ISSN 2614-5103 (Print)
2614-5111 (online)
IndoMath
Indonesia Mathematics Education
https://indomath.org/index.php/indomath
Vol 5, No. 2, August 2022, pp. 109 – 122

# Analysis of Mathematics Problem Solving Ability of Junior High School Students Based on APOS Theory Viewed from the Type of Kolb Learning Style

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**ABSTRACT**

The purpose of this study was to describe students' mathematical problem solving based on APOS theory in the form of Kolb's learning style. The research type is qualitative with a descriptive approach. The subjects of this study were four students who represented each of Kolb's learning styles. Data collection techniques in this study used Kolb's learning style questionnaire, APOS theory-based problem-solving aptitude test, and unstructured interviews. This research analyzes data to reduce, present, and conclude. The study results concluded that the subject of assimilator and converger learning styles could solve problems correctly from the action, and process, while the object has not been able to because there are still errors in calculating absolute values and errors in inputting $x_i$ and schema stages, although with different problem-solving steps. Issues with the type of accommodation and diverger learning styles can only solve problems correctly at the action, process, and object stages, while for the schema stage, they have not been able to provide correct solutions.

Keywords: Apos Theory, KOLB Learning Style Problem Solving Ability

**ABSTRAK**

Lemahnya kemampuan pemecahan masalah membuat siswa belum bisa menyelesaikan matematika dan belum mengetahui tahapan yang akan dikerjakan terlebih dahulu. Tujuan penelitian ini ialah mendeskripsikan pemecahan masalah matematis siswa berbasis teori APOS pada gaya belajar Kolb. Jenis penelitian ini adalah kualitatif dengan pendekatan deskriptif. Subjek penelitian ini hasil angket gaya belajar Kolb yaitu empat siswa yang mewakili masing-masing indikator gaya belajar Kolb dengan memperoleh kategori tertinggi serta diambil berdasarkan atas saran dari guru. Teknik pengumpulan data dalam penelitian ini menggunakan angket gaya belajar Kolb, tes bakat pemecahan masalah berbasis teori APOS, dan wawancara tidak terstruktur. Analisis data penelitian ini adalah mereduksi data, menyajikan data, dan menarik kesimpulan. Berdasarkan hasil penelitian disimpulkan bahwa subjek gaya belajar asimilator dan konvergen dapat mengerjakan masalah dengan tepat mulai tahap tindakan, tahap proses, tahap objek, dan tahap skema meskipun dengan langkah pemecahan masalah yang berbeda. Subjek dengan tipe gaya belajar accomodator

dan diverger hanya mampu menyelesaikan masalah dengan benar pada tahapan aksi, dan proses sedangkan objek belum mampu karena masih terdapat kesalahan dalam menghitung nilai mutlak dan kesalahan mengimput $x_i$, sedangkan untuk tahapan skema belum mampu memberikan solusi yang tepat. Dalam penelitian ini menyarankan untuk membuat soal lebih dalam lagi dengan mengacu pada indikator APOS.

Keywords: *Gaya Belajar KOLB, Kemampuan Pemecahan Masalah, Teori APOS*

## INTRODUCTION

According to the Regulation of the Minister of National Education of the Republic of Indonesia Number 22 of 2006, it is explained that one of the objectives of learning mathematics in schools is for students to acquire problem-solving skills, including understanding. Problems, designing mathematical models, refining the models, and interpreting the solutions obtained. Depending on the objectives of learning mathematics, it requires students to have special skills, namely solving mathematical problems is a must that must be achieved in learning mathematics (Ibrahim et al, 2021. But real problem solving is one of the most challenging skills for students to learn (Amam, 2017; Fuchs et al., 2019; Efriana, 2021; Izzatul & Istiqlal, 2019; Rinaldi & Afriansyah, 2019; Septian et al, 2022). If the student's problem-solving ability is low, the objectives of the educational pillars that have been described previously will not be achieved. Besides that, the direct impact that can be seen on students' mathematics learning achievement is low (Dewi et al., 2020; Kristina & Widodo, 2018; Mulhamah & Putrawangsa, 2017; Oktaviyanthi & Agus, 2019; Puadi & Habibie, 2018).

students often could not complete mathematics due to weak problem-solving skills and not knowing the stages to do first (Siswanto et al, 2018; Mustafia, 2018; Turyanto, 2019). Practical problem solving is impossible to ignore because problem-solving is not only a skill taught and used in mathematics but also incorporated into students' daily situations or decision contexts so that problem-solving capabilities can help individuals solve their problems. Therefore, the teacher's task is significant in developing students' problem-solving abilities (Murwaningsih et al., 2014; Astutiningtyas, 2017; Pujiastuti, 2020; Masfufah et al., 2021; Widodo et al, 2021). The description above shows the importance of developing and improving students' problem-solving abilities because by being equipped with problem-solving skills, students can solve everyday mathematical problems, so they no longer think that mathematics is just a theoretical concept, useless in learning. Everyday life.

Problem-solving skills are not just in systematically solving problems on the given material but can model, find concepts, simplify, and use ideas in solving more complex issues (Beghetto, 2018; Rinaldi & Afriansyah, 2019). Yarmayani (2016) states that students can solve mathematical problems when they can understand and find the right strategy to apply to situation solving. The ability to solve mindless problems well also affects better academic performance in mathematics. The outline of learning mathematics is the ability to solve mathematical problems routinely or non-routinely in everyday life (Lestari & Rosdiana, 2018).

Cooney revealed that students' mathematical problem-solving skills are more analytical in making life decisions and become a reference for understanding a mathematical concept, so it is necessary to analyze the possibilities. Students' problem-solving abilities for mathematical concepts.

Ningsih (2016) suggests that it can be used in the APOS step to determine how students understand mathematical concepts such as algebra, statistics, analysis, and other mathematical topics. APOS is a constructivist theory in teaching the studied mathematical concepts. APOS theory indicators (action, process, object, and schema) measure problem-solving ability. Lestari (2015) revealed that during the action phase, object transitions were deemed necessary by individuals and groups according to step-by-step procedures on how to perform operations. Process steps are mental constructs that occur internally when a person can repeatedly achieve a level of action. The object stage can be understood as something that is the result of mental construction that has been implemented in the process stage. A schema is a collection of actions, processes, and objects that are encapsulated in a schema. Therefore, APOS theory can be used as an analytical tool to find solutions for students' Mathematics learning. Learning styles are central to the development of achievement in the workplace, school, and interpersonal situations.

According to (DePorter & Hernacki, 2000), in learning, everyone tends to have one learning style, both in communication and processing. Each individual's learning style can show the best and fastest process for each student in the effort to absorb information. One of the appropriate learning styles is the Kolb learning style, which consists of four types: diverger, assimilator, converger, and accommodations (Alqahtani & Al-Gahtani, 2014; D'Amore et al, 2012).

Research related to the analysis of mathematical problem-solving abilities has been carried out. Ariawan & Nufus's (2017) study shows that the higher the mathematical problem-solving ability, the higher the students' mathematical communication skills. Research Kurniawan & Setiawan (2019) on solving mathematical problems of junior high school students have carried out with the help of contextual questions on flat-sided geometry with the result that the mathematical problem-solving ability of junior high school students was still relatively moderate, so efforts were needed to improve.

Research that links mathematical problem-solving abilities with APOS theory has been carried out. Jazim et al (2021) showed that students with field-independent cognitive styles in solving mathematical problems could go through all APOS theory stages, including the steps of action, process, object, and schema, properly and correctly. Students with field-dependent cognitive styles in solving mathematical problems can go through all APOS theory stages, including the action, process, object, and schema stages, but mistakes are still made at the process and object stages. Anam et al (2018) researched students' mathematical problem-solving abilities based on the APOS theory in the Florence Littauer personality type by showing the results that not all Florence Littauer personality types can meet all the indicators of the Florence Littauer theory. Research on problem-solving abilities associated with APOS theory in learning style has not been studied. Thus, research on students' mathematical problem-solving skills based on APOS theory in terms of Kolb's learning style is the novelty of this study.

Based on the background of the problem, the researcher tried to analyze the students' mathematical problem solving based on the APOS theory in terms of Kolb's learning style. Therefore, according to David Kolb, it is necessary to research various learning styles in learning mathematics. This study aims to describe students' mathematical problem-solving abilities based on APOS theory in the Kolb learning style.

## METHODS

This type of research is qualitative with a descriptive approach. The population in this study was class VIII students consisting of 15 students at the Assyifa Learning Center Pasuruan Foundation, with the trial subjects in this study being four students. The selection and determination of the research trial subjects were carried out after 15 students filled out the questionnaire that had been provided. After that, the type of learning style of each student will be known. Furthermore, of each kind of Kolb learning style consisting of four research subjects with assimilator, accommodator, converger, and diverger learning styles, one student with a high category will be taken. The assimilator indicator is in a formal learning situation (Tenri Awaru et al, 2020). He prefers to read, teach, explore analytical models, and take the time to think about things in depth. The indicator of the accommodator is that in formal learning situations (Adam, 2019), he prefers to work with others to complete tasks, set goals, do fieldwork, and test various problem-solving. Convergence indicates that he tends to experiment with new ideas, simulations, and practical applications in formal learning situations (Kolb, 2014). Diverger indicators are in legal learning situations. He prefers to work in groups and receive personal feedback. He can listen with an open mind (Azrai et al, 2017; 2018).

Data collection techniques in this study were using a learning style questionnaire, a problem-solving ability test based on APOS theory, and unstructured interviews. The questionnaire used is Kolb's learning style questionnaire with a Likert scale. The results of this Kolb learning style questionnaire, to take the research subject are four students who represent each Kolb learning style indicator by having the highest criteria and bringing this subject is also based on the teacher's suggestion. Furthermore, the four students were given a problem-solving ability test based on the APOS theory used in this study in the form of a description test question of 1 question containing the APOS theory indicators. This test aims to determine the problem-solving ability based on APOS theory regarding Kolb's learning style. After being given a test for the four students, interviews were conducted to obtain more detailed or in-depth information about problem-solving abilities based on APOS theory. APOS indicators are actions, processes, objects, and schemas. Action is to determine what is known and answered. The process is to explain the troubleshooting steps of the test. The thing solves the problem with the stages of completion coherently and clearly. Schema is to explain back the results of his work.

The instrument used in this research is a Kolb learning style type questionnaire to classify the types of student learning styles. Then the test instrument to determine students' mathematical problem-solving abilities based on the APOS theory used a description question to strengthen and clarify answers, using an interview guide that contained an outline of questions about how to solve the problems he was working on. Problem-solving test questions do the method of data collection. Furthermore, one student will be selected from each Kolb learning style and the results of problem-solving tests to participate in the interview stage.

After the data is collected, the data analysis procedure is carried out based on the data analysis conducted by Miles & Huberman, which consists of data reduction, data presentation, and conclusion drawing. Data reduction in this study includes activities involving selecting, focusing attention, simplifying the raw data in the field, abstracting, and transforming. The presentation of the

data is to analyze the problem-solving ability based on the APOS theory of the four categories of Kolb's learning style. The data can be in the form of a description and the relationship between various learning styles. Drawing conclusions based on verification of the collected data analysis results because the previous data are provisional and not strong without consistent evidence. Furthermore, concluding the study aimed to describe problem-solving abilities based on APOS theory in Kolb's learning style.

## RESULTS AND DISCUSSION

The results of this research and data analysis were based on data obtained when research at the Assyifa Learning Center Foundation in Pasuruan was conducted in February 2022. The research was carried out in class VIII with different public and private schools to determine the diversity of Kolb learning styles. In this study, only four students were taken to make the research subjects. Subjects were selected based on the results of Kolb's learning style questionnaire by having a high category for each type of learning style, namely assimilator, accommodator, converter, and diverger. So that it was obtained four students from the results of the Kolb learning style questionnaire analysis, which had a high category and supported this research as well as the agreement with the teacher, namely AS was a student with an assimilator learning style type, AK was a student with an accommodator learning style type, KO was a student with a converger learning style. And DI are students with divergent learning styles. The problem-solving ability test based on the APOS theory used in this study was a test question in the form of a description of 1 question containing APOS indicators, namely Action, Process, Object, and Schema. This interview was conducted to obtain in-depth or detailed information about problem-solving abilities based on APOS theory.

### Problem-solving ability based on APOS theory with Assimilator learning style type

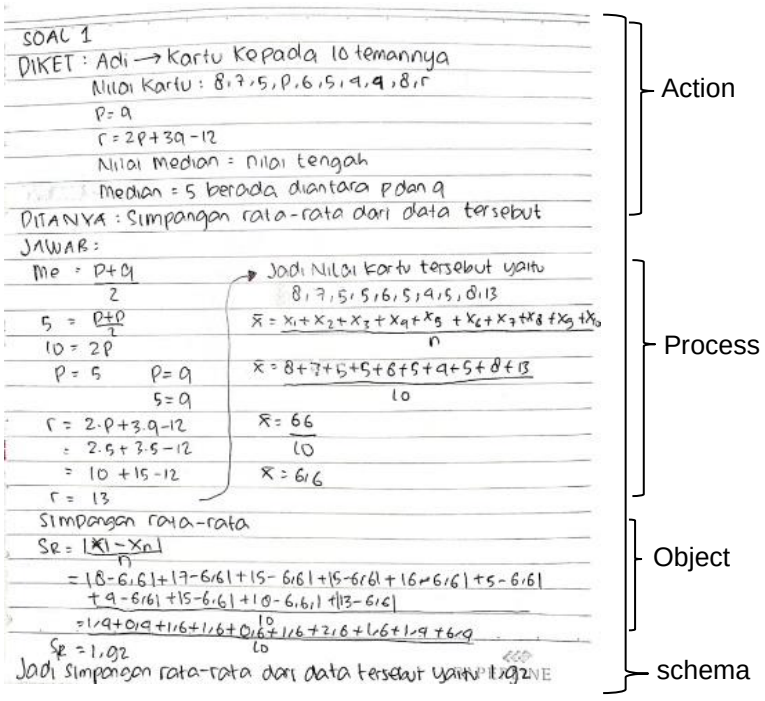


Figure 1. US Student Answer Sheet with assimilator learning style

Based on the results of AS' work, students could give the correct answer in the action stage. At the time of the interview, US students initially did not know the information about the median, but when the researcher asked for more details, the SK students could answer the questions fluently and accurately. At this stage of the process, students answered correctly in determining the median formula and looking for the average value of the bridge card. At the time of the interview, US students can mention the method used in working on the problem using the Me formula to find the value of p and q, the value of r, and the average value of the bridge card.

At the object stage, students can determine the formula for the average deviation value, which previously looked for the average value of the bridge card value, and can correctly complete the S-R (average deviation) results. At the time of the interview, AS students could explain well the method used in determining the value of S-R (average deviation) and calculating the absolute value of the mean deviation, which they could understand. At the schema stage, AS students answer correctly and can explain the results of their work. At the time of the interview, US students can explain the answers they get from beginning to end so that they get the correct conclusions and answers and try to recheck the work from the start. This is supported by research by Ghufron & Risnawita (2014) that individuals with the assimilator type have advantages in understanding various presentations of information collected from multiple sources. The similarity of these studies is that the assimilator style type has advantages in presenting and collecting data from multiple sources—problem-solving ability based on APOS theory with the Accommodator type of learning style.

**Problem-solving ability based on APOS theory with Accommodator type of learning style**

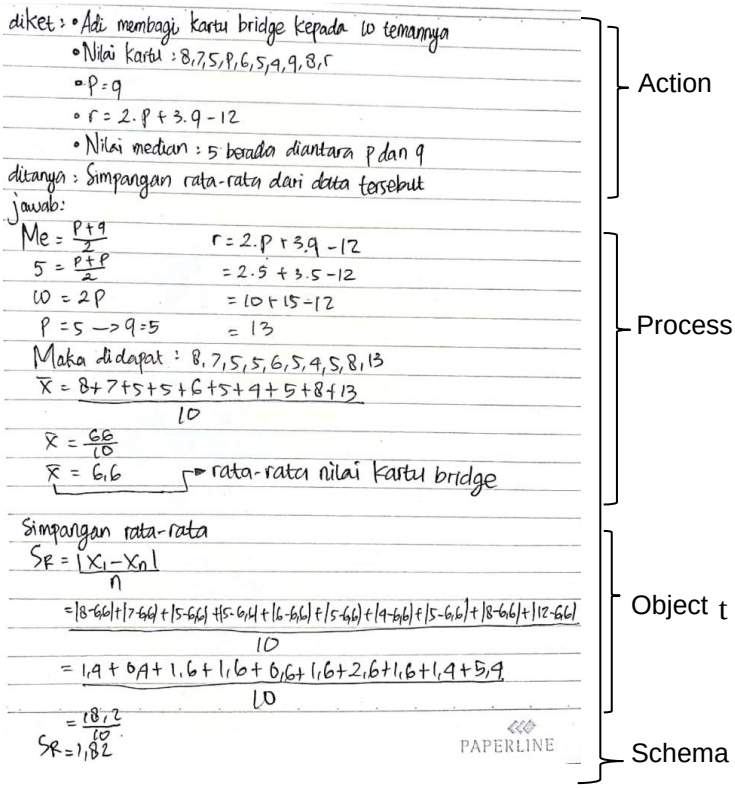


Figure 2. AK Student Answer Sheet with the accommodator learning style

Based on the results of AK's work, at the action stage, students could give correct answers, namely the *value of the bridge card*, $p = q$, $r = 2p + 3q - 12$, and the median, and wrote down what was asked. At the time of the interview, AK students initially did not know the information about the median on the question, but when it was read and understood again, AK students were able to answer questions smoothly and precisely. At this stage of the process, students answered correctly in determining the median formula and looking for the average value of the bridge card. At the time of the interview, AK students can mention the method used in working on the problem using the Me formula to find the values of p and q, the value of r, and the average value of the bridge card.

At the object stage, AK students can determine the formula for the average deviation value, which previously looked for the average value of the *bridge card,* and can complete the S-R (average deviation) correctly. At the time of the interview, AK students can explain well the method used in determining the value of $S_R$ (average variation) and in calculating the absolute value of the average deviation can be understood and understood. It can relate the results of the average weight to the deviation formula average. This is in line with Apiati & Hermanto's (2020) research being able to answer the questions he made using the right, complete and correct strategy. At the schema stage, the AK students have not written the conclusion. There is an error in the inputting process in one of the scores on $x_i$ and resulting in the wrong final answer. At the time of the interview, AK students had not been able to explain the answers to the conclusions, which resulted in errors in calculating the final results, and AK students rushing to work on the questions resulted in incorrectly inputting the value on one of the scores $x_i$and not checking the work again from the beginning. Hakima's (2020) shows the accommodator learning style has not been able to provide appropriate conclusions. According to the study of Fuad (2015) the accommodator is more appropriate if the way of learning is by using problem-solving methods.

**Problem-solving ability based on APOS theory with Converger learning style type**

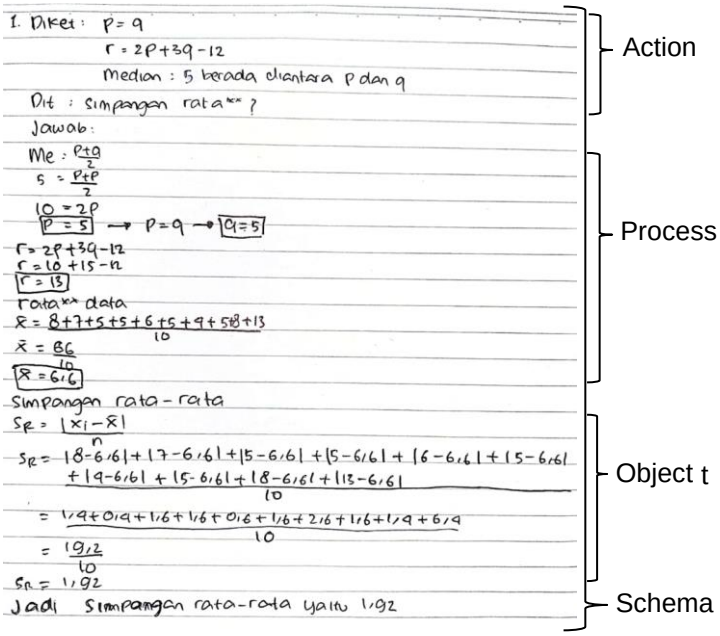


Figure 3. KO Student Answer Sheet with the converger learning style

Based on the results of the knockout work, the students could give the correct answer at the action stage. It was seen that the knockout wrote what was known on the problem, but there was a piece of information that had not been written down, namely the *bridge card value* in the worksheet. During the interview, the knockout students did not write down some information because they were in a hurry to work on the problem. However, the knockout can understand what is known and asked in this problem. At this stage of the process, students answered correctly in determining the median formula and looking for the average value of the bridge card. At the time of the interview, knockout students were able to understand the concept of finding the value of p, and q, using the median formula and seeing the value of r by entering the values of p and q at r = 2p + 3q – 12 and looking for the average value of the bridge card.

At the object stage, students can determine the formula for the average deviation value, which previously looked for the average value of the bridge card value, and can correctly complete the SR (average deviation) results. At the time of the interview, knockout students were able to explain well the methods used in determining the value of S R (average deviation) and calculating the absolute value of the average deviation. They could be understood and understood. At the schema stage, knockout students answer correctly and can explain the results of their work. At the interview, knockout students can present their answers from beginning to end, starting from what is known, asked, concepts and working procedures so that they get the correct conclusions and answers and try to recheck the work from the beginning. This is in line with what Ghufron & Risnawita (2014) said: individuals with the converger type usually have good problem-solving and decision-making abilities. This is also supported by research by Azrai et al. (2018) that the convergent learning style in decision-making can issue ideas with good abilities.

**Problem-solving ability based on APOS theory with Diverger learning style type**

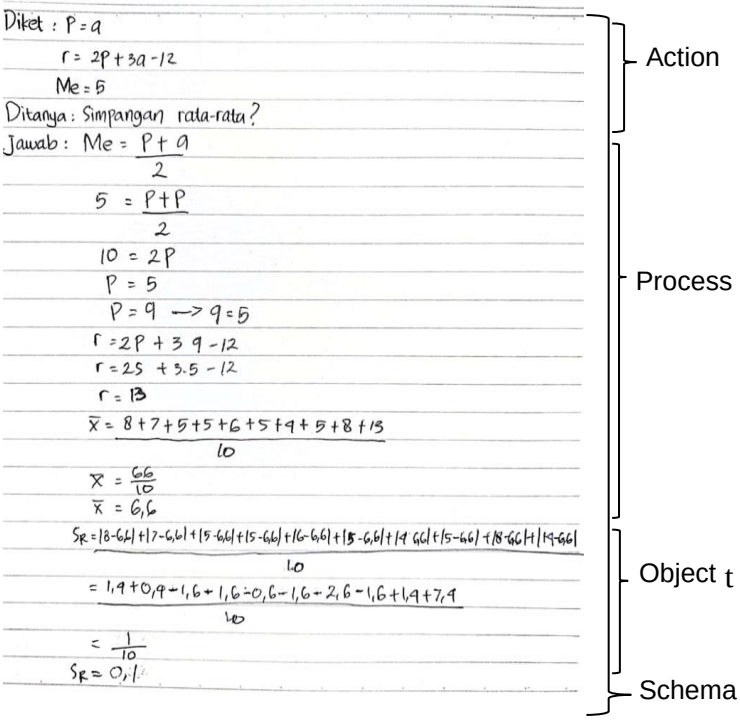


Figure 4. Student Answer Sheet DI with the learning style divergent

Based on the results of DI's work, the students could give correct answers at the action stage. It was seen that DI wrote what was known on the problem, but part of the information had not been reported, namely the bridge card value, and the median explanation, which was 5, was unclear. It should be written Me = 5, between p and q. At the interview, DI students did not write down some information because they were in a hurry to work on the problem. However, in this problem, DI can understand what is known and asked. At this stage of the process, students answered correctly in determining the median formula and looking for the average value of the bridge card. At the time of the interview, DI students were able to understand the finding value concept of p, and q, using the median formula and seeing the value of r by entering the value of p and q at r = 2p + 3q – 12 and looking for the average value of the bridge card.

At the object stage, students can determine the formula for the average deviation value, which previously looked for the average value of the bridge card value, and can correctly complete the SR (average deviation) results, but there is an error in calculating absolute, namely $|x_i - x_n|$ and get an error in inputting the value of $x_i$. At the time of the interview, DI students could explain well the method used in determining the value of SR (average deviation) value, but DI students were still hesitant to calculate the absolute value on the average variation resulting in wrong At the schema stage, DI students have not written the conclusion, and there is an error in calculating process the absolute value, namely $|x_i - x_n|$ and there is an error in the process of inputting one of the values in $x_i$. At the time of the interview, DI students can explain well the method used in determining the SR value (average deviation), but the results of the conclusion that there are still errors in calculating the absolute value of DI students do not understand the calculation of total value and rush to work on questions resulting in incorrectly inputting the weight on one value $x_i$ and they were not checking again. This is in line with Af-idah & Suhendar's (2020) research that students were less precise in writing the results during the completion process. It could be concluded that students were less thorough in providing completion results, so the schema stage had not been appropriately fulfilled even though the final answer to the problem was correct. Hakima's (2020) research shows that the diverger type of learning style cannot provide good final results. Table 1 shows the similarities and differences in the results of student answers based on the type of Kolb learning style with problem solving test questions based on the APOS theory.

Table 1. Table 1 similarities and differences in student answers based on Kolb's learning style

| Learning Style | Action | Process | Object | Scheme |
|---|---|---|---|---|
| Assimilator | Students can answer what is known and answered according to the questions correctly | Students answered correctly in determining the median formula and looking for the average value of the bridge card | Students can determine the formula for the average deviation value previously looking for the average value of the bridge card and can correctly complete the S R (average deviation) results. | Students answer conclusions correctly and can explain the results of their work. |

| Learning Style | Action | Process | Object | Scheme |
|---|---|---|---|---|
| Accommodator | Students can answer what is known and answered according to the questions correctly | Students answered correctly in determining the median formula and looking for the average value of the bridge card | Students can decide on the procedure for the average deviation value previously looking for the average value of the bridge card and can correctly complete the S R (average deviation) results, but there is an error in importing $x_i$ that is $\|12 - 6{,}6\|$ by generating 5,4 resulting in a calculation error. | The student has not written the conclusion. There is an error in the process of inputting one of the scores $x_i$ and the result is an incorrect final answer. |
| converter | Students can answer what is known and answered according to the questions correctly | Students answered correctly in determining the median formula and looking for the average value of the bridge card | Students can determine the formula for the average deviation value previously looking for the average value of the bridge card and can correctly complete the S-R (average deviation) results. | Students answer conclusions correctly and can explain the results of their work. |
| Diverger | Students can answer what is known and respond according to the questions correctly. However, there is still information that has not been written, namely the value of the bridge card and the explanation of the median, namely 5, which is unclear. It should be noted that Me = 5 is between p and q. | Students answered correctly in determining the median formula and looking for the average value of the bridge card. | Students can determine the formula for the average deviation value previously looking for the average value of the bridge card and can correctly complete the SR (average deviation) results, but there is an error in calculating absolute, namely $\|x_i - x_n\|$ and get an error in inputting the value of $x_i$. | Students have not written the conclusion, and there is an error in the process of calculating the absolute value, namely $\|x_i - x_n\|$ and there is an error in the process of inputting one of the values in $x_i$. |
| Equality | The assimilator, converger, accommodation, and diverger indicators can correctly write down what is known and asked. | The assimilator, converger, accommodation, and diverger indicators can determine the median formula and find the average value of the bridge card | The assimilator, and converger, indicators can determine the formula for the average deviation value, which previously looked for the average value of the bridge card and can complete the SR (average deviation) correctly. | The assimilator and converger indicators can answer conclusion correctly and can explain the results of their work |

| Learning Style | Action | Process | Object | Scheme |
|---|---|---|---|---|
| Difference | Overall, the diverger indicator can write down what is known and asked correctly, but there is still information that has not been written. | Overall, the four indicators of learning style have been able to answer the process. | On the accommodation and diverger indicators, there are still errors in absolute calculations, namely $\|x_i - x_n\|$ and get an error in inputting the value of $x_i$. | On accommodation, the conclusion has not been written, and there is an error in the process of inputting values $x_i$ and results in the definitive answer being wrong. and the diverger has not written the conclusion, and there is an error in the process of calculating the absolute value, namely $\|x_i - x_n\|$ and there is an error in the process of inputting one of the values in $x_i$. |

Using the APOS theory in problem-solving, it is possible to find student errors in solving problems on questions using the APOS indicator. In this study, it is suggested to go deeper in making questions by referring to the APOS indicator.

## CONCLUSION

The results of data analysis in the discussion, conclusions that can be drawn on students' problem-solving abilities based on APOS theory (Action, Process, Object, Schema) in terms of the type of KOLB learning style. Based on the four research subjects, each of which represents the type of Kolb's learning style, namely diverger, assimilator, converger, and accommodations. Subjects with assimilator and converger learning styles have matched the indicators of each step of the APOS theory with different problem-solving steps. However, the type of learning style accommodation and the diverger does not meet all the APOS theory step indicators. However, it has been completed in the action, process, and object steps, while the schema step has not been able to complete it correctly and correctly. In this study, it is suggested to go deeper in making questions by referring to the APOS indicator.

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