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THE INFLUENCE OF STEM EDUCATION ON MATHEMATIC ECONOMICS' LEARNING OUTCOME

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Abstract

The purpose of this research is to examine the differences in mathematical economics' learning outcomes taught with STEM Education and Explicit Instructions. This research used a quasi-experimental method with a non-equivalent control group design. The population of this research was Universitas IBBI students who were learning mathematical economics, totaling 40 students. The sample selection in this research used simple random sampling; therefore, the sum of the sample in this research was 36 students. The data collection technique in this research used a high-order thinking-based test based on Taxonomy Bloom Theory. The data analysis techniques used in this research were descriptive statistics, pre-requisite tests, and inferential statistics to test hypotheses. There are several findings in this research. Firstly, there are significant differences in mathematical economics' learning outcomes taught with STEM Education and Explicit Instructions. Secondly, the learning outcomes of STEM Education are higher than the learning outcomes taught with Explicit Instruction. Thirdly, the higher the implication of STEM Education, the higher the student learning outcome of mathematical economics. Fourthly, Explicit Instruction has a positive effect on mathematical learning outcomes. Finally, both STEM Education and Explicit Instruction can be used by a lecturer or teacher in teaching mathematical economics. The recommendation for future research is to use the experimental method with factorial design in order to be able to include aspects of behavior and aspects of intelligence in order to find the best learning model that suits the character and ability of students.

Keywords: STEM Education, Explicit Instruction, Mathematical Economic, Learning Outcome

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INTRODUCTION

Problems faced by humans from time to time are increasingly complex and complicated in the 21st century. In the 21st century, problem-solving by humans does not only depend on one science but involves several disciplines. One field of science that can help other fields of science to solve problems in everyday life is mathematics. Mathematics is a field that studies number theory, algebra, geometry, arithmetic, calculus, building, and space. Mathematics plays a role in helping other fields of science to solve problems by quantitatively proving both models and concepts. Therefore, it is not uncommon for mathematics to be used in economics, engineering, computers, actuarial, and other fields of study.

Mathematics helps explain and solve the phenomena of problems in economics. The combination of economics and mathematics is called economic mathematics. Economic mathematics is applied in management, economics, business, and accounting. Economic mathematics is a subject that is closely related to other subjects such as microeconomics, macroeconomics, managerial economics, financial management, and accounting. Therefore, it is not uncommon for mathematical economics to become a faculty course and a pre-requisite course, especially in the faculty of economics and business.

A student is said to have successfully studied economic mathematics if they pass the economic mathematics course. Student graduation will be reflected in the learning outcomes of economic mathematics. The learning outcomes of economic mathematics are students' achievements after attending economic mathematics lectures. If the learning outcomes of economic mathematics are high, then students are said to be successful in solving economic problems given by lecturers; otherwise, if students have low economic learning outcomes, then these students will undoubtedly have difficulty in applying economic mathematics in everyday life. However, in real life, not all learning in universities can occur to expectations; this was found at Universitas IBBI. The lecturer reports that many students have not been able to master economic mathematics well; this is evidenced that the longer it is, the more students who do not pass. The lecturer reports the state of economic mathematics learning outcomes in Table 1.

-	**Chapters**	**Number of students passing midterm exam**	**Number of students who did not pass the midterm exam**
1	Mathematics for Economics and Business	18	22
2	Economic Modelling	15	25
3	Linear Functions	8	32
4	Non-Linear Functions	4	26
5	Exponent and Logarithmic	-	-
6	Arithmetic and Geometry	-	-
7	Derivatives	-	-

Table 1. Mathematical Economics Learning Outcome Academic Year 2022/2023

Table 1 shows that in the midterm exam for the material of mathematic for Economic and Business, the number of students passed was 18 students. In comparison, the number of students who did not pass was 22 students. Furthermore, for the economic modelling, 15 students passed, while 25 did not. Then, for linear function, eight students passed, and 32 students did not pass. Next, for non-linear functions, the number of students who passed was four students. In comparison, the number of students who did not pass this material was 26 students, and the material of exponent and logarithm functions, rows series, and derivatives will be tested in the semester's final exam.

Thus, the learning outcomes of economic mathematics have decreased trend.

From interviews with several students, some say that mathematics is a complex subject from elementary school to college. Some students say they chose economics, management, and accounting majors, hoping to avoid complicated calculations. However, mathematics cannot be avoided in economics, management, and accounting majors; some students say that in infield practice, the mathematics used is only add, subtract, divide, and multiply; other than that, it is not used in daily economic activities. Thus, students' interest in economic mathematics is low, and students have yet to be able to integrate economic mathematics into solving problems in everyday life.

From the dialogue with the lecturer concerned regarding classroom learning, the lecturer said that the lecturer used the behaviorism theory approach in teaching students. Behaviorism theory is a learning theory that believes in changing human behavior by giving stimulus to humans by reward or punishment (Zhou & Brown, 2017). The behaviorism theory is Explicit Instruction. Explicit Instruction is a lecturer-centered learning where lecturers play an active role in delivering material to students. Explicit Instruction has several learning stages: setting learning objectives, demonstrating learning material, providing practice, evaluating practice, and providing further practice and feedback (Fathurrohman, 2015). The Explicit Instruction used by the lecturer concerned has not been able to improve learning outcomes; until now, it has yet to be successfully applied by the lecturer concerned. When reviewing previous research conducted by several researchers, many concluded that Explicit Instruction improved learning outcomes (Gunn et al., 2021; Hinton & Flores, 2015; Magbanua, 2018; Magsalay et al., 2019; Ogunjimi & Gbadeyanka, 2023; Petermann & Vorholzer, 2022; Ping et al., 2019; Roos & Bagger, 2022; Root, 2019; Sahade & Amsa, 2020; Yuwono et al., 2021). Thus, the researcher concludes that there is a gap between the application carried out by lecturers and the results of previous research.

One of the efforts that is thought to improve mathematics learning outcomes successfully is the application of STEM Education. STEM (Science, Technology, Engineering, and Mathematics) Education is learning that combines the concepts of science, technology, engineering, and mathematics in solving problems that exist in daily life. STEM Education aims to directly provide practice to students to integrate each aspect at once (Riyanto et al., 2021).

STEM Education has several eight steps. Firstly, the lecturer asks questions and introduces the problem. Second, lecturers instruct students to identify problems and build problem-solving models. Third, the lecturer gives directions to students to carry out planning and investigation. Fourth, the lecturer instructs students to analyze and interpret data. Fifth, lecturer’s direct students to use mathematics and computers to solve problems. Sixth, the lecturer gave instructions to build explanations and design solutions. Seventh, the lecturer directs students to provide based on the evidence that has been collected. Eighth, lecturers provide Evaluation and communicate learning outcomes to students (Handayani et al., 2020).

There are advantages of STEM Education. Firstly, STEM Education has an open discussion-based learning style. Second, STEM Education can accommodate interdisciplinary disciplines. Third, STEM Education is based on problem-solving, so STEM Education is very interactive (Handayani et al., 2020).

In addition to the previously mentioned advantages, STEM Education can improve critical thinking, mathematical, language, and computational skills and increase motivation and problem-solving skills (Agussuryani et al., 2022; Elsayed, 2022; C. He, 2022; X. He et al., 2021; Hoa et al., 2023; Ilyas & Meiyani, 2022; Matawali et al., 2019; Milaturrahmah et al., 2017; Nursyahidah & Mulyaningrum, 2022; Perdana et al., 2021; Pratama et al., 2022; Richardo et al., 2023; Saw et al., 2019; Yakob et al., 2021). Because of the many advantages of STEM Education, the researchers decided to use this learning to improve learning outcomes in economic mathematics.

The novelty of this research is in the subject, research sample, and research design. Previous research cited in this research researched mathematics, language, history, chemistry, biology, and pure science subjects. In contrast, the subject used in this research is economic mathematics, a combination of mathematics and economics. Furthermore, the research samples used in previous studies were kindergarten students, elementary schools, junior high schools, senior high schools, and students undergoing foundation. In contrast, this research used students studying in the first semester. The research design used by some previous studies used survey, regression, pre-experiment, and quasi-experiment without control class. In contrast, this research used a quasi-experiment with a non-equivalent design to compare the effectiveness of STEM Education and Explicit Instruction.

RESEARCH METHODS

The research method used in testing the differences in economic mathematics learning outcomes taught with STEM Education and Explicit Instruction is quasi-experimental. The design used in this research is a non-equivalent control group design. More details can be seen in the table below (Sugiyono, 2018).

Class	**Before**	**Treatment**	**After**	**Sample Size**
A	Y_1	X_1	Y_3	18 Students
B	Y_2		Y_4	18 Students

Table 2. Research Design

Description:
Y_1 = Experimental Class Pre-Test
Y_2 = Control Class Pre-Test
Y_3 = Experimental Class Post-Test
Y_4 = Control Class Post-Test
X_1 = STEM Education Implementation

The research population totaled 40 students studying at Universitas IBBI. The sampling technique used simple random sampling with the help of a lottery so that the number of samples in this research amounted to 36 students. Class A will be treated in STEM Education, while Class B will continue to apply Explicit Instruction learning. The data collection technique in this research used a test. The research procedure consists of several steps. First, researchers conducted a pre-test on students to determine the initial ability of students. Second, researchers applied STEM Education to class A and Explicit Instruction to class B. Third, researchers conducted a Post-Test on students to determine their initial ability. Third, researchers conducted a Post-Test for Class A and Class B to determine the final ability of students. Fourth, researchers conducted data analysis and discussion; Fifth, researchers concluded the research results. Data analysis techniques used descriptive statistics, pre-requisite tests, and inferential statistics to test hypotheses.

RESULTS AND DISCUSSION

This research starts by designing a STEM Education syllabus for economic mathematics courses, while the Explicit Instruction syllabus follows the syllabus that has been made before. The STEM Education syllabus is designed with Bloom's Theory Taxonomy based on HOTS (High Order Thinking Skills in the form of analysis, Evaluation, and creating abilities (Anderson et al., 2001). This research may not fully display the STEM Education syllabus and Explicit Instruction. Briefly, the STEM Education syllabus can be seen in the table below.

Chapter	Sub-Chapter	Output	Case Study
Exponent and Logarithmic	1) Compound Interest 2) Growth Function	Simple Finance Calculator	1) Savings interest 2) Total labor force
Arithmetic and Geometry	1) Present Value of Compound Interest 2) Present Value of Annuity	Simple Finance Calculator	1) Banking Interest 2) Home Ownership Loan
Derivatives (Static Comparative Analysis)	1) Demand Elasticity 2) Supply Elasticity 3) Revenue Function 4) Cost Function 5) Maximum Profit	Simple Finance Calculator	1) Market demand 2) Market supply 3) Maximum profit of the business

Table 3. STEM Mini Syllabus

After completing the design of the learning syllabus, the researchers then conducted a pre-test to determine students' initial abilities. After the pre-test, the researchers would apply the STEM Education treatment and the Explicit Instruction. After the treatment application, the post-test will be conducted to determine the final ability of students. The pre-test and post-test results can be seen in the table below.

	Mean	Maximum	Minimum
STEM (Pre-Test)	45,05	60	30
STEM (Post-Test)	77,89	90	62
Explicit Instruction (Pre-Test)	45,17	58	32
Explicit Instruction (Post-Test)	68,89	80	60

Table 4. Descriptive Statistic

The table above shows that the mean of the STEM Education pre-test is 45.05, while the maximum value of the STEM Education pre-test is 60, and the minimum value of the STEM Education pre-test is 45.17. Furthermore, the mean of the STEM Education post-test is 45.17, while the maximum value is 90, and the minimum value of the STEM Education post-test is 62. Thus, STEM Education can improve economic mathematics learning outcomes. The table above shows that the mean pre-test of Explicit Instruction learning is 45.17, while the maximum value is 58 and the minimum value is 32. Furthermore, the mean post-test of Explicit Instruction is 68.89, while the maximum value is 80 and the minimum value is 60. Thus, Explicit Instruction can improve economic mathematics learning outcomes. After successfully obtaining pre-test and post-test data, the research continued at the hypothesis testing stage; the results of hypothesis testing can be seen in the table below.

	Value	α	Interpretation
Shapiro Wilk (STEM Pre-Test)	0,790	0,05	Data is normally distributed
Shapiro Wilk (EI Pre-Test)	0,641	0,05	Data is normally distributed
Shapiro Wilk (STEM Post-Test)	0,406	0,05	Data is normally distributed
Shapiro Wilk (EI Post-Test)	0,428	0,05	Data is normally distributed
Levene's Test	0,087	0,05	Equal population variances
Independent Samples T-Test	0,001	0,05	There is a significant difference

Table 5. Inferential Statistic

The normality test results of the STEM Education pre-test, STEM Education post-test, Explicit Instruction pre-test, and Explicit Instruction post-test have a value greater than 0.05, so all data are typically distributed. Next, the Levene's Test results showed a value of 0.087, higher than 0.005, so the research data had the same variance. The Independent Samples Test results showed a value of 0.001 higher than 0.05. Thus, there is a significant difference in the learning outcomes of economic mathematics taught with STEM Education and economic mathematics outcomes taught with Explicit Instruction.

There is a significant difference in the learning outcomes of economic mathematics taught with STEM Education and economic mathematics learning outcomes taught with Explicit Instruction due to several things. First, the difference in the learning approach. STEM Education uses a student-centered approach, while Explicit Instruction uses teacher-centered learning. STEM Education, which has a student-centered learning approach, can make students learn independently while the lecturer still directs Explicit Instruction. Second is the difference in student experience. Students in STEM Education get a better experience than students who learn using Explicit Instruction because, in STEM Education, students can provide discovery experiences that start looking for theories, using mathematics, making simple calculator finance, and solving cases given by lecturers.

In contrast, students who learn using Explicit Instruction get little experience because when the lecturer has finished explaining the learning material, the lecturer only provides guided exercises in case studies related to mathematical economics. Third, the difference in class atmosphere. In STEM Education, the class atmosphere tends to be more active because students who experience difficulties will try to ask lecturers and other students to complete the stages of scientific method-based learning. Besides, STEM Education gives students the freedom to learn by inquiry, while students who learn with Explicit Instruction are more passive than students who learn with STEM Education because lecturers dominate learning; students only actively discuss when given exercises by lecturers.

This research confirms previous research that discusses the advantages of STEM Education. STEM Education can improve students' critical thinking skills, problem-solving, and learning outcomes (Agussuryani et al., 2022; Elsayed, 2022; C. He, 2022; X. He et al., 2021; Hoa et al., 2023; Ilyas & Meiyani, 2022; Matawali et al., 2019; Milaturrahmah et al., 2017; Nursyahidah & Mulyaningrum, 2022; Perdana et al., 2021; Pratama et al., 2022; Richardo et al., 2023; Saw et al., 2019; Yakob et al., 2021). The results of this research also confirm that STEM Education can make students discuss openly, and STEM Education can be used in cross-science courses such as economic mathematics (Handayani et al., 2020). Thus, the researcher concluded that STEM Education improved the learning outcomes of economic mathematics. This research also confirms previous research, which says that STEM Education has a disadvantage because it requires a long time in teaching and learning activities (Nursyahidah & Mulyaningrum, 2022). Furthermore, STEM Education requires a large amount of money to conduct by the syllabus because it needs to present mathematics experts, technology experts, computer experts, and economic science experts to be able to achieve High Order

Thinking Skills (analyzing, Evaluation, and Creating) by Taxonomy Bloom Theory and STEM Education is not suitable for students who have low material absorption because STEM Education requires high independence and adequate mathematical intelligence so that they can create simple calculator finance (creating products).

The Explicit Instruction is good, but the lecturer did not provide intensive exercises at the time of the previous application, so learning has not improved learning outcomes. The advantage of this is that it can improve students' conceptual abilities in learning (Hinton & Flores, 2015). Besides that, it can achieve learning objectives effectively because of the efficient use of time in presenting material. Furthermore, students with low material absorption can be taught with this because they get direct training guidance from the lecturer concerned. The weakness of this lies in lecturer-centered learning, which makes students bored because lecturers play a dominant role in learning; it is not uncommon when learning, some students are busy talking to fellow students, and some also do activities that are not relevant to learning, such as playing mobile phones, drawing on paper and other activities. However, when reviewing previous research, Explicit Instruction is proven to improve learning outcomes (Gunn et al., 2021; Hinton & Flores, 2015; Magbanua, 2018; Magsalay et al., 2019; Ogunjimi & Gbadeyanka, 2023; Petermann & Vorholzer, 2022; Ping et al., 2019; Roos & Bagger, 2022; Root, 2019; Sahade & Amsa, 2020; Yuwono et al., 2021).

CONCLUSION

Two conclusions can be drawn from this research. First, STEM Education and Explicit Instruction positively affect economic mathematics learning outcomes; in other words, the higher the application of the two learning models, the higher the student's mathematical economic' learning outcomes. Second, the learning outcomes of STEM Education are higher than the learning outcomes taught with Explicit Instruction. This research has been conducted thoroughly but is not free from weakness. The weakness of this research is that it only tested the effect on the learning outcomes of economic mathematics, so it has yet to consider aspects of mathematical intelligence, intellectual intelligence, emotional intelligence of students, and aspects of student behavior. Suggestions for future researchers who are interested in researching the same topic as researchers: using the experimental method with factorial design in order to be able to include aspects of behavior and aspects of intelligence in order to be able to find the best learning model that suits the ability of students.

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