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UTILIZING GEOGEBRA FOR SOLVING ECONOMIC MATHEMATICS PROBLEMS: PROMOTING LOGICAL REASONING IN PROBLEM-BASED LEARNING

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Abstract

Penalaran logis sangat penting untuk digunakan oleh setiap orang sebagai dasar dari aktivitas kreatif seperti menciptakan atau menerapkan konsep matematika di dunia nyata. Kemampuan penalaran logis dapat dikembangkan melalui pembelajaran dengan menerapkan *Problem-Based Learning* (PBL) berbantuan *GeoGebra*. Studi ini dilaksanakan untuk menginvestigasi pengaruh implementasi PBL berbantuan *GeoGebra* terhadap kemampuan penalaran logis mahasiswa dalam memecahkan masalah matematika ekonomi. Studi ini menerapkan pendekatan kuantitatif berjenis penelitian eksperimen semu, *one-group pretest-posttest design*. Mahasiswa dibelajarkan menggunakan model PBL dengan bantuan *GeoGebra* untuk memfasilitasi proses penalaran logis dalam pemecahan masalah matematika ekonomi. Berdasarkan uji statistik non parametrik uji Wilcoxon dapat disimpulkan bahwa terdapat peningkatan kemampuan penalaran logis mahasiswa setelah implementasi PBL dengan bantuan *GeoGebra*. Dengan hasil tersebut, dapat ditunjukkan bahwa dengan penerapan *Problem Based Learning* berbantuan *GeoGebra* menunjukkan adanya peningkatan kemampuan penalaran logis mahasiswa. PBL berbantuan *GeoGebra* direkomendasikan untuk digunakan sebagai media dalam membantu mahasiswa dalam mengembangkan penalaran logis dalam pemecahan masalah matematika ekonomi.

Keywords: Matematika Ekonomi, Pemecahan Masalah, Penalaran Logis, *Problem-Based Learning* Berbantuan *Geogebra*.

Abstract

Logical reasoning is very important to be used by as the basis of creative activities such as creating or applying mathematical concepts in the real world. By implementing Problem-Based Learning (PBL) with GeoGebra's assistance, logical reasoning abilities can be developed. This research intends to investigate the effect of utilizing GeoGebra to support PBL on students' capacity for logical reasoning while addressing economic mathematics problems. This study employed a quantitative method with one group pretest-posttest quasi-experimental research design. GeoGebra was used in classroom instruction as part of the PBL model to help students solve economic math problems logically. Following the implementation of PBL with the aid of GeoGebra, it may be inferred that there are disparities in students' capacities for logical reasoning based on the non-parametric statistical test of the Wilcoxon test. These findings demonstrate that using GeoGebra in collaboration with problem-based learning improves students' capacity for logical reasoning. GeoGebra-assisted PBL is recommended to be used as a medium to assist students in developing logical reasoning in solving economic mathematics problems.

***Keywords**: Economic Mathematics, Geogebra Assisted Problem-Based Learning, Logical Reasoning, Problem Solving.*

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INTRODUCTION

Understanding mathematics and using mathematics in daily life requires reasoning. It serves as the basis for creative endeavors like creation and the practical application of mathematical ideas (Serna & Serna, 2015). Students can use logical reasoning to analyze information, form hypotheses, test those hypotheses, develop arguments, and evaluate those arguments in order to solve problems correctly (Bancong, 2013; Dowden, 2019; Yu et al., 2022).

Facts that happened on the ground show that educators face problems with low students' logical reasoning in solving the problem in economic mathematics (Cresswell & Speelman, 2020; Tashtoush et al., 2022). Considering the outcomes of the interviews and observations during learning place is known that students often understand the problem and know the solving plan, but at the moment they apply the concepts, students are hindered by a low understanding of concept construction, and fail in the application of the complicated formula, difficulty in draw graphic function which is the main concept that can be used in solving the problem in the field economy and business.

Based on need analysis and learner characteristics, learning with a problem-based learning model-assisted GeoGebra is designed. Of the models used in education, Problem-Based Learning (PBL) is the most modern paradigm (Chinchua, Kantathanawat, & Tuntiwongwanich, 2022). This model is effective in facilitating the problem-solving and self-regulation skills that are widely reported in education. Making use of the PBL paradigm, it is expected that students' reasoning and thinking abilities will develop well.

This PBL model is integrated with the software GeoGebra. Software GeoGebra is software that is available online, offline, and available in mobile applications. GeoGebra can be integrated into learning mathematics or education mathematics studies (Condori, 2023; Dahal et al., 2023; Hadi & Faradillah, 2022; Gonzales et al., 2023; Misrom et al., 2020; Radović et al., 2020; Sulistyawati & Rofiki, 2022; Suryani et al., 2020). With this *software,* students can focus more on the process of solving problems not on results because GeoGebra simplifies the process. Basic concepts and complex calculations can be more easily completed with the help of this software.

PBL integration with GeoGebra media has already lots applied in various studies with various objectives for example increasing the connection mathematics (Nasution, 2018; Septian, 2022; Septian & Komala, 2019), understanding the mathematics concepts (Eviliasani et al., 2022; Owusu et al., 2023; Tatar & Zengin, 2016; Yerizon et al., 2022) increasing students' motivation (Subekti & Kusuma, 2015), as well increasing problem-solving ability (Suratno & Waliyanti, 2023). Although there is already research that applies this PBL model to increase the ability to reason in spatial (Haris & Rahman, 2018), however from studies the not yet been in a manner specific to investigate enhancement reasoning logically. Study reasoning logically not yet lots did. Research about reasoning logically still focuses on the relationships between learning mathematics with the reasoning (Nunes et al., 2015), reasoning in the problem-solving (Bancong, 2013), and the exploration of reasoning through the integration STEM approach (Utomo et

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al., 2020). Hence, this current research focuses on filling the research gaps with the aim of examining the effects of PBL-assisted GeoGebra on students' capacity for logical reasoning in solving economic mathematics problems.

Given how crucial it is for students to be able to reason logically, research into logical reasoning needs to be done. Logical reasoning and mathematics are essential for understanding mathematics and using mathematics in everyday life. It is the foundation of creative activity such as creating or applying mathematical concepts in the real world (Rofiki et al., 2017a). Using logical reasoning, students can evaluate facts, make assumptions, test assumptions, give arguments, and examine arguments to reach a valid conclusion in a problem-solving process.

METHOD

A one-group quasi-experimental pretest-posttest design was used in this study's quantitative methodology, preventing the use of class comparison. The population in this study is a student majoring in Sharia Finance Management, Faculty of Islamic Economics and Business UIN Sayyid Ali Rahmatullah Tulungagung who studying economic mathematics which consists of four classes. The chosen class, using application cluster random selection, is Sharia Finance Management Grade 3D. As a representative study with up to 46 students. 38 females and 8 men are present. The typical student age is from 18 to 20. Already, students are paying attention to both macroeconomics and microeconomics.

Students' logical reasoning in problem-solving is identified through problem-solving tests in economic mathematics. Following the pretest, the student received instruction in PBL using GeoGebra media, and a post-test was then administered.

Problem-Solving Test (PST), a question-and-answer procedure that assesses problem-solving in the economics mathematical discipline, was used to collect data. Three expert validators participated in the PST instrument's feasibility test. The instrument was valid and thus appropriate for use in research, according to the overall validation results. The required test results were analyzed using a normality assumption after the pre-and post-test data were gathered. Because two samples collected in different ways came from the same population, a homogeneity test is not conducted. The first sample was obtained before accepting treatment and the samples second was obtained after the given treatment.

If the findings of the pre-test and post-test were both abnormal, the mean difference test was carried out using non-parametric statistics, such as the Wilcoxon Test, to assess whether the students' ability to utilize logic to solve problems has changed after the adoption of PBL using GeoGebra. The hypothesis being investigated is whether implementing Problem-Based learning-assisted GeoGebra will have an impact on students' capacity to use logical reasoning in solving economic mathematics problems.

RESULTS AND DISCUSSION

GeoGebra software is used in GeoGebra Assisted Problem Based Learning to integrate instructional models and learning resources. Learning is done by adhering to the syntax of the GeoGebra Assisted Problem Based Learning paradigm, which includes the learning processes.

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Problem-Solving Before and after the Problem-Based Learning process with GeoGebra support, tests are administered. The results of the mathematics learning test are presented in the Table 1.

Table 1. Analysis Descriptive Problem-Solving Test Scores

Information	Pretest	Posttest
Min Value	54	100
Maximum Value	67	100
Means	87.33	90.78
Standard Deviation	10.72	7.91

According to the data, the lowest and maximum PST scores for the pretest are respectively 54 and 100. A higher minimum score is obtained by students in the posttest, namely 67, while the maximum score is the same, namely 100. If we look at the mean or average pretest and posttest scores, respectively 87.32 and 90.78 indicating that there was an increase of 3.46 points or just 3.96%. This increase was indeed not significant enough, but to find out whether there was an effect or not, further tests were carried out.

A standard deviation is a measurement that shows how far measurements for a group deviate from the mean or anticipated value. The majority of the statistics are likely to be close to the mean if the standard deviation is low. When the standard deviation is higher, the data are more erratic.

Based on this understanding, it is known that the standard deviation for pretest scores is greater than for posttest. This shows that the post-test scores do not deviate too far from the average or mean. This shows a good thing because, with a deviation that is not too big, it means that when viewed from the post-test scores, many students have experienced an increase. To find out the amount can be done in further tests.

A testing hypothesis is done using the Wilcoxon test via steps as follows.

1. Determine H_0
   H_0: By using GeoGebra-assisted Problem-Based Learning, students' mathematics, and economic problem-solving skills are not influenced by their skill for logical reasoning.
2. Determine H_1
   H_1: Through the use of GeoGebra-assisted Problem-Based Learning, students' logical thinking skills are influenced in addressing mathematical economic problems.
3. Determine $\alpha = 0.05$
4. Define Rejection CriteriaH_0
   Reject Ho if $Asymp.Sig\ (2-tailed) < 0.05$
5. Perform the Wilcoxon Test and determine the sig. Based on SPSS output.

Table 2. Wilcoxon test results

Information		N	MeanRanking	Sum of Ranks
Posts - Pretest	Negative Ranks	13 [a]	19.85	258.00
	Positive Ranks	32b -	24.28	777.00
	ties	1 [c]		
	Total	46		

Based on Table 2, Negative Ranks or the difference (negative) between pretest and post-test scores is 13 (N = 13). This value shows 13 students experiencing a decrease in scores from the pretest to the posttest with an average decrease (mean ranks) of 19.85 and a total decrease (Sum of Ranks) of 258.

Positive rankings or the 32-point difference between the pretest and posttest scores. Thus, it can be observed that from N = 32, it can be inferred that 22 students saw an improvement in their

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results from the pretest to the posttest, with an average decline (mean ranks) of 24.28, and that the sum of the positive rankings is 777.

Similarities between the pretest and posttest are shown by ties. The information in the table reveals that the scores from the pretest and posttest have a single number. According to the test's outcomes, $Asymp.Sig.(2-tailed) = 0.003 < 0.05$ the meaning is H_o rejected and H_1 accepted to conclude that the use of GeoGebra-assisted PBL has affected students of the Sharia Financial Management Study Program's logical reasoning skills in addressing mathematical economic problems.

Based on the hypothesis test findings, it is possible to conclude that employing PBL, which GeoGebra supports has an impact on how they solve mathematical economic problems. This demonstrates how students' cognitive learning results alter when GeoGebra-assisted PBL is used, resulting in increasing students' comprehension of the subject matter and piquing their interest. This is coherent with the study's findings, which demonstrated that the implementation of the PBL model in the study of advanced statistics was able to enhance student comprehension because the instructional process placed a greater emphasis on the application of statistical techniques and procedures, making it simpler for students to comprehend ideas and how they are applied (Ssemugenyi, 2023). In order to foster critical thinking and problem-solving in real-world learning scenarios, PBL has been extensively implemented in a diverse array of educational environments and field settings. (Yew & Goh, 2016). Students' interest in learning both inside and outside of the classroom can be increased by using the PBL model when learning advanced statistics. This occurs because the learning process is given more assignments of case analysis both individually and in groups, thus demanding the participation of all students in the learning process. (Putrawangsa & Hasanah, 2018).

The second phase in PBL is organizing students. In this phase, students are grouped into 8 groups consisting of 5-6 students. Students are grouped heterogeneously by considering differences in gender and mathematical abilities. From this phase, students will have more opportunities to interact, support one another, and express their thoughts when they work in groups, particularly when they are put in diverse groups. There will be communication and reciprocal partnerships via solving challenges in groups. For instance, the correctional opinion of one's own thoughts, extra recommendations, or comments. When analyzing the material acquired, the acceptance and rejection of novel ideas will stimulate logical thought. For the process of information sharing to be facilitated during this stage of problem-based learning, student participation in groups is crucial. Almulla (2020)'s research shows that the PBL approach increases student engagement by promoting knowledge and information exchange and discussion.

In PBL, the first phase is to orient students to the problem. In this phase, learning begins with giving apperception and conveying learning objectives. The apperceptions were given by reminding the concept of derivatives of algebraic functions, extreme values of functions, and graphical sketches using GeoGebra that had been studied in the previous meeting. Furthermore, students are presented with a problem that will be solved with their group, namely the

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problem of a shift in the supply curve due to the provision of subsidies on certain goods. This problem is related to the provision of subsidies to some commodities which ultimately affect the change in the number of goods offered and the prices of goods offered. Problems are then presented on student activity sheets which are distributed to groups formed in the next phase. To build a learning environment that encourages the development of reasoning skills, it is crucial to complete this step. Logical reasoning abilities can be greatly enhanced by giving pupils opportunities to debate problems and by emphasizing problems. To succeed in learning mathematics and solving mathematical problems, students must use reasoning (Rofiki et al., 2017a; 2017b).

The capacity to reason and think mathematically is directly tied to student achievement in problem-solving. Because the critical thinking abilities seen in this study include the capacity to recognize, analyze, and resolve problems, as well as the ability to reason logically, make informed decisions, and conclude, the application of problem-based learning is also thought to have the potential to increase and develop critical thinking abilities (Fakhriyah, 2014). Two factors that cannot be disregarded when someone solves an issue are critical thinking and logic.

The fourth stage of PBL is when the work is developed and presented. Each group is allowed to present the problem-solving process by presenting the answers in front of the class and discussing them with other group members. In this phase, the lecturer's role is to guide the course of the discussion and ensure that each group member has the same opportunity to present their ideas. This calls for teachers to focus more on giving students in this group the right help to promote proper problem-solving by fostering their logical reasoning and bolstering each step of the solution process, such as by regularly implementing problem-oriented learning in a group setting. For learners in this group to finally become autonomous, independent, and self-motivated learners who learn in line with the objectives of instruction, they need scaffolding that will enable them to lead to many alternative issue solutions with the help of others. In order to do this, flexible and dynamic scaffolding must be attentive to the emergence of learners who need aid from social groupings (Anghileri, 2006).

The analysis and assessment of the solution-finding process is the fifth stage of PBL Learning. After all, groups have presented the results, the lecturer provides feedback on each work or problem-solving results given. Lecturers provide directions and instructions regarding important information to be carried out in the problem-solving process. The lecturer also emphasized which steps are logical to take and which steps are not appropriate to take to solve the problem. Students are guided to generalize the problem-solving process by comparing the solutions manually with comparing the results of work using GeoGebra. Visual reasoning-based argumentation is more cognitively taxing since extrapolating what is observed in visual situations may imply that reliable routines, such as those that may be used in algebraic processes, are not always available (Arcavi, 2003; Ramírez-Uclés & Ruiz-Hidalgo, 2022).

PBL's third phase is guiding individual and group investigations using GeoGebra learning media. Lecturers go around facilitating ongoing discussions and providing scaffolding to

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bridge the problem-solving process with the help of GeoGebra software. Students in each group are given the freedom to ask questions and submit opinions during the discussion process. Group members share tasks to complete or solve the problems presented. Utilizing media software GeoGebra allows pupils to investigate answers to challenges in problem-based learning. Students who taught using the GeoGebra program's problem-based learning model exhibited improved problem-solving abilities than those who received instruction using the direct learning model (Hidayatsyah, 2021). Study results show that students' problem-solving abilities increase better when using a problem-based learning model using GeoGebra than when using a more conventional teaching model (Septiyana et al., 2019).

Concerning learning mathematics, many people acknowledge that the aspect of understanding for students is a very important (Japa, 2014). Problem-solving skills require an understanding of one's self towards the problem at hand, and understanding and problem-solving abilities are part of the reasoning aspect. The outcomes of this research imply that employing the PBL paradigm influences pupils' capacity for logical reasoning. This is consistent with Rustina's research, which found that students who participated in learning utilizing the PBL model had greater mathematical reasoning abilities than students who took conventional learning (Rustina, 2015).

PBL with GeoGebra can make it easier to use logic to solve issues. GeoGebra allows students to reason and explore more flexibly so that in the reasoning process students have confidence in the truth of assumptions and facilitate generalizations. This is aligned with the study's findings which concluded that students carry out software exploration GeoGebra to identify information according to existing knowledge. Several techniques for operating the GeoGebra application, namely dilation and reflection, were carried out by the research subjects. Some emphasis on coordinate points was made by the subject when drawing the function graph presented by the software GeoGebra. The subject proves the answer by including all the points in the function. The subject believes in the correctness of the results by pointing to GeoGebra. To help students strengthen their logical thinking skills when tackling mathematical issues, technology must be included in all courses (Utomo et al., 2020).

Including technology in all subjects will provide students the chance to practice using logic to solve mathematical problems. Students who are beginning to think logically will find GeoGebra, which can display information visually, to be of great assistance. The importance of diagrams and other visual aids in mathematical discoveries has long been acknowledged by mathematicians (Barwise & Etchemendy, 1996). Students can consider the conclusions made during problem-solving since GeoGebra may be used to analyze the reliability of the findings produced through testing assumptions. These results demonstrate that logical reasoning is aided by the conscious, reflective processing system (DeWall et al., 2008). GeoGebra helps students visualize abstract ideas that are frequently found in mathematics and makes the process of studying mathematics engaging and fun. However, students with minimal computer literacy may find it difficult to use GeoGebra activities (Bilgin, & Serin,

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2022; Birgin & Acar, 2022; Celen, 2020; Wassie & Zergaw, 2019).

CONCLUSION AND SUGGESTION

According to the test's outcomes, $Asymp.Sig.(2-tailed) = 0.003 < 0.05$ the meaning is H_o rejected and H_1 accepted to conclude that the use of GeoGebra-assisted PBL has affected students of the Sharia Financial Management Study Program's logical reasoning skills in addressing mathematical economic problems. To enhance students' capacity for logical reasoning, PBL may be effectively applied in economic mathematics courses. Learning already held following learning model syntax Integrated PBL with GeoGebra software for facilitating student logical reasoning. The use of PBL, aided by GeoGebra, has improved students' capacity for logical inference while tackling mathematical economic issues. Students' logical reasoning skills have improved with the use of PBL by helping GeoGebra. By the application of assisted PBL *GeoGebra* shows exists enhancement of the ability to reason logically to the student.

Implementing GeoGebra-assisted PBL has an impact on logical reasoning skills; as a result, this instructional strategy can be taken into account in classroom instruction that intends to improve logical reasoning skills. For future research, it is imperative to investigate the integration of GeoGebra in a PBL model to explore the students' logical reasoning in solving other mathematics topics.

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