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The Effect of Learning Strategies and Critical Thinking Skills on Mathematical Understanding Based on Initial Ability

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This research was conducted on students of the mathematics education program UM Metro, with a sample of 40 students divided into two classes. The purpose of this study is to determine whether there is an influence of learning strategies and critical thinking skills in mathematical understanding, based on initial abilities. Retrieval of data using tests, 2x2 factorial experimental research design, data analysis using ANCOVA. The results of the study obtained that: 1) there is a mathematical understanding using the Reciprocal Teaching strategy, and Expository, based on initial ability (sig = 0,043 < 0,05); 2) mathematical understanding using the Reciprocal Teaching strategy (mean = 58.95) is higher than Expository Learning strategies (mean = 54.20, 3) there is an influence of the interaction between learning strategies and the critical thinking skills on students' mathematical understanding, based on initial ability (sig. = 0.00 < 0,05). The conclusion is that Reciprocal Teaching strategies more effective than Expository Learning, based on fundamental skills and are advised to use the Reciprocal Teaching modification strategy to lecturers and further research.

Keywords: *Reciprocal Teaching strategies, critical thinking skills, mathematical understanding, and initial abilities*

Introduction

The learning process is the process of interaction between lecturers and students through organising individual potential and learning environments so that behaviour changes occur. The purpose of learning is for the learning process to happen to students. Therefore, in the

classroom, lecturers try to improve the quality of learning in the cognitive, affective, and psychomotor domains. Factors that influence the quality of learning include: 1) internal factors such as physical factors and psychological factors; and 2) external factors including) social factors (family, school, community and group), cultural factors and physical environmental factors (Ahmadi & Supriyono, 2013).

The quality of learning for students of the mathematics education program UM Metro is still low. It can be seen from the mathematical understanding in the Real Analysis course that there are still many difficulties that can be seen from the 60% student scores below 68.5 (< B). From the observation of the learning process, the lecturer explains the learning material expository, and students follow and record the material presented by the lecturer. After teaching the material, the lecturer provides guided assignments and independent assignments. When completing tasks, many mistakes occur because students do not understand the material.

Understanding the material on mathematical evidence is essential because, without understanding, students will have difficulty proving and solving mathematical problems. Many students experience difficulties in mathematical proofs, one of which is proof of real analysis courses (Imamah, 2016). Evidence of mathematics is the expression of individual reasoning and justification, by developing ideas, exploring phenomena, justifying results, and using mathematical conjectures. Reasoning skills are essential for understanding mathematics (NCTM, 2000).

Learning strategies that are often applied in Real Analysis courses are expository learning strategies, where lecturers present learning material accompanied by structured/guided tasks and independent assignments. The Expository learning strategy is a learning process Expository learning strategy, according to Sanjaya (2008) is a learning strategy that emphasises the process of delivering material from a lecture to a group of students with verbal methods that aim to be able to master the subject matter optimally. Besides, Suparman (2012) calls it a lecture method in the form of teacher explanations for students and is usually followed by a question and answer about the content of the lesson that is not yet clear.

Expository learning strategies are implemented in the classroom in the form of sequences or learning steps. The steps in applying expository learning strategies are preparation, presentation, correlation, and generalisation (Sanjaya, 2008). The syntax of direct/expository learning consists of five activities, namely: orientation, presentation, structured practice, guided practice, and independent practice (Joyce et al., 2009).

Expository learning is a learning strategy that emphasises the process of delivering idea(s) or providing information with an oral or written report from a lecturer to students to optimise mastering the subject matter. Teaching materials are arranged systematically and

hierarchically, after the delivery of material is usually followed by a question and answer about the contents of the lesson that is not yet clear. Expository learning can be applied to any field of study, and it can also be used to subjects that are performance or performance-oriented. So the expository learning strategy in this study is a learning strategy that emphasises the process of deduction, pointing to the procedures commonly used by lecturers in actual practice in the field.

Efforts that can be made to improve the quality of learning include applying various learning strategies. Lecturers must be able to choose learning strategies that are by the conditions and characteristics of their students. Reciprocal teaching is an alternative learning strategy. Reciprocal teaching is a discussion technique that is scaffolded or supported by the teacher by combining four main strategies, namely: predicting, questioning, clarifying and summarising, which the reader uses by working together to understand the text (Oczkus, 2005). Students and lecturers dialogue and ultimately exchange roles when they work with texts to develop questions, clarify information, make predictions, and summarise (Dell'Olio & Donk, 2007).

Reciprocal teaching is a learning strategy that involves students in dialogue and collaboration to increase students' understanding of lecture material, using key activities, generating questions, predicting, clarifying, and summarising. Gradually students and lecturers exchange roles in the learning process. Lecturers act as motivators and support students to understand the text.

The learning process cannot be separated from thinking activities to understand the material, and problem-solving thinking is the behaviour carried out using ideas, in the form of symbolic activities (Sarwono, 2010). Thinking is a mental power process that can lay the connection between our knowledge. Thinking is a dialectical process, meaning that during thinking, a question and answer process occurs to be able to lay down the relationship of our understanding (Ahmadi & Supriyono, 2013). Thus thinking is a process of using ideas that can be symbolic activities that are useful for solving problems, making decisions, and gaining understanding.

Critical thinking is one part of this type of thinking. Critical thinking is thinking clearly and rationally, carried out appropriately and systematically by following the rules of logic and scientific reasoning (Lau, 2011). When students think critically, they are encouraged to think for themselves, question hypotheses, analyse and synthesise events, go further by developing new hypotheses and testing facts (Karakoç, 2016).

Based on the above opinion, critical thinking is the process of making decisions in problem-solving using logic and scientific thinking clearly and rationally. In critical thinking, students are encouraged to think independently and seek root causes by analysing and synthesising

events based on facts and data. The aim is to get complete and correct knowledge and understanding, not to show self-excellence.

Critical thinking has aspects that are characteristics that a person has critical thinking skills. Fisher (2004) lists essential skills of thinking as follows: 1) identifying elements in the case in mind; 2) identifying and evaluating assumptions; 3) clarifying and interpreting statements and ideas; 4) assessing credibility and claims; 5) evaluating various arguments; 6) analysing, evaluating and producing explanations; and 7) analysing, evaluating and making decisions, drawing conclusions and producing argument arguments.

Every student who starts a learning activity has initial abilities or skills. Initial ability (entry behaviour) as a skill that must be mastered by students before he begins learning (Dick et al., 2009), the initial ability is related to the knowledge, skills, and attitudes that have been mastered by students so that they are eligible for learning (Suparman, 2012).

Based on the knowledge above, the initial ability is the ability or skill that students already have before starting new learning. This ability is a prerequisite for following the next learning and has a relationship with learning outcomes, which includes cognitive, affective, and psychomotor skills.

Methods

The research variables consisted of 4 variables composed of 1) independent variables, namely learning strategies; 2) moderator variables, namely critical thinking level; 3) controlling variables (covariates), namely initial abilities; and 4) dependent variables (criterion) namely mathematical understanding. This study used a quasi-experimental method to design *treatment by level* 2x2.

The population in this study was all students of the Mathematics Education Study Program FKIP Muhammadiyah University of Metro 2016/2017 academic year who participated course of Real Analysis I. There were 60 students, divided into two classes, each composed of 30 students, using a purposive sampling technique. Samples comprised of 40 students were grouped into four groups, divided into Reciprocal Teaching (A_1) learning groups and expository learning groups (A_2), with two categories, namely high critical thinking ability (B_1) and the low critical thinking ability (B_2). The treatment design is as follows in Table 1.

Table 1. Learning Design in Reciprocal Teaching and Expository Learning Strategies

Learning Design	
Reciprocal Teaching Strategy	**Expository Learning Strategies**
1. Stage of Questioning Students read and study line material and limits in groups, asking questions, and lecturers explaining. **2. Stage of Predicting** Lecturers guide students to discuss ideas to solve problems in groups **3. Stage of Clarifying** Students clarify problem-solving, write down the sequence, and reasons for solving it. **4. Stage of Summarising** The results of problem-solving are presented in front of other groups, other groups and lecturers ask/respond and correct the wrong concept. Students submit summary results in PowerPoint media. Gradually the role of the lecturer turned to the students	**1. Stage of Presentation** Lecturers explain lecture material about ranks and limits, provide definitions/accept examples of problem-solving **2. Stage of guided practice** Students practice in the form of training in collaboration with friends and guided by lecturers **3. Stage of independent practice** Students do the exercises independently to find out the understanding of students, **4. Stage of generalisation** The results of independent training are presented in front of students, and they ask/respond, lecturers straighten the wrong concept. Students submit conclusions

To measure the variables of critical thinking skills, initial abilities, and mathematical understanding, skills using essay-shaped tests. The material in the initial capability is the Real Number System, and mathematical understanding is the Rows and Limit Functions, which are the material in the course of Real Analysis I. Before the test is given to students, it is first tested and analysed for its validity and reliability. Valid instruments for critical thinking skills were 13 items. Initial abilities were 12 items and mathematical understanding of 12 items, while instrument reliability was 0.85 for critical thinking skills, 0.867 for initial abilities, and 0.838 for mathematical understanding, with the very highest category.

Results and Discussion

The results of descriptive statistical analysis describe the mathematical understanding of students obtained from the treatment of learning strategies and attributes of critical thinking levels and initial ability scores, which are presented in Table 2.

Table 2. Recapitulation of Initial Ability Scores and Mathematical Understanding of Students in All of the Groups

Instructional Strategy / Critical thinking level		Reciprocal teaching (A_1)		Expository (A_2)		Total	
		Initial ability (X)	Mathematical understanding (Y)	Initial ability (X)	Mathematical understanding (Y)	X	Y
High (B_1)	n	10	10	10	10	20	20
	Mean	64,70	67,90	50,70	47,40	57,70	56,65
	S	5,10	4,36	7,41	5,74	9,48	11,60
Low (B_2)	n	10	10	10	10	20	20
	Mean	49,30	50,00	60,00	61.00	54,65	55,50
	S	5,83	6,78	7,75	8,68	8,64	9,45
Total	N	20	20	20	20	40	40
	Mean	57,00	58,95	55,35	54,20	56,18	56,58
	S	9,53	10,70	8,79	10,00	9,09	10,50

The results of the inferential statistical analysis as a prerequisite test show that each group of students formed by learning strategies and critical thinking levels shows the normal distribution, homogeneous. The probability value (sig.) Deviation from linearity (0.866 > 0.05) then accepts H_0, so regression Y on X is linear with the model of the regression equation being: $\hat{Y} = 9{,}78 + 0.83X$. On the probability value (Sig.) 0.567 > 0.05, H_0 is accepted, or the linear influence of Y on X does not have a significant difference between the four groups of students formed by learning strategies and the level of critical thinking. The results of the analysis are presented in Table 3.

Table 3. Regression Linearity Test Results Y on X

			Sum of Squares	Df	Mean Square	F	Sig.
Mathematical understanding * Initial ability	Between Groups	(Combined)	3170,608	23	137,853	1,953	,086
		Linearity	2234,004	1	2234,004	31,655	,000
		Deviation from Linearity	936,604	22	42,573	,603	,866
	Within Groups		1129,167	16	70,573		
	Total		4299,775	39			

Primary data sources are processed with SPSS Version 22.0

Table 4. Line Alignment Test Results

Dependent Variable: Y

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	3055,830[a]	7	436,547	11,230	,000
Intercept	558,795	1	558,795	14,375	,001
A * B	106,381	3	35,460	,912	,446
X	198,803	1	198,803	5,114	,031
A * B * X	80,062	3	26,687	,687	,567
Error	1243,945	32	38,873		
Total	132329,000	40			
Corrected Total	4299,775	39			

R Squared = ,711 (Adjusted R Squared = ,647)

The next hypothesis testing was carried out using covariance analysis techniques (ANCOVA), and the results were obtained in Table 5.

Table 5. Summary of ANCOVA Results with Test F About Mean Differences in Mathematical Understanding (Y) Based on Initial Ability (X)

Dependent Variable: Y

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	2975,768[a]	4	743,942	19,666	,000	,692
Intercept	618,140	1	618,140	16,340	,000	,318
A	167,555	1	167,555	4,429	,043	,112
B	9,467	1	9,467	,250	,620	,007
A * B	625,674	1	625,674	16,540	,000	,321
X	223,293	1	223,293	5,903	,020	,144
Error	1324,007	35	37,829			
Total	132329,000	40				
Corrected Total	4299,775	39				

a. R Squared = ,692 (Adjusted R Squared = ,657)

Based on the results of Table 5, it can be explained as follows:

1. There are differences in mathematical understanding using Reciprocal teaching and expository learning strategies based on initial abilities

Statistical hypothesis 1:

H_0: $\mu_{res(A1)} = \mu_{res(A2)}$

H_1: $\mu_{res(A1)} \neq \mu_{res(A2)}$

Based on the results of the analysis in table 5, it shows that with the F-Test obtained sig. = 0.043 < 005 so that H_0 is rejected, meaning. there are differences in mathematical understanding using Reciprocal Teaching and expository learning strategies based on initial abilities.

In the Reciprocal teaching strategy, students are presented with text containing material Sequences and Limit Functions. In the text, besides containing the material and explanations, it also contains examples of questions, their solutions, and some exercises. Students and lecturers eventually exchange roles when they work with the text through stages, namely, generating questions, predicting, clarifying, and summarising (Dell 'Olio & Donk, 2007). This strategy is cooperative learning, encouraging students to work together in small groups and help each other in the learning process through stages: Composing Questions, Predicting Answers, Clarify, and Summarisation (Prasetyo, 2018). Students understand the material by reading and analysing the text, asking the lecturer, predicting what is in the text in the opinion of the students. Students can have a dialogue with the lecturer and fellow students and ask if they experience difficulties. Then the students explain again and conclude the results of problem-solving.

In reciprocal teaching strategy, students dialogue with each other and cooperate in solving problems. In the questioning stage, students discuss and ask fellow friends to think deeply about a text/material. They also enjoyed the opportunity to become teachers and ask questions during discussions. Oczkus (2005) states that questions motivate students to discuss texts and ask each other questions, motivate students to interview, and challenge to think deeply about a text. It is also supported by the statement of Trianto (2012), which states that the use of the reciprocal teaching approach was chosen because 1) is a routine activity that can be carried out by readers, 2) can increase understanding and monitor their understanding and 3) dialogue and cooperation.

The expository learning strategy is a learning strategy that emphasises the delivery of learning directly to students. Management of direct learning helps focus the teacher's attention on two things: first so that the subject matter can be mastered, and second, the evolution of student understanding during the learning process (Dell 'Olio & Donk, 2007). The lecture method takes the form of a teacher's explanation for students and is usually followed by a question and answer about the content of the lesson that is not yet clear (Suparman, 2012).

In the expository method, after the teacher gives some information (lecture), the teacher starts by explaining a concept, the student asks, the teacher checks (checks) whether the student has understood or not. Next, the teacher gives examples of the application concepts, and students are asked to solve them. Math teachers in schools commonly use this because it is effective and efficient. Students who receive explicit learning in the rhetorical structure of expository texts can build their expository texts effectively (Amir, 2013).

Expository learning strategies are learning activities in the classroom using lecturers explaining material and students following or paying attention to learning material. In this strategy, lecturers are more active in providing information in the form of material accompanied by theory, definitions and examples, and discussion. Next, the lecturer provides guided training and independent training, so students understand the learning material.

2. The mathematical understanding of students using reciprocal teaching strategies is higher than those using expository learning strategies based on initial ability.
   Statistical hypothesis 2:
   H_0: $\mu_{res(A1)} > \mu_{res(A2)}$
   H_1: $\mu_{res(A1)} < \mu_{res(A2)}$

The analysis results in Table 2 show that the mathematical understanding of students using reciprocal teaching strategies (mean = 58.95) is higher than those using expository learning strategies (mean = 54.20) based on initial ability

The course of Real Analysis I is a course that requires more mathematical understanding. By understanding the material in mathematics, students can solve evidentiary problems. The tasks given by the teacher need to be analysed in depth because problem-solving requires deductive verification and valid logic reasoning. The analysis in mathematics develops several basic principles and solution techniques for solving problems, exploring activities, investigating, and finding new results (Radulescu et al., 2009).

The Reciprocal teaching strategy aims to improve understanding. The mathematical understanding of students using the Reciprocal Teaching strategy is higher than those using conventional/expository learning (Qohar 2013). The use of reciprocal Teaching models has a positive effect on achieving reading comprehension compared to traditional models (Al Saraireh & Hamid, 2016; Namaghi & Shahhosseini, 2011).

The Reciprocal teaching method is having a significant impact on students' understanding and involves students to optimally use schemata and metacognitive theories (A'yun & Yunus, 2017). Implementing a reciprocal teaching strategy to improve students' reading comprehension in the experimental group is more effective than the control group taught in the traditional way (Gomaa, 2015).

In applying the Reciprocal Teaching strategy, the lecturer plays a role as a model that becomes an example. This motivator always gives support and enthusiasm to students and as a guide who directs students when learning takes place. But students also have problem-solving skills so that they will create meaningful, useful, and enjoyable learning in the classroom that can optimise student learning outcomes. In contrast to learning that uses expository learning, during education, students look less active, because lecturers guide more activities. In solving problems, students are more likely to follow the example given by the lecturer; they lack the initiative to determine alternative problem-solving.

3. There is an influence of the interaction between learning strategies and the level of critical thinking on a mathematical understanding based on initial abilities.
   Statistical hypothesis 3:
   H_0: Int. AxB = 0
   H_1: lnt. AxB ≠ 0

Table 5 shows that with F Test statistics, sig. = 0.00 <0.05 means H_0 is rejected, or there is a very significant interaction effect between learning strategies and the level of critical thinking towards student learning outcomes in Real Analysis I based on initial abilities.

In the Reciprocal teaching strategy, the use of understanding strategies is one of the three main components, along with dialogue and role transition between lecturers and students (Agoro & Akinsola, 2013). Students have discussions with fellow students or with lecturers, and in understanding texts or problem-solving, they predict by finding and searching for problem-solving. At the stage of clarifying answers, they explained again what was obtained from the predicting stage so that understanding of the material was better. Next, they summarise the results of understanding in the form of a PowerPoint media display. Gradually they took the role of the lecturer in presenting learning material.

Reciprocal teaching is an interactive and cooperative learning strategy based on Vygotsky's fundamental theory of the role of social interaction, and The Zone of Proximal Development (ZPD) is used to develop an understanding of the text. By involving high social interaction and collaboration in which learners step by step, learn to assume the responsibility of helping their colleagues create an understanding of the text (Ghorbani et al., 2013). In reciprocal teaching with Pre-service teachers, there are significant differences in learning outcomes using Reflective-Reciprocal Peer Tutoring learning strategies, Reflective-Reciprocal Teaching, and modified Conventional learning strategies (Agoro & Akinsola 2013). Pre-service teachers are part of the teaching and learning process. They can prepare teaching materials, plan lessons, deliver lessons, receive feedback from peers, and identify possible problems and solutions to other classes. They function as tutors, while teachers act as facilitators. Peers teaching is a program to help students who need academic assistance;

students who do not understand the lesson are taught and nurtured by friends who already understand the material (Yaumi, 2012).

In the context of learning Reciprocal teaching, peers who can facilitate discussion and group assignments can help students improve understanding both individually and in groups (Raslie, Mikeng & Ting, 2015). There is a difference in increasing the ability to write definitions and theorems in symbolic forms before and after learning is done using the Reciprocal Teaching model (Ahmad & Lanteri, 2017). In reciprocal teaching, students learn to predict, make questions, identify main paragraph ideas, to clarify wording, phrases, or sentences that are not clear, and summarise the reading. The four main strategies help them overcome difficulties when reading texts, monitor understanding, evaluate planning, and learning outcomes (Namaghi & Shahhosseini, 2011).

The primary purpose of learning activities is to facilitate students in learning and understanding learning materials. In understanding material and solving problems requires the ability to think. Critical thinking is rational decision making for what is believed and done (Ikman & Rezky, 2016). Students with better critical thinking skills tend to have better mathematical performance. Mathematics teachers need to improve the scheme in different learning strategies to enhance students' critical thinking skills (Alcantara & Bacsa, 2017). Mathematical critical thinking skills of students with independent cognitive styles are higher than students with dependent cognitive techniques (Agoestanto et al., 2017)

Based on the findings and opinions above, reciprocal teaching strategies and critical thinking skills can improve students' mathematical understanding based on their initial abilities.

Conclusion

Based on the results of the study concluded that: 1) there are differences in mathematical understanding using Reciprocal teaching and expository learning strategies based on initial abilities; 2) Reciprocal teaching strategies are more effective for improving students' mathematical understanding compared to expository learning strategies based on initial skills; and 3) there is an influence of interaction between learning strategies and the level of critical thinking on mathematical understanding, based on initial skills. To the lecturers, it is recommended to apply reciprocal teaching strategies and be more creative in designing learning to motivate and improve students' mathematical understanding. Students who use complementary teaching strategies should improve critical thinking levels to enhance mathematical understanding. Researchers develop strategy innovation Reciprocal teaching uses various methods and media to improve understanding and standards of critical thinking.

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