Students' mathematical critical thinking reviewed from self-regulated learning

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Abstract. Critical thinking is the ability to think logically, reflectively, and productively which is applied to produce a good decision. Therefore, it is necessary for mathematics learning. This study aims to analyze the students' mathematical critical thinking in solving numerical analysis problems in terms of self-regulated learning (SRL). The subjects of this study were the seventh semester students of mathematics education at Universitas PGRI Madiun, selected using purposive sampling technique. The instrument in this study was a test for mathematical thinking analysis and a self-regulated learning questionnaire for subject selection. The results suggest that students with high and intermediate SRL are both having a good ability to make generalizations, identify and justify concepts, while students with low SRL only have a good ability to make generalizations, but performed low on the ability to identify and justify the concepts of analysing algorithm.

1. Introduction

Mathematics is a basic foundation of science and technology which has an important role in developing a country's socioeconomic and therefore mathematics is taught at every level of education [1-4]. To understand mathematics, good critical thinking skills are needed besides that critical thinking skills are also one of the goals of education throughout the world [5-8] which means there is an increase in recognition of the importance of developing students' mathematical critical thinking skills. This shows that critical thinking ability is one of the thinking skills that must be possessed by every student. With the ability to think critically a student can carefully use his mind to find meaning and understanding of something, exploration of ideas, decision making, problem-solving with the best consideration and revision of the previous process of checking learning material [9, 10].

To maximize this critical thinking ability, learning should empower the ability to think. In the learning process in class, critical thinking processes are very necessary in learning mathematics. Because in learning mathematics there are many problems that require students to think about how to solve these problems.

One of the subjects that is considered difficult by students is the numerical method course. This is related to this course discussion. Students need to master the prerequisite courses. In the numerical method course these students must master the prerequisite courses, namely linear algebra, calculus, differential. From the pretest scores taken, there were 68.9.4% of students who scored below 70. This shows that students' mathematical criticism in solving numerical methods was very low.

Many factors lower the level of students' mathematical thinking. One of them is influenced by self-regulated learning. Some of writers explains SRL connects with independent learning, examines the effect of SRL on science learning and many suggestions for improving SRL [11-14]. In these articles,

SRL has many different definitions, but the authors have the same three characteristics of SRL: planning goals, choosing strategies, and monitoring cognitive and affective processes that occur in completing academic assignments [15]. The definition of self-regulated learning is an active constructive process where students set their learning goals and monitor, regulate and control their cognition, motivation, and behavior, guided and limited by their goals and the contextual features of their environment [16, 17]. Strategies from of the SRL process and are specific skills that can be taught to students to put into real world practice [18, 19]. The application of SRL strategies typically predicts high academic achievement in the traditional learning environment [20]. On the other hand, the ability to think critically is evident in the literature that there is much discourse about the benefits of critical thinking in education [5, 21] and the various approaches to teaching it in the literature [7, 22, 23]. For this reason, researchers are interested in conducting research related to the analysis of students' mathematical critical thinking processes viewed from self-regulated learning.

2. Method

This type of research is descriptive research. Descriptive research is a research that aims to describe a situation or phenomenon as it is without manipulating the research object. The subjects of this study were students of Semester 7 of mathematics education department at Universitas PGRI Madiun. Taking the subjects in this study was conducted by purposive sampling technique. The instrument in this study was a test for mathematical thinking analysis, a self-regulated learning questionnaire for subject selection. Here we provide an example of the test instrument used in this research.

"Given $f(x) = \cos 3x$. Determine the Mclaurin series of order 5 for $f(x)$. Then, using the series, calculate the value of $f(0.24)$ and determine the absolute error and the relative error of the nears. (Exact value of $f(0.24) = 0.7518057$)".

We also administered a questionnaire as presented in Figure 1.

SELF-REGULATED LEARNING QUESTIONNAIRE

Charging instructions :

1. This questionnaire is distributed and filled out in class.
2. The assessment is carried out on the aspects in the following table by circling the numbers (1-4) in the score column.
   1 = not very good / very low / never / very inappropriate
   2 = not good / low / rare / inappropriate
   3 = good / high / frequent / appropriate
   4 = very good / very high / always / very appropriate

No	Statement	Score			
1.	I noted important things that were explained by the lecturer.	1	2	3	4
2.	I visit the library to do assignments and look for various sources.	1	2	3	4
3.	I use the internet as a learning resource.	1	2	3	4
4.	I mark important things in notebooks and textbooks.	1	2	3	4

Figure 1. Sample of SRL questionnaire

The critical thinking skills measured consist of three indicators. The instrument is in the form of one description item. Students' answers are further categorized into two categories namely True (B), and False (S).

3. Results and discussion

We gave a self-regulated learning questionnaire to all VII semester students who were used to determine the subject. Students are included in the categories that have been determined by researchers based on the results of the questionnaire given. Based on the results of the questionnaire distribution, it was found that students with SRL high 16 students, SRL medium 34 students, and SRL low 18 students. The results showed that the questions tested on students turned out to have varying categories in each of the aspects tested. The results of the analysis of student answers can be seen in Table 1. Table 1 presents the distribution of the answer categories and the number of students.

Table 1. Students' mathematical critical thinking abilities based on types of SRL

Type of SRL	Indicator of mathematical critical thinking ability											
	1				2				3			
	T	%	F	%	T	%	F	%	T	%	F	%
High	13	81.25%	3	18.75%	11	68.75%	5	31.25%	9	56.25%	7	43.75%
Intermediate	25	73.53%	9	26.47%	18	52.94%	16	47.06%	22	64.71%	12	35.29%
Low	10	55.56%	8	44.44%	6	33.33%	12	66.67%	3	16.67%	15	83.33%
Total	48	70.59%	20	29.41%	35	51.47%	33	48.53%	34	50.00%	34	50.00%

In Table 1, Indicator 1 is the ability to generalize, namely the ability to complete data or information that supports. Indicator 2 is the ability to identify and justify concepts, namely the ability to give reasons for mastery of concepts. Indicator 3 is the ability to analyze algorithms, i.e. evaluating or checking an algorithm.

Based on Table 1, it can be seen that overall the number of students who answered correctly the most is on Indicator 1 which is as much as 70.59%. While the number of students who answered correctly on Indicator 2 and Indicator 3 had the same percentage of 51.47% and 50.00%. This indicates that students can make generalizations that are marked by being able to complete supporting data or information. Furthermore, most students can be said not to have the ability to identify and justify the concepts needed to solve the problem and also cannot analyze the marked not able to evaluate the truth of an answer presented. The sample of the students' answer is presented in Figure 2.

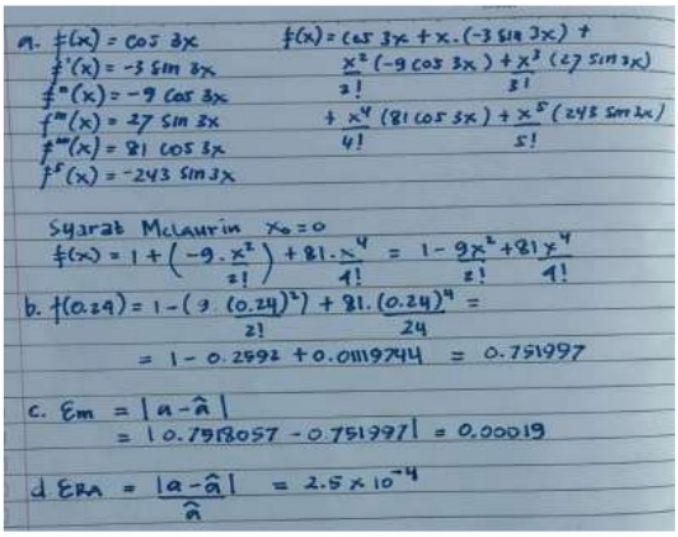

Figure 2. Sample of student answer

From several students' answer sheets, we obtained information that most students could not solve the questions for Indicator 2 correctly, due to: (1) Students still did not understand about trigonometry derivatives from first to nth derivatives; (2) Students cannot distinguish between looking for something close to the Taylor series and the Mclaurin series. Whereas for Indicator 3, students cannot solve problems correctly due to: (1) Students are still not careful enough to substitute trigonometric derivatives into the Maclaurin series; (2) Students are correct in substituting derivatives into the Maclaurin series but still lacking in careful calculation anally (3) There are parts that can determine answers to the end but students do not re-check whether the answers that have been presented are correct or not. Furthermore, based on the student answer sheet for Indicator 1, the researcher found that most students could complete the data provided, this shows that the students had understood or explored information from the questions presented related to the Maclaurin series.

3.1. Data analysis on the high SRL

In Indicator 1, there are 81.25% of students answered correctly this shows that students can complete the data or information related to the problems that have been given. And based on interviews, students can name any information from the questions. In Indicator 2, there are 68.75% of students who answered correctly this also shows that students can understand the concept of derivatives in trigonometry, can write Maclaurin's series well. And in the Indicator 3, there are 56.25% of students able to solve problems in accordance with the sequence of work and can calculate analytically until a correct answer is found, although many students do not re-correct the answer right or wrong but at the interview, students are able to explain well how to step out of their solution and be able to explain whether their answer is right or wrong. For students of SRL Higher than 3 indicators, all reaching 50% and above it shows the ability to generalize, identify and justify the concept of analyzing a good algorithm. This is in line with Duron's opinion which states that critical thinkers are able to analyze and evaluate information, raise vital questions and problems, arrange these questions and problems clearly, gather and assess relevant information using abstract ideas, open-minded, and communicate them with effective [24]. Jin added that critical thinkers can criticize, ask questions, evaluate, and reflect on the information obtained [25].

3.2. Data analysis on the intermediate SRL

In Indicator 1 there were 73.53% of students answered correctly this shows that students can complete data or information related to the problems that have been given. And based on interviews, students can name any information from the questions. In the Indicator 2, there were 52.94% of students who answered correctly this also shows that students can understand the concepts of derivatives in trigonometry, can write Maclaurin's series well. And in Indicator 3, there were 64.71% of students are able to solve problems according to the sequence of work and can calculate analytically until a correct answer is found, although many students do not correct the answer again right or wrong, but at the interview, students are able to explain well how to step out of their solution and be able to explain whether their answer is right or wrong. In the SRL students, all of the 3 indicators also reached 50% and above it shows the ability to generalize, identify and justify the concept of analyzing a good algorithm. Based on this, it is clear that students in working on mathematical critical thinking problems still experience difficulties with several indicators in analyzing a question, answer, relevant argument and re-checking a statement or process that can be said still cannot prove the correct result or is wrong [26].

3.3. Data analysis on the low SRL

In Indicator 1 there were 55.56% of students answered correctly this shows that students can complete the data or information related to the problems that have been given. And based on interviews, students can name any information from the questions. In Indicator 2, there were 44.44% of students who answered correctly it also shows that students still have difficulty in reducing the function into trigonometry, in writing the Maclaurin series in the second-order has not been listed by dividing the two factorials. And in Indicator 3, there were 16.67% of students have not been able to solve the problem by the sequence of work and can calculate analytically until the correct answer is found. The low SRL

students showed that the ability to generalize is good but the ability to identify and justify the concepts of analyzing algorithms is low. This is because many students are discouraged when they do not find the answer and have a weak struggle in dealing with problems that will lead to results that are not optimal, so that in the end they cannot solve the problem being faced [27-32].

4. Conclusion

The conclusion obtained is the conclusion from the results of this study is students with high SRL and medium SRL are both having a good ability to generalize, identify and justify concepts while students with low SRL only have a good ability to generalize but on the ability to identify and justify the concept of analyzing low algorithms.

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