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IMPROVE STUDENT LEARNING OUTCOMES USING STUDENT WORKSHEETS BASED ON THE APOS MODEL ASSISTED BY GEOGEBRA

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Abstract

The observation results showed that practicum activities and student learning outcomes in algebra courses were not optimal. Therefore, a learning model is needed that can make students carry out practical activities directly in class and can improve student learning outcomes This study aimed to determine the increase in student learning outcomes through the use of Rational Function Student Worksheets based on the GeoGebra-assisted APOS model. The type of research carried out is Classroom Action Research (CAR). The research instrument was in the form of a learning achievement test sheet. The subjects of this study were first semester students of the Mathematics Education Study Program at Bengkulu University in 2022. The results showed that the average learning outcomes were 71.26 in cycle I and 82.05 in cycle II with a percentage of completeness in student learning outcomes of 82.05%. in cycle II. So it can be concluded that learning using rational function student worksheets based on the APOS model assisted by GeoGebra can improve student learning outcomes.

Keywords: APOS Model; GeoGebra; Learning outcomes; Rational Function; Student worksheets

Abstrak

Hasil observasi menunjukkan bahwa kegiatan praktikum dan hasil belajar mahasiswa pada mata kuliah aljabar belum optimal. Oleh karena itu, diperlukan model pembelajaran yang dapat membuat mahasiswa melakukan kegiatan praktikum secara langsung dikelas dan dapat meningkatkan hasil belajar mahasiswa. Penelitian ini bertujuan untuk mengetahui peningkatan hasil belajar mahasiswa melalui penggunaan Lembar Kerja Mahasiswa fungsi rasional berbasis model APOS berbantuan GeoGebra. Jenis penelitian yang dilaksanakan adalah Penelitian Tindakan Kelas (PTK). Instrumen penelitian berupa lembar tes hasil belajar. Subjek penelitian ini yaitu mahasiswa semester I Program Studi Pendidikan Matematika Universitas Bengkulu Tahun 2022. Hasil penelitian menunjukan bahwa rata-rata hasil belajar yaitu 71,26 pada siklus I dan 82,05 pada siklus II dengan persentase ketuntasan hasil belajar mahasiswa sebesar 82,05% pada siklus II. Sehingga dapat disimpulkan bahwa pembelajaran menggunakan lembar aktivitas mahasiswa fungsi rasional berbasis model APOS berbantuan GeoGebra dapat meningkatkan hasil belajar mahasiswa.

***Kata kunci**: Fungsi Rasional; GeoGebra; Hasil belajar; Lembar Kerja Mahasiswa; Model APOS*

INTRODUCTION

Learning is a process of interaction between students and teachers in a learning environment that exchanges information (Kahar et al., 2020). Learning activities are inseparable from learning outcomes which are also one measure of success

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in education (Saihu, 2020). Student learning outcomes are influenced by many things, one of which is the learning model. The learning model is a pattern that is used as a guide in planning learning in class (Rahayu et al., 2020). Using an inappropriate learning model can cause low learning outcomes or not achieving learning outcomes (Astuti & Muncarno, 2021).

Based on information obtained from Ms. Tria Utari, a lecturer in low-level algebra in semester 1 of the Mathematics Education study program at Bengkulu University, the average student learning outcomes were not optimal at 70.23. In addition, a lot of material in this course requires practical activities using applications such as GeoGebra. However, the absence of special practicum hours makes students carry out practicum activities independently, do not try directly in class so that they cannot discuss, exchange ideas and practicum activities carried out are not optimal. Therefore, to be able to optimize the success of learning outcomes and practicum activities, lecturers should use learning models that can make students carry out practical activities directly in class which can improve understanding and student learning outcomes.

One alternative learning model that can be used to optimize classroom practicum activities and student learning outcomes is the APOS (Action-Process-Object-Schema) learning model with the ACE (Activities-Class discussion-Exercise) approach. If learning Mathematics is taught using APOS theory and a student-centered approach, students' higher-order thinking skills will develop (Hanifah, 2019). The APOS learning model is integrated into computer use and group learning which pays close attention to students' mental construction in understanding concepts, skills, communication, and generating ideas (Yerizon, 2013). This learning model contains a small group discussion phase which makes students exchange opinions about the problems raised so that students are used to solving a problem (Hanifah & Istikomar, 2022).

Learning with the APOS model includes practicum stages where the implementation of activities uses application programs. One application program that can be used is GeoGebra. GeoGebra can be used as a media and tool in learning mathematics, especially in geometry and algebra material to improve the quality of learning and is easy to use (Tanzimah, 2019; Tamam & Dasari, 2020). Learning by using GeoGebra allows students to get a more detailed visual experience regarding function graphs so that they can carry out deeper analysis and more easily understand the material (Wulandari, 2019). In addition to using the GeoGebra application, students also need student worksheets that contain material summaries, instructions, learning steps and problem solving regarding rational functions.

Student worksheets can encourage students to be able to practice learning independently, make it easier for students to understand the material provided, and increase students' active role during the learning process (Sukmawati & Yenni, 2020). Thus learning will be created that allows students to directly carry out practicum activities and group discussions and guide students to improve their learning outcomes.

Previous research has also been carried out by Fatimah et al. (2021) which has almost the same title but different samples, namely "Peningkatan Hasil Belajar Matematika Melalui Teori

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APOS Pada Siswa Kelas VIIC Mts Husnul Khatimah". The thing that distinguishes it from previous research is college students as research subjects. While the novelty of this study is the use of geogerba-assisted worksheets on rational function material.

Based on the background as stated above, a study was carried out which aimed to describe how to improve the learning outcomes of Bengkulu University Mathematics Education students in Low Algebra subjects using student worksheets based on APOS models assisted by GeoGebra.

METHOD

Type of the research is class action research. Classroom action research is research that has its own rules and procedures for learning activities in the form of an action, which is deliberately raised and occurs in a class together (Mu'alimin & Cahyadi, 2014: 5). Classroom Action Research which will be carried out in several cycles. Before carrying out Cycle I, a preliminary test (pretest) was carried out and at the end of each cycle a final test was given, to obtain student learning outcomes (see in Figure 1). This research is focused on efforts to improve student learning outcomes with the APOS model assisted by GeoGebra.

The subjects in this study were first-semester students of the mathematics education study program, faculty of teacher training and education, Bengkulu University which amounted to 35 students. Subject was selected by *purposive sampling* technique. The research was conducted at Bengkulu University, Bengkulu City in the odd semester of the 2022/2023 academic year with the subject matter of rational functions.

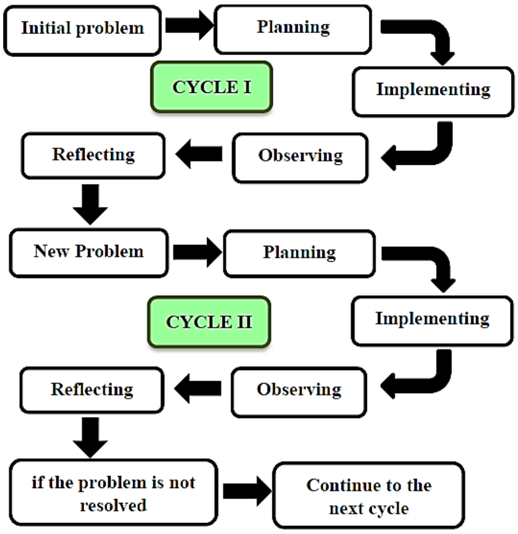

Figure 1. Class Action Research Cycle (Adaptation from Mu'alimin & Cahyadi, 2014)

Data collection techniques used in this study are test and observation techniques. In this study, tests were carried out in the form of pretests and posttests. Observations were made to observe the activities of students. The instruments used were learning achievement test sheets and observation sheets of student activities.

The data analysis carried out in this study was the analysis of test result data, observation data and student response data.

1. Analysis of Average Learning Outcomes

To calculate the average value of learning outcomes, the following formula is used

$$SM_i = \frac{JS}{TM} \times 100 \quad (1)$$

Information :
SM_i= score of the i-th student
JS = total student scores
SM = total score

The percentage of student mastery is calculated using the formula for calculating the percentage (%) of completeness as follows (Aqib et al., 2016).

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$$P = \frac{\sum \text{students who have finished studying}}{\sum \text{students}} \times 100\% \qquad (2)$$

A student is said to have completed his learning outcomes if he has the specified criteria, namely obtaining a minimum score of 70. Meanwhile, classically, a class is said to be complete if students who have score ≥ 70 are at least 85% of the number of students taking the test (Aini & Irawati, 2018).

2. Analysis of Observation Results

Observation data using the lecturer's observation sheet. For each aspect observed, it will be measured with the provisions of scoring as below:

$$N = \frac{TS}{SM} \times 100 \qquad (3)$$

Information :
N = value
TS = total score obtained
SM = maximum total score

To see the criteria for evaluating the observation sheet, it can be seen in Table 2. (Aqib et al., 2016).

Table 2. Observation Sheet Assessment Criteria

Score	Level of Success	Criteria
5	81-100	Very Good
4	61-80	Good
3	41-60	Fairly Good
2	21-40	Less Good
1	10-20	Not Good

Based on Table 2., the results of observations regarding student activity are said to be good if they have a score between 61 to 80 and are said to be very good if the score between 81 to 100.

RESULT AND DISCUSSION

Classroom action research through the application of student worksheets based on the APOS model assisted by GeoGebra to improve student learning outcomes in semester 1 of the Mathematics Education Study Program, Faculty of Teacher Training and Education, University of Bengkulu in low algebra courses consists of four steps, namely: 1) planning; 2) carry out; 3) observing; 4) reflect. Learning tools and instruments to be used in the form of learning implementation plans, student worksheets, observation sheets and learning achievement test sheets have been validated by experts beforehand and are suitable for use.

At the first meeting, a pretest was carried out for students. Students were given an initial test in the form of a description of three questions. The purpose of holding this initial test is to determine the initial ability of students in rational function material. Based on the results of the pretest, the average value of the student's pretest was 8.46. The highest pretest score obtained by students was 15 and no students had scored > 70. This shows that students' conceptual understanding of rational function material is still very low.

The learning process in the first cycle was carried out by model lecturer and observed by levtcturer who teach low-level algebra courses for the 2022/2023 academic year. In this cycle, the material studied is rational functions of the form $y = \frac{ax+b}{px+q}$ and rational functions of the form $y = \frac{ax^2+bx+c}{px+q}$. Learning is carried out in groups using student worksheets based on the APOS model assisted by GeoGebra. This

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student worksheet consists of five phases, namely the orientation phase, practicum phase, small group discussion phase, classroom discussion phase and exercise. The students were asked to discuss in groups to be able to understand rational function material by observing and following the steps contained in the student worksheets to solving problems contained in the student worksheets.

In the orientation phase students are introduced to the material to be studied. Then it is continued with the practicum phase which asks students to use the GeoGebra application to be able to describe the graphs of the rational functions contained in the worksheet according to the instructions and steps that have been given. After that, students discuss to find solutions to problems in the group discussion phase. Several groups were appointed to be able to present the results of their discussions in front of the class which would be responded to by other groups. Then each student answer the questions on the exercise phase.

At the end of the first cycle of learning, students were given post test questions. The post-test results of students in cycle I showed that the average score obtained was 71.26 with the percentage of completeness of student learning outcomes in this cycle of 58.97%. In cycle I it can be said that there was an increase in student learning outcomes from pretest to posttest cycle I. However, the learning outcomes obtained in cycle I did not reach the expected success criteria. This can be caused by students who are still not thorough and are not actively involved in solving problems in groups which causes them to not understand the material and cannot solve problems properly. Therefore further research is needed in cycle II.

At the time of the implementation of the first cycle, observations were made of student activities in the learning process using student worksheets based on the APOS model assisted by GeoGebra. This observation is the result of observations made by lecturers in low algebra courses. The results of the observations show that in general the activities of model lecturers in the teaching and learning process using student worksheets based on the GeoGebra-assisted APOS model on rational function material are in the very good category with a value of 84.61 which means that the lecturer has played an active role in carrying out the learning process.

The implementation of learning in cycle II is still the same as the previous cycle but with different sub-materials and improvements from the reflection results in the previous cycle. The learning process in cycle II was carried out in groups by discussing material on rational functions of the form $y = \frac{ax^2+bx+c}{px^2+qx+r}$. Students are given student worksheets consisting of five phases to be completed in groups with guidance from the lecturer. Before starting the lesson the lecturer reminds students to be more thorough and help each other among group members so that all members can understand and solve the problems given. This is an action step from the reflection of cycle I which is intended so that each student is more active, understands the material, and can solve problems regarding rational functions

The results of the post-test cycle II showed that the average score of students was 81.05 with a complete percentage of student learning outcomes in this cycle of 82.05%. Students can

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solve problems more thoroughly and coherently. In cycle II it can be said that there was an increase in student learning outcomes from the posttest cycle I to the final test cycle II. The learning outcomes obtained in cycle II have achieved the expected success criteria. Therefore there is no need to continue to the next cycle.

The results of observations of student activity observations show that in general lecturer activities in the teaching and learning process using worksheets based on the APOS model assisted by GeoGebra on rational function material are in the very good category with a value of 89.23. This showed that students actively participate in learning from the preparatory stage to the end of learning. Besides that, model lecturers are seen to have played an active role and are sufficiently knowledgeable in class learning

Based on the implementation of the action research of cycle I and cycle II, it was obtained an increase in learning outcomes and the percentage of classical learning completeness. Increasing student learning outcomes in each cycle can be seen in Figure 2.

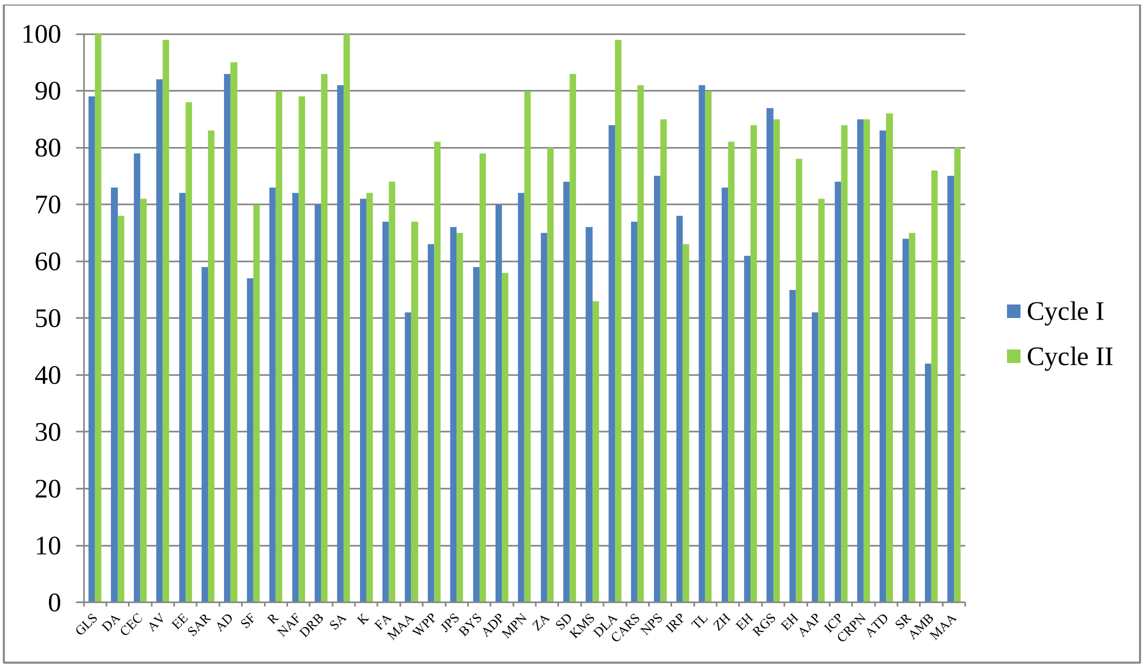

Figure 2. Graph of student learning outcomes in cycles I and II

Based on Figure 2 it can be seen that the value of each student has increased a lot from cycle I to cycle II with the average score and percentage of complete learning outcomes also increasing. In the first cycle indicators of success have not been achieved. The number of students who scored ≥70 totaled 23 students with an average student score of 71.26 and a completeness percentage of 58.97%. In cycle II the indicators of success were achieved, students were able to increase their scores with the number of students who completed as many as 32 people with an average of 81.05 and a completeness percentage of 82.05%. So that it can be said that students succeeded in completing the questions given regarding rational functions by learning using rational function worksheets based on the APOS model assisted by GeoGebra.

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Students can understand learning material and improve learning outcomes because they directly discover the characteristics of each form of rational function and how to solve it through instructions and problem solving on the given student worksheets. The use of the GeoGebra application during the practicum phase also helps students visualize graphical forms and they can check the correctness of the graphs they have painted manually during learning. In addition, they can try various forms of rational functions to see the different graphical forms in GeoGebra.

This research is in line with Listiawati (2019) which revealed that the completeness of student learning outcomes given learning based on the M-APOS approach in Abstract Algebra Subjects reached 95% and the average student response to learning was 91.5%. According to Ilmi et al. (2022) the M-APOS learning model has a positive effect on improving students' mathematical abilities so that it can improve student learning outcomes. In addition, Mentari & Sanova (2019) also revealed that GeoGebra assisted learning can improve students' mathematics learning outcomes, namely 50, 00 in cycle I to 82.76 in cycle II with 80% of students having achieved completeness in the cycle. II.

After observing in the cycle I and the cycle II on aspects of the observation sheet in learning activities using student worksheets based on the APOS model assisted by GeoGebra, the results are as shown in the Figure 3.

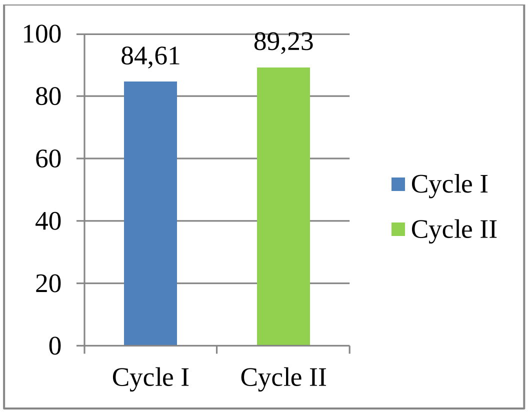

Figure 3. Graph of Observation Sheet Observation Results for Cycles I and II

Based on Figure 3., it can be seen that there is an increase in the success rate of implementing learning and student activities using worksheets based on the GeoGebra-assisted APOS model in cycle I and cycle II. The results of observing the success rate of using observation sheets in both cycles were in the very good category with a score of 84.61 and 89.23. This shows that learning is carried out very well. Students are actively involved in the learning process, they discuss with their group mates, exchange ideas, and help each other in understanding the material and solving problems about rational functions.

This is in accordance with Fatimah et al. (2021) which revealed that in general from cycle I to cycle II there was an increase in the learning activities of students who participated in learning using the APOS theory, namely from an average of 66.13% in the active category (not yet reaching research activity indicators). up to 90.45% in the very active category and have achieved research indicators. Permatasari & Susanah (2019) also states that the teacher's ability to manage learning using APOS can increase student activity and motivate students to take part in learning and students can work

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on worksheets according to the instructions contained in the worksheets, explain orally the results of work on worksheets, determine the results obtained after the presentation , and complete practice questions. In addition, Setiawan (2019) explained that learning using GeoGebra can increase student activity with pre-cycle initial conditions. It was found that all indicators of learning activity were lacking with an average score of 25 which was included in the medium category. Then it increases every cycle, namely 32 and is in the high category in cycle I, 33 in cycle II and 36 in cycle III, each of which is in the high category.

Therefore, the implication of this research is to be able to improve the quality of learning by using student worksheets based on the APOS model assisted by GeoGebra so that there is an increase in learning activities and student understanding which has an impact on improving student learning outcomes.

CONCLUSION

Based on the implementation and discussion of action research conducted on students of the Mathematics Education Study Program at Bengkulu University with low Algebra courses, it can be concluded that the use of student worksheets based on the Geogebra-assisted APOS model can improve student learning outcomes.

It is suggested that future researchers can develop research using student worksheets based on the APOS model assisted by GeoGebra to improve student learning outcomes in other subjects whose characteristics are different from the subjects that have been studied.

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