Cognitive Growth Model to Improve Problem Solving Ability and Activities of the Second Semester Students in Integral Calculus Course

Aprilia Nurul Chasanah[1a)] , Arief Budi Wicaksono[2b)]
[1,2]Mathematics Education Study Program, Universitas Tidar, Magelang, Indonesia
e-mail: [a)]aprilianurul@untidar.ac.id, [b)]ariefbudiw@untidar.ac.id

Abstract

The problem solving ability is needed for the students to be able to face the challenges of education on cognitive aspects. Meanwhile, in the affective aspect, the students' activities also play an important role in the process of learning mathematics in higher education. Armed with activities and mathematical problem solving ability, they are expected to be more adaptive in their efforts to find solutions for each problem. The purpose of this research is to improve the activities and ability to solve mathematics problems in the second semester students in the Integral Calculus course using the Cognitive Growth model. This is a Classroom Action Research (CAR in the even semester 2018/2019). The subjects of this research are the second semester students of the Mathematics Education Study Program at a higher education institution in Magelang, Central Java, Indonesia. The data collection techniques in this research are the test, observation, and interview. The percentage for the aspect of the students' activities in the first cycle = 51.51%, the second cycle = 58.56%, and the third cycle = 65.48%. The percentage of improvement in the students' mathematical problem solving ability in cycle I = 45.08%, cycle II = 40.08%, and cycle III = 56.59%. Therefore, it can be concluded that the application of the Cognitive Growth model can improve the activities and problem solving ability in the second semester students in the Integral Calculus course.

Keywords: activities, Cognitive Growth, problem solving ability

INTRODUCTION

At the college level, mathematics is increasingly difficult to learn. Suryana (2012) argued that mathematics learning is often negatively viewed by the students and they have considerable difficulties with several mathematical processes such as reasoning, problem solving, and proofing. Problems that are categorized as problem solving are not easy to find, because they need to apply the mathematical mindset and knowledge or have previously obtained to a new or unusual situation (Kesan, et al., 2010). Mathematics cannot be separated from the problem solving process. The thinking process in the problem solving needs to get more serious attention from the lecturers to help the students to develop their ability to solve many problems in both the real world and mathematical contexts.

Problem solving is an integral part of mathematics learning (NCTM, 2000). Krulik & Rudnick (1995) defined the ability to solve problems (problem solving) as a means of individuals in utilizing their knowledge and ability that have been previously owned to be synthesized and applied to new and different situations. Polya (1973) defined the indicators problem solving are the understanding problem, planning the solution, implementing, and re-examining. Anderson (2009) stated that problem solving is one of the life skills that involve the process of analyzing, interpreting, reasoning, predicting, evaluating, and reflecting. So, the problem solving ability is an

ability to apply previously owned knowledge to new situations that involve higher-order thinking process.

An initial study on mathematics education students at a higher education institution in Magelang, Central Java, Indonesia showed that the activities and ability of students in the second semester of the 2018/2019 academic year were still low. This could be seen when the researchers conducted a learning process in the initial condition. The learning was done twice (face-to-face) and from 30 students in class 01, it turned out that there were only 5 students who dared to ask the lecturer. Meanwhile, during the learning process, the researchers gave questions to the students and those who dared to raise their hands were only three. During the learning, from 30 students, there were 4 students who fell asleep. 20 students did the assignments earnestly. Given different questions, apparently, there were 3 students who could answer correctly. Meanwhile, the low ability to solve mathematical problems could be seen from the daily test scores after the initial condition learning was complete. Of the 30 students who took part, the highest score was 65, and the lowest one was 32. Most of the students' scores ranged from 57, the mode was 56, the median was 59, and the mean was 61. The low ability might be caused by less appropriate learning models and devices the researchers applied in this initial condition.

Cognitive Growth model is one of the learning models that can be used to improve the critical thinking ability (Chasanah, 2019). According to Piaget (as cited by Joyce & Weil, 2008), the Cognitive Growth model in learning is intended to improve thinking ability (cognitive). Based on the views of Jean Piaget and Lawrence Kohlberg, the presentation of learning must be adjusted to the level of thinking/moral reasoning of the learners and should be able to encourage the level of thinking/moral learners one level higher (Joyce & Weil, 2008). Therefore, the Cognitive Growth model fits in with the stages of learning development and improves the students' mathematical problem solving ability. The syntax of cognitive growth learning refers to Joyce's opinion as follows in Table 1.

Table 1. Syntax of Cognitive Growth Model

Phase	Description
Phase 1 *Confrontation with stage-relevant tasks*	The integration of tasks/problems according to the stage, and the students' orientation on the problem to be studied; it is intended that students are ready to think more critically in the next learning phase.
Phase 2 *Inquiry*	Organizing the students to raise their sensitivity and improving their critical thinking ability; performing in group formation activities in a class. Analyzing and evaluating the process; the learning process that has been implemented is evaluated/reflected in order to improve the learning activities, while the results are criticized and discussed together in the class.
Phase 3 *Transfer Phase*	The integration of tasks/problems according to the stage, and the students' orientation on the problem to be studied; it is intended that students are ready to think more critically in the next learning phase.

This research aims to improve the activities and ability to solve mathematics problems on the integral calculus course using the cognitive growth model. The contribution of this research is to provide additional knowledge about learning mathematics, especially in efforts to improve the ability to solve mathematical problems. Besides, it is also expected to provide inputs to the educators to innovate more through learning using cognitive growth models.

RESEARCH METHOD

This was a Classroom Action Research (CAR). The subjects of this research were the second semester students at a college in Magelang, Central Java, Indonesia, as many as 30 students.

The research instrument consisted of test questions, rubric indicators of problem solving ability, interview guidelines, and activities observation sheets. The activities observation sheets were used to observe the students' activities according to the indicators.

Meanwhile, the Problem Solving Ability Test (TKPM) was used to determine the students' mathematical problem solving ability based on the indicators of understanding the problem, planning problem solving, carrying out the plan of solving, and re-examining.

RESULT AND DISCUSSION

The implementation of learning using the Cognitive Growth model on each cycle is described in Table 2.

Table 2. Activities of Each Cycle in the Classroom Action Research

No	Stage	Activities
1.	Cycle I	• Problem Identification • Planning I • Learning implementation using Cognitive Growth Model and Observation Material: Indefinite integrals, limit on the number of Riemann, the elementary basic theorem of calculus • Reflection
2.	Cycle II	• Planning II (Results of Reflection Cycle I) • Learning implementation using *Cognitive Growth* Model and Observation Material: Average Value Theorem, Intermediate Basic Calculus Theorem, Symmetry Theorem, Area and Volume, Curve Length • Reflection
3.	Cycle III	• Planning III (Result of Reflection Cycle II) • Learning implementation using *Cognitive Growth* Model and Observation; Material: Partial Integral Engineering, Uncommon Integral • Reflection

Table 3. Phase/Syntax of Cognitive Growth Learning Model

Phase one Confrontation with stage-relevant tasks	**Phase two** Inquiry	**Phase three** Transfer
The students are faced with a puzzling situation that matches the stage of thinking development.	• Getting the students' responses and asking for their reasons • Giving *counter-suggestion,* exploring the students' responses	• Providing other relevant tasks exploring the students' the reasons/arguments of students • Giving *counter-suggestion*

In the first stage, the students are faced with illogical problems such as puzzles and crosswords. At this stage, the problem is presented relatively in accordance with the stages of students' development. The choice of forms (verbal, nonverbal, or environmental manipulation) also depends on their developmental stage. They choose the problems based on the lecturer's guides.

Figure 1. First Stage of Cognitive Growth Model-Confrontation with Stage-Relevant Tasks
(The Students are Faced with The Problem)

The stage two tries to look at the students' responses and investigate them to see their reasoning level. Generally, this stage consists of asking for reasons and giving counter-suggestions. The initial question depends on the type of task, for example, "what do you think?" or "what do you imply?" for the positive justice task, or "what are the steps you use to solve this problem?" for the correspondence one. Furthermore, they are asked to write the results of their works.

Figure 2 Second Stage of *Cognitive Growth-Inquiry*
(The Students Give Responses and Find the Solutions)

This second stage aims to get the right responses from the students. Each counter-suggestion is to check the students' ability to defend their reasons.

Stage three is the transfer stage. It aims to see whether the students will give the same reasons in different but related assignments or not. Once again, the lecturer presents the problem; the students deliver their views. The lecturer asks for a reason and then gives a counter-suggestion.

Figure 3. Third Stage of Model *Cognitive Growth*- Transfer (The Students Defend Their Works/Opinions and Present Them in Front of Their Friends)

The improved activities per aspect consisting of courage, motivation, cooperation, creativity, and interaction can be seen in Table 4.

Table 4. Summary of Students' Activities Scores

Indicator of Students' Activities	CYCLE I	CYCLE II	CYCLE III
Courage	69,95	72,15	82,06
Motivation	66,67	69,95	81,13
Cooperation	60,53	75,55	80,67
Creativity	55,75	70,73	85,33
Interaction	69,05	77,62	80,73
Percentage	51,51%	58,56%	65,47%

Meanwhile, the students' critical thinking ability obtained using the Problem Solving Ability Test sheet (TKPM) which contains some aspects of indicators of mathematics problem solving in the Integral Calculus course are presented in Table 5.

Tabel 5. Results of Mathematics Problem Solving Test (TKPM)

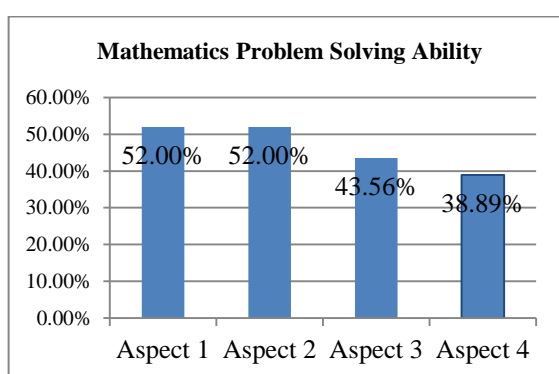| Assessed Aspect	CYCLE I	CYCLE II	CYCLE III
Understanding the problems	50,00%	46,67%	59,33%
Planning the solution	53,33%	46,67%	63,67%
Implementing the solution planning	40,33%	33,67%	56,67%
Re-examining	36,67%	33,33%	46,67%
Average Percentage	45,08%	40,08%	56,59%

Figure 4 Students' Mathematics Problem Solving Ability

Based on Figure 4, the "re-examining" indicator in the three cycles only reaches 38.89%. This means the students are not familiar with the complete steps in solving a mathematical problem until the re-examining stage. Therefore, we need treatment or practice in order to improve the ability to solve the mathematics problems in second semester students, especially in the integral calculus course. Sometimes, the students are not accustomed to facing the problem solving questions, while the problem solving process is one of the demands of critical thinking assessment (Thompson, 2011). Furthermore, Ben-Chaim, et al. (2000) stated that the ability to think critically is very important for success in life, as a step for change to keep going, and as complexity and improvement of mutual dependence. The students tend to trust and accept the information given about the problem without checking/re-checking the issue once again. Through the Cognitive Growth model, students can explore abilty to express reason, ideas, and explain to other students. This is certainly very supportive of stuthe dent's problem solving abilities.

CONCLUSION

Based on the results and discussions, it can be concluded that the application of the learning using the Cognitive Growth model for the second semester students in the integral calculus course in the Mathematics Education study program can improve the students' activities and the students' problem solving ability. The Cognitive Growth model may be useful in monitoring the students' mathematics problem solving abilities, however, further research is necessary to expand upon the observed dimensions, for example in terms of the students' ability to think logically, creativity, and cognitive style. These dimensions are estimated to be able to influence the students' mathematics problem solving abilities.

REFERENCES

Anderson, J. (2009). Mathematics curriculum development and the role of problem solving. *ACSA Conference*. Retrieved on 13 September 2019 from http://www.acsa.edu.au/pages/images/judy%20anderson%20-%20mathematics%20curriculum%20development.pdf.

Ben-Chaim, D., Ron, S., & Zoller, U. (2000). The disposition of eleventh-grade science students toward critical thinking. *Journal of Science Education and Technology*, *9*, 149-159. doi:https://doi.org/10.1023/A:1009474023364

Chasanah, A. N. (2019). Pembelajaran model cognitive growth berbasis scientific approach untuk meningkatkan aktivitas dan kemampuan berpikir kritis. *Anargya: Jurnal Ilmiah Pendidikan Matematika*, *2*(1), 21-26. doi:https://doi.org/10.24176/anargya.v2i1.2986

Joyce, B. & Weil, M. (2008). *Models of teaching* (8th ed.). London: Allyn and Bacon.

Kesan, C., Kaya, D., & Guvercin, S. (2010). The effect of problem posing approach to the gifted student's mathematical abilities. *International Online Journal of Educational Sciences*, *2*(3), 677-687.

Krulik, S. & Rudnick, J. A. (1995). *The new sourcebook for teaching reasoning and problem solving in elementary school*. Boston: Allyn and Bacon.

National Council of Teachers of Mathematics (NCTM). (2000). *Principles and Standards for School Mathematics*. Retrieved from www.nctm.org.

Polya, G. (1973). *How to solve it, a new aspect of mathematical method*. New Jersey: Princeton University Press.

Suryana, A. (2012). *Kemampuan berpikir matematis tingkat lanjut dalam mata kuliah statistika matematika*. Yogyakarta: UNY.

Thompson, C. (2011). Critical thinking across the curriculum: Process over output. *International Journal of Humanities and Social Science, 1*(9), 1-7.