test for Equality of Variances		T-test for equality of means		
		F	Sig.	t	df	Sig. (2-sided)
Ability_basic	Assumed equal variance	.472	.496	.906	38	.371
	Assumed unequal variances			.847	18.142	.408

Based on Table 2, the results obtained in the form of data on basic mathematical abilities of women and men have a homogeneous distribution characterized by a sig value = 0.496>0.05 and obtained a t value of 0.906 with a sig value = 0.371>0.05 so that H0 is accepted and rejects H1 which means that the basic abilities of female students are the same as men.

The results of the equality test mean allow the research to continue to the next stage, namely the application of Geogebra-based learning media. After the treatment was given to male and female students, a posttest of students' ability to construct evidence was conducted. The results of the posttest were then analyzed and tabulated and then conducted a comparative test to determine differences in the ability to construct evidence of male and female students. The results of the normality test as a prerequisite for the comparative test are shown in Table 3.

Table 3. Test of Normalization Final Test (Posttest)Data

	Kolmogorov-Smirnov		
	Statistic	df	Sig.
constructing_evidence	0.092	40	0.2

Based on the results of the Kolmogorof-Smirnov test, the sig value = 0.2>0.05 indicates that the data on the ability to construct evidence is normally distributed, then the homogeneity test and comparison test are carried out simultaneously. The results of the homogeneity test and comparison test appear as Table 4

Table 4. Homogeneity and comparability test of Posttest Data

		Levene's Test for Equality of Variances		T-test for equality of means	
		F	Sig.	t	df
constructing_evidence	Assumed equal variance	.0.538	.468	1.865	38
	Assumed unequal variances			1.959	23.431

Based on Table 4, the results obtained in the form of data on basic mathematical abilities of women and men have a homogeneous distribution marked by sig =0.468>0.05 and obtained the value of t_{count}=1.865>$t_{table(38,0.05)}$=1.69 so that H0 is rejected and accept H1 which means that the ability to construct evidence of female students is superior to men.

Based on the results of the study, the ability to construct evidence between female students is better than male students, this happens because the use of geogebra-based learning media makes it easier for female students to construct evidence. this is in line with research (Kaliky & Juhaevah, 2018) and (Erawati & Purwati, 2020) which states that women are easier to learn by using a visual learning style, besides that women are more thorough and have no difficulty in providing mathematical reasons. Judging from the indicators of the ability to construct evidence, women have advantages in organizing and processing facts and compiling proof steps systematically to build evidencevalid . They are also

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better able to connect the facts provided with what will be proven. In contrast, men tend to be less strong in both indicators. However, men showed ability superior in utilizing premises relevant theorems to construct a or definitions and proof.

CONCLUSION

Referring to the results and discussion of the research that has been done, it can be concluded that the ability to construct evidence of female students is superior to male students. In addition, there are suggestions in this study, namely the use of sample sizes between male and female is also very important students in gender-related research. The use of large and equal-sized samples is highly expected in the continuation of this research to obtain more saturated research data. In addition, there are various factors that affect the ability to construct evidence in this study so that further research is needed.

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