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Cognitive Growth Model to Improve Students' Mathematical Problem Solving and Activities in Differential Calculus Course

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Abstract. The students' ability to solve mathematical problems is inseparable from their understanding the subject matters. In order to solve complex mathematical problems, they must understand the matters well. Therefore, an effort is needed to improve the students' activity and ability to solve the mathematical problems using Cognitive Growth model in the Differential Calculus course. The subjects in this study were first semester students of the Mathematics Education Study Program at Universitas Tidar. The data collection methods used are test and observation which are then analyzed to formulate the results of the research. The percentage increase in the students' activity in the cycle I = 33.79%, cycle II = 51.21%, and cycle III = 89.65%. Meanwhile, the percentage increase in the problem solving skills in the cycle I = 51.70%, cycle II = 58.30%, and cycle III = 61.80%. Based on the results, it can be concluded that the application of Cognitive Growth mathematics learning model can improve the activities and mathematical problem solving ability of the first semester students in Differential Calculus course.

1. Introduction

The current paradigm of education nowadays requires a change in the learning process within the classroom. The role of lecturers is currently directed to become a facilitator who can help the students in learning, not just conveying the materials. The lecturers must be able to involve their students in the learning activities optimally. According to [1], the learning will be more meaningful if the students are given the opportunity to participate in various learning activities, so that they are able to actualize their abilities inside and outside the classroom.

At the college level, the materials of mathematics are increasingly difficult to learn. [2] argued that the mathematics learning is often negatively assessed by the students and they have considerable difficulties with several mathematical processes such as reasoning, rarely problem solving activities, and proofs. Studying mathematics in higher education level generally involves high-level cognitive abilities such as analytical, synthesis, and evaluation skills, not just remembering factual knowledge or simple applications.

Mathematics cannot be separated from problem solving. The process of thinking in problem solving needs to get the attention from the lecturers to help the students to develop the ability to solve many problems in both the real world and mathematical contexts. Problem solving is an integral part in

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mathematics learning [3]. [4] defined the problem solving as a means of individuals in using knowledge and abilities that have been previously owned to be synthesized and applied to new and different situations. [5] stated that problem solving is a life skill that involves the process of analyzing, interpreting, reasoning, predicting, evaluating, and reflecting. In general, problem solving is not routinely applied, so it is classified as a high-level mathematical thinking ability [6]. Therefore, problem solving is an ability to apply previously owned knowledge to new situations that involve higher-order thinking process.

[7] stated that the problem solving can be interpreted as a series of learning activities that emphasize on the process of solving problems faced scientifically. There are three main characteristics of problem solving: (1) problem solving is a series of learning activities, meaning that in the implementation of problem solving, there are a number of activities that must be done by the students and require them to actively think, communicate, search and process data, and finally conclude, (2) learning activities are directed to solve the problems, which means the problem solving puts problems as the keywords of the learning process, and (3) problem solving is done by using a scientific thinking approach, namely the process of deductive and inductive thinking, and carried out systematically (through certain stages) and empirically (based on clear data and facts).

The material to be developed in this research is Differential Calculus. Differential Calculus is also a topic that requires the ability to interpret the meanings of mathematical symbols and concepts. This makes it difficult for the students to study. Moreover, they, in the learning process, sometimes have difficulty remembering what they have learned previously.

At the initial condition before the research was conducted, the ability to solve mathematics problems in the class 01 of Mathematics Education Study Program in semester 1 of academic year 2018/2019 was still low. It could be seen by the researcher when conducting the learning process at the initial condition. The learning was conducted three times involving 29 students in class 01, but apparently only five who dared to ask questions, while there were only three who tried to answer the questions for the researcher. During the learning process, from 29 students there were seven who were sleepy. There were only 20 students who did the assignment given seriously. Given a different problem, it turned out there are only 3 students who could solve them. While the ability to solve mathematical problems was still low, it can be seen by researchers from the scores of the quiz after the initial learning condition was finished. Of the 29 students who took part, the highest score was 65 and the lowest was 32. The students' ability to solve math problems in 01 class was still low, possibly because the initial condition of teaching had not used an appropriate learning model and devices that supported the learning.

Cognitive Growth model is a learning model that can improve the problem solving skill. According to Piaget [8] the Cognitive Growth model in learning is aimed more at improving the thinking skill (cognitive). Therefore, it fits with the stages of learning development and enhances the students' mathematical problem solving ability. The role of students in learning is highly demanded to elicit responses and ask for justification in delivering the outcomes of the learning process. With such a process, the lecturers are also required to prepare materials and condition the class so that learning activities are carried out in accordance with the learning objectives. The sintax of Cognitive Growth model could be seen in the following Table 1.

Table 1. Sintax of Cognitive Growth Model

Phase	Descriptions
Phase 1 Confrontation with stage-relevant tasks	Integration of tasks/problems according to the stages, students' orientation on the problems to be studied. It is intended that the students are ready to think more critically and solve problems in the next learning phase.
Phase 2 Inquiry	Organizing the students to raise their sensitivity and problem solving skill; being active in group formation activities in a class.
Phase 3 Transfer Phase	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.

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The difficulty of solving mathematical problems can be seen from the mistakes in the process of solving the problem [9]. Therefore, the task of mathematics lecturer is to mobilize all of his abilities to build their students' abilities, one of which is the ability to solve the problems. Before the lecturer builds the students' problem solving ability, he must understand first the characteristics of a good problem solver, so the identification process is not only focused on the results of the students' answers, or on the suitability of the settlement process. Based on the background that has been described, the mathematical learning model of Cognitive Growth is developed to improve the activities and problem-solving ability of the students in the Mathematics Education Study Program, particularly in Differential Calculus course.

2. Research Methods

This was a Classroom Action Research conducted in the odd semester of the academic year 2018/2019. The subjects of this study were the first semester students of class 01 of the Mathematics Education Study Program Universitas Tidar, as many as 29 students. The instruments used were student activity questionnaire sheets, problem solving ability test sheets, and learning implementation observation sheets. The stages of the research included planning, implementing actions, observing, reflecting and revising. In detail, the implementation of classroom action research could be seen in the following Table 2.

Table 2. Activities of each cycle

No	Stage	Activity
1.	Cycle I	• Identification of Problem • Planning I • Implementation of Learning using Cognitive Growth model and Observation • Reflection
2.	Cycle II	• Planning II (Results of Cycle I Reflection) • Implementation of Learning using Cognitive Growth model and Observation • Reflection
3.	Cycle III	• Planning III (Results of Cycle II Reflection) • Implementation of Learning using Cognitive Growth model and Observation • Reflection

The data of the observation of students' activities consisted of 20 items by giving an assessment in the scale of score and assessment categories as follows: disagree = 1, doubtful = 2, agree = 3, and strongly agree = 4. Furthermore, the average score was grouped by intervals assessment as follows: low = 1-64, moderate = 65-74, high = 75-84, and very high = 85-100.

Problem Solving Ability Test (TKPM) was used to determine the level of students' mathematical problem solving ability that measured understanding of the problems, preparing plans to solve the problems, implementing problem solving, and double checking the results of problem solving to the students after the implementation of the learning using the Cognitive Growth model. This instrument had been validated by a validator and declared as valid.

3. Results and Discussions

The results obtained in this research are the students' activities and mathematical problem solving ability. The details can be explained as follows.

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The students' activity is obtained by using a student activity observation sheet consisting of questions that contain indicators of student activity. The results of student activity starting from cycle I, cycle II, and cycle III can be seen in Table 3 and Figure 1.

Table 3. Recapitulation of students' activity score

Indicator of Students' Activity	Cycle I	Cycle II	Cycle III
Courage	34,48	54,03	87,17
Motivation	34,48	56,00	89,31
Cooperation	37,07	57,31	91,31
Creativity	30,17	54,17	89,00
Interaction	33,62	34,48	91,48
Percentage	33,97%	51,21%	89,65%

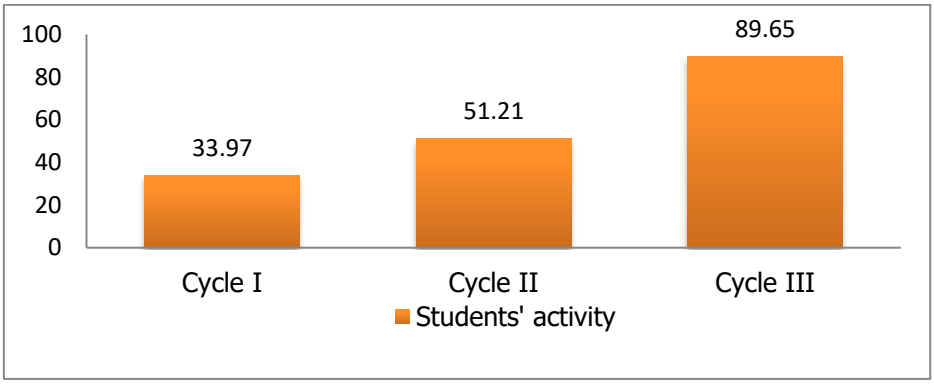

Figure 1.Result of students' activity

Based on Figure 1, it can be seen that there is a visible increase in the average score of cycle I, cycle II, and cycle III. The average score of the first cycle of student activity is 33.97 or low category, the average score of the second cycle is 51.21 or low category, and the average score of the third cycle is 89.65 with a very high category. Increased student activity can also be seen from the results of observation that show the students seem interested and enthusiastic about the learning and dare to ask and answer questions, and become more interactive.

Increased activity per aspect of activity consisting of the aspects of courage, motivation, cooperation, creativity, and interaction can be seen in Figure 2.

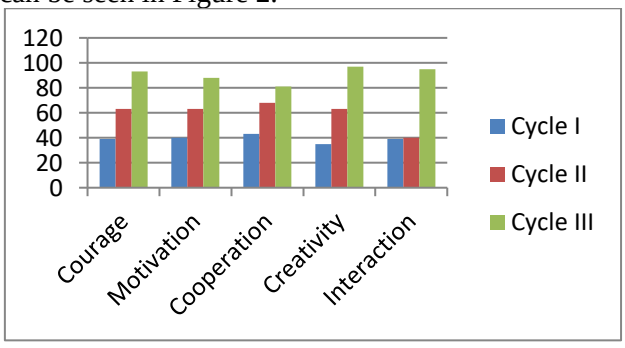

Figure 2. Result of the research viewed from the aspect of students' activity

Based on Table 3 and Figure 1, it can be found that the learning using Cognitive Growth model improves the activity of the students of class 01 of the Mathematics Education Study Program at UniversitasTidar.

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The students' problem solving skill is examined by using the Mathematical Problem Solving Ability Test (TKPM) sheet which contains aspects of indicators of problem solving skill. The results of the students' problem solving ability test can be seen in Table 4 and Figure 3.

Table 4. Recapitulation of mathematics problem solving ability test scores

Assessed Aspect	Cycle I	Cycle II	Cycle III
Average Score	51,70	58,33	61,80
Lowest Score	29,20	22,92	35,40
Highest Score	72,90	83,33	83,33
Percentage	51,70%	58,33%	61,80%

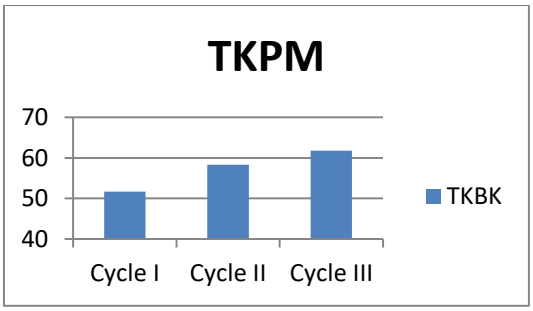

Figure 3. Mathematical problem solving ability test result

At the end of the first cycle, the students are given an evaluation problem to measure the ability to solve mathematical problems. After analyzing the results of the evaluation of the first cycle on the topic of real numbers inequality, it is obtained the average score of the students is 51.70, with the lowest score 29.20 and the highest 72.90. The student's activity in the first cycle was still low. This can be seen from the average percentage of 33.97%. Based on the data, it can be shown that the first cycle did not yet meet the established indicators, so that the next cycle must be carried out.

Based on the reflection in the first cycle, it indicates a pretty good improvement. After analyzing the data of the results of the second cycle evaluation on the topic of functions, it is obtained the average student score is 58.33, the lowest score is 22.92 and the highest one is 83.33. The students' activity in the second cycle is even better. This can be seen from the average percentage of 51.21% which means sufficient increase from the first cycle which reached 17.24%.

In cycle III, it shows a better improvement. After analyzing the results of the evaluation of the cycle III with the topic of Limit, it is obtained the average score is 61.80, with the lowest score is 35.40 and the highest one is 83.33. The students' activity in cycle III is even better. This can be seen from the average percentage of 89.65% which is a significant increase from the second cycle which only reaches 38.44%.

The percentage increase in the ability to solve the problems in the cycle I = 51.70%, cycle II = 58.33% and cycle III = 61.80%. The percentage for aspects of students' activity in the cycle I = 33.97%, cycle II = 51.21% and cycle III = 89.65%. Based on the results of data analysis about the activity and ability to solve the mathematical problems using the Cognitive Growth model, it has been proven that it is effectively applied in class 01 of the Mathematics Education Study Program in Differential Calculus course. It is supported research conducted [10], the mathematical critical thinking skills of the students in solving problems on differential calculus topic compiled based on the indicators of mathematical critical thinking skills in learning using cognitive growth model has been improved well.

4. Conclusions

Based on the results of research and discussion it can be concluded as follows.

1. The application of Cognitive Growth learning model can improve the activity of the students of class 01 Mathematics Education Study Program in Differential Calculus courses.
2. The application of Cognitive Growth learning mathematics model can improve the ability to solve mathematics problems of class 01 students of the Mathematics Education Study Program in Differential Calculus course.

Suggestions that the author can recommend as follows.

1. Learning mathematics using the Cognitive Growth model should be further developed because it is proven to be able to improve the students' mathematical problem solving ability
2. The submission of assignments and presentations from the students in lecturing activities should be used as a training medium to improve the students' activity.

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