



Student Response to Geometry Student's Worksheet Based on APOS Model Assisted GeoGebra

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Abstract. This Ex Post Facto study aimed to determine the response of each small group of students about the Geometry student's worksheet (LKPD) based on the GeoGebra-assisted APOS Model made by 12 teachers or prospective mathematics teachers who are currently studying in the Mathematics Education Master's Degree Study Program, FKIP UNIB FY 2021. Every teacher produced one LKPD and has tried the LKPD on three students. The instrument used to collect data is a response questionnaire in the form of a Likert scale. The results of percentage analysis showed that the students' response scores was 84.9% and was in the *very good* category. This indicates that students are very happy to learn with Geometry LKPD based on APOS Model Assisted GeoGebra.

Keywords: LKPD Geometry · GeoGebra · Student response

1 Introduction

Mathematics learning is a process that is intentionally designed to create an environment that allows the implementation of mathematics learning activities [1]. Mathematics learning activities are intended so that children have the ability to understand mathematics. Children's ability to understand mathematics is influenced by the teacher's ability to mathematics so that in presenting mathematics material, teachers should pay attention to the needs and characteristics of students [2]. This can be done by the teacher by providing opportunities for students to be fully and actively involved in learning, and students are required to take full responsibility for their own learning efforts while the teacher is tasked with facilitating it. Frankl in Mulyati states that to find a good understanding can be done by working on it, experiencing it, or by interacting with other people [2].

The standard of mathematical ability that students need to have as stated in the standard process formulated by the NCTM (National Council of Teachers of Mathematics) are: (1) learning to solve problems (mathematical problem solving), (2) learning to reasoning and proof (mathematical reasoning and proof), (3) learning to communicate (mathematical communication), (4) learning to relate ideas (mathematical connections), (5) learning to represent (mathematical representation) [3]. Thus mathematics learning should be able to achieve the standard process formulated by the NCTM.

Learning will be effective if it pays attention to various factors supporting the success of the teaching and learning process such as choosing learning strategies and models, learning resources other than books can use computers with various applications as learning support media, computers help students in understanding mathematical concepts and can motivate students to proactive in the learning process [4]. The effectiveness and practicality of a learning media is the usability and convenience felt by the users of the learning media, the effectiveness of the GeoGebra-assisted mathematics learning media can be seen from the results of the learning test which shows that the percentage of students' learning mastery is 75.86% and the percentage is not complete is 24, 14%, and the percentage of concept understanding is more than 70%. The practicality of the GeoGebra-assisted mathematics learning media can be seen from the percentage of students' response analysis results of 89.7% which indicates that the learning media used meet the practicality criteria in their use [3]. From the trial of using GeoGebra-assisted mathematics learning media, students and teachers were very enthusiastic about using GeoGebra-assisted mathematics learning media, this can be seen from student response questionnaires and the results of interviews with teachers, with learning using interactive media in the learning process can improve students' conceptual understanding on the material of geometric transformation, it is also seen that students are more interested in the learning process using this application compared to learning with simple tools and materials such as rulers and compasses, so as to improve student achievement.

The importance of ICT in learning, including in computer-assisted learning, was conveyed by the following practitioners. Computer-assisted learning is very important for teachers and students [5]. Computer-assisted learning is important for teachers, among others because: (1) teachers play more roles as student facilitators, (2) provide more alternative changes to variations in learning methods, and (3) minimize the level of misunderstanding of concepts/theories that are often faced by students so that efficiency and learning effectiveness can be achieved. For students, computer-assisted learning is important because: (1) students understand abstract learning materials more easily and quickly because abstract concepts/theories are presented carefully and clearly so that students understand abstract learning materials more easily and quickly, (2) increase student motivation in the process. Learning, (3) improve student learning outcomes, and (4) can accommodate slow students, so as to create an effective climate individually [6].

GeoGebra has various facilities that support mathematics learning. GeoGebra can be used to demonstrate or visualize mathematical concepts as well as a tool for constructing mathematical concepts. The use of GeoGebra in mathematics learning can foster creative mathematical reasoning, support collaboration, make students more involved in the learning process and more senses are involved in learning and learning to be effective. As a tool to construct mathematical concepts. The use of GeoGebra in mathematics learning can foster creative mathematical reasoning, support collaboration, make students more involved in the learning process and more senses are involved in learning and learning to be effective. The use of GeoGebra can support in practicing thinking and reasoning and drawing conclusions; develop creativity; develop problem solving skills; and develop the ability to communicate ideas, also known as the 4Cs.

When designing learning, what needs to be considered is the activeness of students during learning, and the ability of students to remember what they have learned [7].

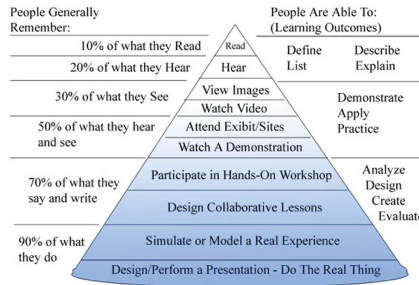


Fig. 1. Dale’s Cone of Experience (Adapted from Davis, B. & Summers, M., 2015) [8]

Figure 1 illustrates the relationship between student activity and the ability to absorb or remember students in learning mathematics.

Based on this, the authors have developed a Mathematical Learning Model Based on Action Theory, Process Objects, and Schemes (APOS Model) (Hanifah, 2015; Hanifah, 2016; Hanifah, 2019) [9–11]. The APOS model is a student-centered learning model with a syntax consisting of phases: Orientation, Practicum, Small Group Discussion, Class Discussion, Exercise, and Evaluation. To implement the APOS Model, a Worksheet based on the APOS Model was developed. The following is an explanation of the APOS Model syntax which consists of 6 phases, namely:

- a. Orientation Phase. The activities of lecturers/teachers are preparing students to take part in learning using the APOS Model-based Worksheet, providing a summary of the material, and explaining the objectives of the week’s learning. Before entering the new Worksheet, the lecturer gives students the opportunity to ask questions, and the lecturer concludes the previous week’s material.
- b. Practical Phase. Student activities are doing practical activities using computer application programs such as Maple, or GeoGebra, which are on the Worksheet. The results of the execution are copied back to the space provided in the LK. The purpose of the practicum phase is to introduce a new concept, information, or situation. Practical activities are carried out in groups, by dividing the task of typing commands or copying Maple’s answers in the table provided, and reading the main source book. In addition to the computer laboratory, the implementation of practicum can take place in class, by means of students bringing laptops. During the practicum phase, the lecturer acts as a guide who walks from one group to another.
- c. Small Group Discussion Phase. This small group discussion will assist students in finding and constructing and understanding the meaning of the execution results of the application program used in the practicum phase. Through small group discussions, students are expected to be able to understand the learning concepts being discussed. To strengthen students’ understanding of a subject, questions are also provided which will be solved manually without the help of an application program. Students are asked to discuss the answers to the questions that have been provided. For a subject that cannot be explained using an application program, it is the duty of the lecturer to provide assistance (scaffolding) on the subject.
- d. Class Discussion Phase. In this phase, the lecturer chooses a group of students to explain in front of the class the answers to the questions on the Worksheet for the Class

- Discussion phase. Another group of students listens and is given the opportunity to ask questions, or express opinions. Lecturers act as mentors who are ready to provide scaffolding when needed during class discussions.
- e. Exercise Phase. The purpose of the Exercise phase is to strengthen students' understanding of a subject, which was discussed in the previous phase. In the Exercise phase, the lecturer gives questions taken from the Practice questions. Limited time in class, so the questions in the Exercise can be used as homework (PR). In completing homework, students are asked to study the main source books, and teaching materials in various forms, so that the limited time and information in class can be completed by students from studying material from various sources from home.
 - f. Evaluation Phase. The evaluation phase is the phase where the lecturer collects information that can be used for decision making, whether the material can be continued or providing assistance for improvement, or for other decisions.

The APOS model has been applied to the Integral Calculus course since FY 2017/2018–FY 2019/2020 at the UNIB FKIP Undergraduate Study Program. The application program used is Maple version 11, and Maple version 17. Learning is carried out in class where students are in small groups. Each group must bring a laptop. However, in FY 2020/2021 learning takes place online, using zoom, google classroom, and WhatsApp. Maple must be operated on a computer/laptop, cannot be operated on a cellphone. Many students do not have laptops, so the APOS Model assisted by the Maple application program cannot be implemented for online learning. Based on experience, the APOS Model has also been applied to the Transformation Geometry course for the 2018/2019 academic year using the GeoGebra application program. GeoGebra can be operated via HP. GeoGebra is very easy to use and the results are very interesting. Based on this, socialization was carried out on the development of geometry learning tools based on the GeoGebra-assisted APOS Model to Bengkulu City Mathematics MGMP teachers on September 15, 2021 which was held at SMP N 6 Bengkulu City. The follow-up in the form of making learning devices by students is rather difficult to implement because the arena of the dense activities of teachers in their respective schools in dealing with UTS and other activities. Previously, the socialization of the GeoGebra-assisted APOS Model had been carried out for mathematics teachers/prospective teachers who were attending master's degree courses at the Mathematics Study Program FKIP UNIB FY 2021/2022 in the Mathematics Learning Psychology Matriculation course.

The APOS model was introduced to students as an example of applying Vygotsky's Social Constructivism learning theory. After being given an example of LKPD based on the APOS model with the help of GeoGebra, students were asked to design their own LKPD for Geometry material. The LKPD has been presented virtually through an application during lectures. Based on this, it is deemed necessary to conduct research on student responses to LKPD made by teachers/prospective mathematics teachers in small group trials (3 students).

2 Research Method

This research is an Ex Post Facto study, namely research conducted to examine an event that has occurred and then look back to find out the factors that can cause the incident [12].

2.1 Research Subject

The research subjects were all students who participated in implementing the teacher-made LKPD or prospective mathematics teachers. Number of LKPD = 12 copies. Each LKPD was tested on 3 students. The total number of students is 36 people.

2.2 Data Type

The type of data in this study is quantitative data.

2.3 Research Instruments

To collect data, the instruments needed in this study are:

1. LKPD Answer Sheet
2. Student response questionnaire about LKPD made by teachers/prospective mathematics teachers

2.4 Data Analysis Techniques

The research data were analyzed descriptively quantitatively. For open questionnaires, all student answers are copied, if there are any, it is enough to copy them. For data in the form of a questionnaire using a Likert scale, the data analysis techniques obtained are as follows [13].

- a) Give a score for each item with the answers: strongly agree (5), agree (4), undecided (3), disagree (2), and strongly disagree (1).
- b) Summing up the total score of each respondent and performing calculations with the following formula:

$$P = \frac{\text{Total score obtained}}{\text{Maximum score}} \times 100\%$$

Note: = *P* Score percentage.

- c) Interpret scores based on Table 1.

Table 1. Score Percentage Categories

Score Interval (%)	Category
$80 < P \leq 100$	Very good/positive
$60 < P \leq 80$	Good/positive
$40 < P \leq 60$	Enough
$20 < P \leq 40$	Not enough
$0 \leq P \leq 20$	Very less

Source: Modification from Sugiyono [13]

3 Result and Discussion

3.1 Result

Figure 2 is an example of the results of the LKPD design for the Practicum phase.

It can be seen in Fig. 2 an example of LKPD answers in the practicum phase in which there are GeoGebra commands and the results obtained. Each LKPD discusses different material so that the contents of the LKPD in the practicum phase are not the same. After the small group students filled out the LKPD made by the math teacher, the students were given a response questionnaire. The teacher checks the LKPD and gives an assessment for each phase. In the exercise phase there are questions that must be done by students without the help of GeoGebra. The value in the exercise phase is used as a benchmark for the success of implementing LKPD in small groups. After the data is processed, the results are obtained as Table 2.

In Table 2 it can be seen that the average value of the answers to questions in the Practice phase is 87.19 and the student's response to the LKPD made by the teacher/prospective mathematics teacher is 85.1% with very good/very positive qualifications. This means that students are very happy to learn with LKPD assisted by APOS Model assisted by GeoGebra.

3.2 Discussion

In Fig. 2 it can be seen that, when the GeoGebra command in the practicum phase is carried out, the results look very interesting and pleasing to the students who fill out the LKPD. The following is a record of the implementation of the small group test represented by two teachers, the message is similar.

3.2.1 The AMN Teacher with the LKPD on the Tangent Line of the Two Circles Outer Fellowship Stated

“Based on the teacher's observations and the results of students filling out a questionnaire about the practicality of the APOS model-based geometry worksheet and GeoGebra-assisted, it can be concluded that the learning that took place was very interesting and students actively participated and were very practical in teaching geometry material.

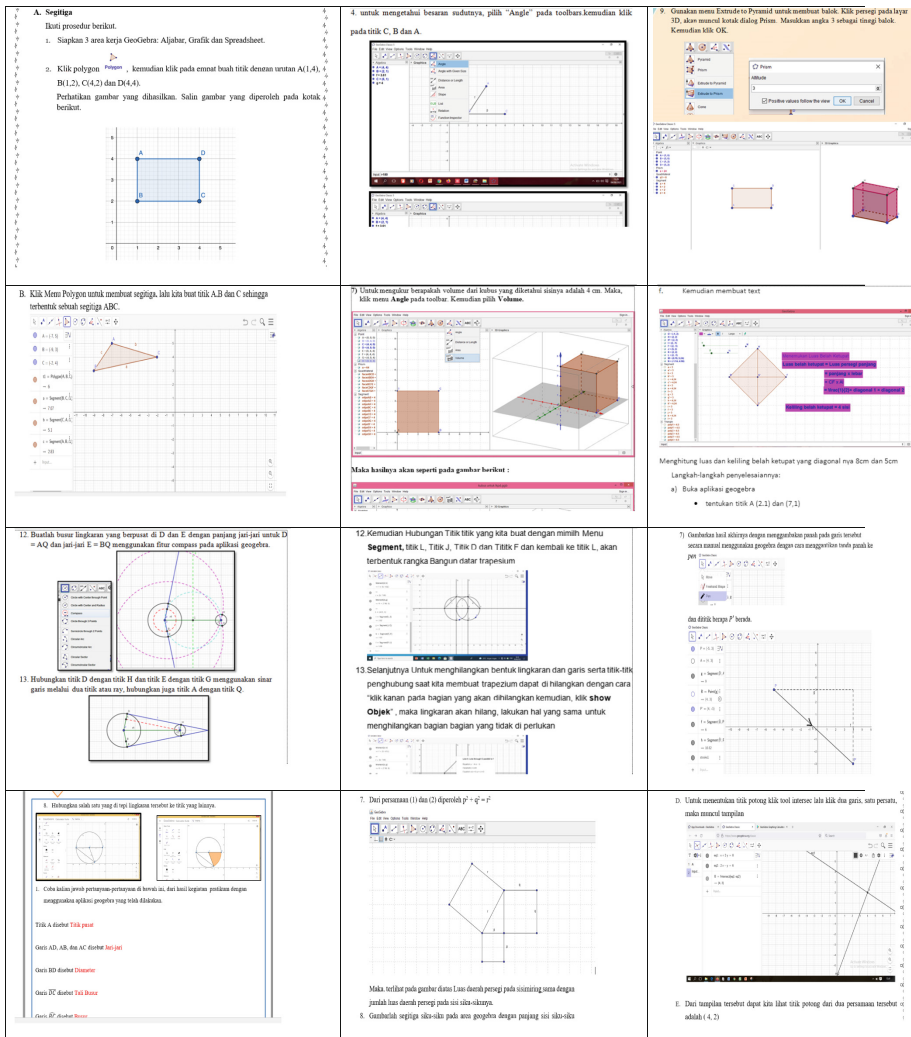


Fig. 2. Examples of LKPD Answers in the Practicum Phase

This LKPD if in the cone of Edgar Gale’s experience includes “engaging in discussions, and doing real things”, so that the learning that students can remember is around 50%–90%. The obstacle faced is that at the beginning of learning students are still afraid and confused to use the GeoGebra application. However, with the provision of confidence and reinforcement from the teacher, students begin to be confident to do it. In 1 group there are variations of students. There are students who are dominant in doing it and there are students who only hand over the work to their friends. With individual exercises, teachers can see which students are really serious about working on the LKPD and which students are less active in participating.”

Table 2. Average Value of Exercise Answers and Student Responses to LKPD Made by Mathematics Teachers

No	Teacher Code	LKPD material	The number of students	Score	
				Exercise	Response (%)
1	AAK	Lines and Angles	3	85.33	82.6
2	AAM	Tangent Line of the Outer Guild of Two Circles	3	93.33	86.6
3	DES	Perimeter and Area of Trapezoid	3	83.33	98.6
4	EPW	Two Variable Linear Equation System	3	86.67	81,3
5	GVE	Area and Perimeter of a Triangle	3	89.67	92.6
6	LGF	Surface Area and Volume of Block	3	88.33	85
7	MAS	Congruence and Congruence	3	84.00	82.6
8	NRW	Congruence Build Flat Side Space	3	85.00	81.2
9	RNB	Material Transformation (Translation)	3	93.33	76.4
10	RAT	Circle Elements	3	80.67	85
11	SMT	Area and circumference of a rhombus	3	90.00	82.8
12	YNT	Pythagorean Theorem	3	86.67	84
Average				87.19	84,9

3.2.2 The RAT Teacher with the LKPD on the Circle Elements Stated That

Seeing the students' responses to the work on the LKPD given, it can be seen how enthusiastic they are about learning mathematics, at first they thought that learning mathematics was only familiar with formulas, but after being given the LKPD, it attracted much sympathy from students to work on the questions in the LKPD that was given. Given and much more enthusiastic about learning by using the GeoGebra application". Mrs. Rat concluded that "From the LKPD test that I did, I think that in a learning process the teacher's role is very important in creating an exciting learning atmosphere. Whether it's in the presentation of material that attracts students' sympathy, or in the way the teacher delivers the material. we can introduce students to many things about

mathematics, one of which is how to use GeoGebra, maybe many of us don't know what GeoGebra is? what is the function of the GeoGebra? how to use the GeoGebra?, as well as students, by presenting varied material, it is hoped that it can increase students' interest in learning mathematics".

Similar opinions were also expressed by several researchers, namely: At the beginning of the trial, students were asked to try to understand Part 1 of the LKS which contains an introduction to the use of GeoGebra software in Linear Program material [13]. At this stage, they are still not familiar with using the GeoGebra Software, so it takes longer to understand the button functions in the GeoGebra Software, either through the instructions provided in the worksheet or by doing trial and error. After understanding how to use GeoGebra Software, they are faster in working on questions in the worksheet [14]. Based on the test results, it can be concluded that the worksheets assisted by GeoGebra software can help students understand the Linear Program material. Students are more motivated and enthusiastic in learning mathematics, especially in Linear Program material. Students can also learn to study independently with the help of GeoGebra software. In addition, with the existence of this worksheet, the teacher feels helped in the implementation of learning.

The results of other studies also show that the results of the percentage of student activities during learning using the GeoGebra software-assisted learning module on the flat-sided geometry material are more than 90%, there is an increase in formative tests, on average more than 50% of students give positive responses, and observers also gave a positive response to the use of the GeoGebra software-assisted learning module for flat-sided geometry [15]. The application of GeoGebra software in the learning process can attract students' interest in learning in the learning process so that it can have a positive impact and increase students' interest in learning [16].

4 Conclusion

Student responses to learning mathematics using geometry LKPD based on APOS models assisted by GeoGebra are in the very good category with a percentage of 84.9%. Learning by geometry LKPD based on APOS models assisted by GeoGebra can increase student interest in learning and be able to provide good student learning outcomes. This can be seen from the results of students' training who obtained an average score of 87.1.

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References

1. Hamzah, A., & Muhlisrarini. (2016). *Perencanaan dan Strategi Pembelajaran Matematika*. PT. RajaGrafindo Persada.
2. Mulyati, T. (2016). Pendekatan Konstruktivisme dan Dampaknya Bagi Hasil Belajar Matematika Siswa SD. *Jurnal Pendidikan Dasar EduHumaniora UPI Kampus Cibiru*. 1(2), (1–8).

3. NCTM 2000. *Principles and Standards for School Mathematics*, Published by NCTM 2000.
4. Irma, M. H., & Sulisworo, D. (2021). Pengembangan Media Pembelajaran Matematika Berbantuan GeoGebra Pada Materi Transformasi Geometri. *Jurnal Equation. Teori dan Penelitian Matematika*, 4(1). ISSN 2599-3291 (Cetak), ISSN 2614-3933 (Online).
5. Purnomo, J. (2021). Kebermanfaatan Penggunaan GeoGebra Dalam Pembelajaran Matematika. *Indonesian Digital Journal of Mathematics and Education*, 8(1). <http://p4tkmatematika.kemdikbud.go.id/journals/index.php/idealmathedu/>. p-ISSN 2407-8530e-ISSN 2502-602X
6. Harini, L. P. I., & Gede Santi Astawa, I. (2015). Peningkatan Kemampuan Guru dalam menggunakan geogebra sebagai Media Pembelajaran Matematika SMP. In *Proceeding SNATIA*.
7. Diana, B. (2021). *The cone of experience in teaching mathematics synchronously and asynchronously*. <https://ojs.ukrlogos.in.ua/index.php/interconf/article/view/9297/9006>, <https://doi.org/10.51582/interconf.19-20.02.2021.018>
8. Davis, B., & Summers, M. (2015). Applying Dale's cone of experience to increase learning and retention: A study of student learning in a foundational leadership course. In *QScience Proceedings. Engineering Leaders Conference 2014*.
9. Hanifah. (2015). Model Pembelajaran Kalkulus Berdasarkan Teori Aksi Proses Objek dan Skema (Model MPK-APOS). *Desertasi UNP*. Tidak dipublikasikan.
10. Hanifah. (2016). *Model APOS Inovasi Pada Pedmbelajaran Matematika*. FKIP Press. UNIB
11. Hanifah. (2019). Model APOS. *Pembelajaran Berbantuan Komputer*. CV.ZIGIE UTAMA. Bengkulu
12. Sugiyono. (2012). *Metode Penelitian Kuantitatif, Kualitatif, dan R&D*. Penerbit Alfabeta.
13. Sugiyono. (2015). *Metode Penelitan Pendidikan (Pendekatan Kuantitatif, Kualitatif, dan R&D)*. Alfabeta.
14. Faizah, H., & Astutik, E. P. (2017). Efektivitas Lembar Kerja Siswa (LKS) Berbantuan Software GeoGebra Pada Materi Program Linier. *FIBONACCI: Jurnal Pendidikan Matematika dan Matematika*, 3, 2.
15. Rhilmanidar, R., Ramli, M., & Ansari, B. I. (2020). Efektivitas Modul Pembelajaran Berbantuan Software GeoGebra pada Materi Bangun Ruang Sisi Datar. *Jurnal Didaktik Matematika*. <https://doi.org/10.24815/jdm.v7i2.17915>
16. Novilanti, F. R. E., & Suripah. (2021). Alternatif Pembelajaran Geometri Berbantuan Software GeoGebra di Masa Pandemi Covid-19. *Jurnal Cendekia: Jurnal Pendidikan Matematika*, 05(01), 357–367.

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