SJME (Supremum Journal of Mathematics Education)
Vol. 07, No.01, January 2023, pp. 69-82
ISSN: 2548-8163 (online)| ISSN: 2549-3639 (print)
DOI: https://doi.org/10.35706/sjme.v7i1.7019

Scaffolding on Sequence and Series Learning for Didactic Anticipation

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Article Information

Article History:

Received: November 29, 2022
Revised: Desember 15, 2022
Accepted: January 26, 2023

Keywords:
Scaffolding,
Learning,
Mathematics,
Didactic,
Anaticipation

ABSTRACT

The purpose of this study is to explain the doctrine expectations of learning mathematics. Data was collected through testing, interviews, and documentation. Researchers have designed a virtual learning trajectory (VLT) based on examining the obstacles students face when learning mathematics. Next, a didactic design was developed from VLT. The method of doctrine was implemented, and the results showed that the situation of the three principles expected by researchers was the doctrine of scaffolding strategy. When determining values that correspond to a pattern of numbers, researchers want to learn lessons and provide instructions in the form of education to solve problems. The researcher's expectation of giving other examples of arithmetic progressions when choosing a definition and the arithmetic progression examples help students better understand collaborative learning. The value of the nth term and the sum of the first n math terms are sent to each shirt to confirm the work and interact directly.

INTRODUCTION

Mathematics has characteristics that distinguish it from other fields of science. Mathematics has aspects of logical and axiomatic reasoning called a deductive process, namely the process of compiling conjectures, compiling appropriate mathematical models, and making analogies and or generalizations based on the analysis of existing data through an inductive process (Warner & Kaur, 2017). Given the nature of mathematics, it takes cognitive abilities and mental processes that occur in one's mind by connecting a concept with other concepts so that mathematics can be understood and studied well (Priawasana, Degeng, Utaya, & Kuswandi, 2020; Shriki, 2010; Warner & Kaur, 2017).

One of the concepts that students in mathematics must learn is the number sequence. To minimize mathematical errors that occur in students, teachers need to analyze the causes of these errors from the beginning of learning (Fuad, Zubaidah, Mahanal, & Suarsini, 2017; Saputra, Joyoatmojo, Wardani, & Sangka, 2019). Some of the students' problems with sequences and series are errors in process skills, students' ignorance of the proper method or approach to solve problems, and their inability to construct mathematical models from the given questions' literacy (Batlolona, Batlolona, Wairisal, & Leasa, 2018; Buchori & Cintang, 2018; Maskur et al., 2020); their poor comprehension, planning, and problem-solving skills (Aidossov, Aidosov, & Narbayeva, 2021; Lapira, Wadee, & Gardner, 2021; "The Effectiveness of Core Models with Scaffolding to Improve The Mathematical

Connection Skill," 2019). Other difficulties that arise are related to concepts and applying concepts in everyday life (Dobbs, 2014, 2014; El-hussein & Cronje, 2010). Based on these problems, it is necessary to overcome the difficulties and obstacles that arise, especially in the material of rows and series, through appropriate learning designs or designs.

In designing learning, an educator must predict possible student responses to a given didactic situation. This is done so that the teacher has an action plan for every possible answer to students, called didactic anticipation (Bagus, Mantra, Handayani, & Suwandi, 2019; Trisna, 2019) (Suryadi, 2013). Therefore, teachers must be able to design learning that can anticipate all student responses that may occur in didactic situations that arise during learning (Chick, Vincent, & Education., 2005; Even & Kvatinsky, 2010). Teaching and learning activities with an innovative atmosphere can also increase students' enthusiasm and interest in learning

Didactic situation theory emphasizes that the innovation of teaching and learning processes can be modeled in an activity that includes three main steps (Maskur et al., 2020; Zazkis & Zazkis, 2010). First, didactic situations are created so students can use their previous knowledge. Second, students try to find ways to increase their knowledge to achieve learning objectives. Third, students are directed to consider the conclusions of the knowledge they have obtained into a concept of knowledge. These three stages are called the action situation, formulation, and validation. Various didactic actions and feedback supported by the right strategies in these stages are expected to encourage the creation of new knowledge processes in students.

States Theory of Didactical Situations in Mathematics (TDSM) as a modern teaching concept requires teachers to stimulate adaptation by presenting "problems" to students (Bagni, 2004). Students must be motivated to act, talk, think, and develop in response to this issue. suggests that in order to stimulate pupils' mental activity, problems with obstacles for them to overcome must be presented at the start of learning. (Ardianti, Sulisworo, Pramudya, & Raharjo, 2020; Nurjanah, Dahlan, & Wibisono, 2021). The issues can be in the form of finding concepts, procedures, problem-solving strategies, or rules in mathematics (Kemampuan et al., 2021). It also showed that if the anticipated mental action does not take place, which is indicated by students' inability to solve the problems presented, the teacher can intervene or indirectly guide them through the use of scaffolding techniques in the form of didactic actions as didactic anticipation that can promote interaction (Keys, Robert; Lindquist, Mary, M; Lambdin, Diana, V; Smith, Nancy, 2015; Rainboth & DeMasi, 2006; Reys, Robert; Rogers, Anna; Bennett, Sue; Cooke, Audrey: Robson, Kylie: Ewing, 2017). To develop thinking and construct student thinking individually and lead to a correct mathematical understanding, teachers can seek guidance.

The term " scaffolding " has been interpreted and applied in various research and educational practices (Margolis, 2020). It also mentions understanding scaffolding as a direct application and operationalization of teaching concepts in the zone of proximal development (ZPD) introduced by Vygotsky (Margolis, 2020; Thomas, Bailey, & Engeness, 2021). Furthermore, scaffolding strategies facilitate students' ability to reinforce prior knowledge and explore new information (Baranovich, Fong, & Hutagalung, 2019; Suwastini, Ersani, Padmadewi, & Artini, 2021). However, when students begin to understand learning, less scaffolding is provided so that students can complete or master concepts independently (Alrawili, Osman, & Almuntasheri, 2020). Further explains that frame in education can be in the form of models, cues, instructions, partial solutions, relevant examples, and direct interaction between teachers and students.

Several research results related to the use of scaffolding techniques in learning mathematics have shown a positive impact on the quality of learning, such as an increase in the mathematical understanding ability(Bakar & Ismail, 2019; Pratiwi, Inganah, & Putri, 2020). In addition, learning through scaffolding combined with the Probing-Prompting learning technique is proven to be able to encourage students to make discoveries, interact socially, to reflect, so that students' ability to solve problems increases significantly, which has an impact on student learning outcomes (Mesah, Wahyuni, & Liliek, 2020; Priawasana et al., 2020; Wu, Chen, & Chen, 2018). In these studies, the scaffolding technique gave students the freedom to think and solve problems individually, but students were still assisted when they had difficulties.

Explains the three layers of scaffolding: a) environmental provisioning, the setting where the teacher offers suitable media so that students can learn freely. There is currently no direct interaction between teachers and students; b) explaining, reviewing, and restructuring, steps with the process of defining, reviewing, and/or restructuring through direct interaction between teachers and students; and c) developing conceptual thinking, through efforts to increase understanding of concepts through processes of abstraction, generalization, and probability. However, in line with the results of the research above, the interactions that occur can help students to learn independently and solve a problem by providing some instructions, encouragement, warnings, outlining the problem into solving steps, and can also, with the teacher's actions provide relevant examples (Hadinugrahaningsih, Rahmawati, & Ridwan, 2017; Surya & Syahputra, 2017).

Regarding the sequence and series material which is the focus of this research, various efforts to encourage student achievement in the sequence and series material have been carried out and developed by several researchers. Among them are mathematics material through cooperative script learning, which has been proven to increase student activity and learning outcomes (Glynn & Winter, 2004; Saad, 2020; Sunanto, Apriliani, & Nafi'ah, 2020). The implementation of the TAI (Teams Assisted Individualization) type of cooperative learning model in the line and series learning by emphasizing cooperation and collaboration between students, both mentally, attitudinally, and socially, has been proven to increase the ability to work together as well as to achieve learning outcomes (Glynn & Winter, 2004; Saad, 2020; Sunanto et al., 2020). Several other studies have developed learning online and series material, both the development of learning designs and tools, media, and question instruments (Boa, Wattanatorn, & Tagong, 2018; Scott, 2015; Sompong & Rampai, 2015; Vlasta Cabanova & Vladimira Zemancikova, 2017).

Most of these studies emphasize achieving final results in a particular ability seen from the quantitative data. However, it does not rule out the possibility that the teacher's didactic actions in learning activities are not conveyed thoroughly. Information on how learning takes place, especially how an educator creates the didactic anticipation as a didactic action against student responses that arise in education, should also be conveyed to provide alternative solutions for educators when they encounter the same problem through the scaffolding process. Providing didactic anticipation in the form of appropriate scaffolding can create a flow of students' thinking in studying the material of sequences and series according to the student's learning trajectory. Thus the learning objectives can be achieved as expected.

METHOD

This study uses a qualitative approach from Didactical Design Research (DDR) in three research phases: prospective pre-learning, meta-education, and retrospective analysis. In the future analysis phase, researchers performed learning barrier analysis based on learning barrier test results, interviews with teachers, and analysis of textbooks used by students. These textbooks are put together in VLT, a mathematical material, and are a fictitious textbook design. These two components were first constructively validated in terms of content by two experts in math lessons and scope.

The meta-didactic analysis stage was carried out through design trials. Finally, in the retrospective analysis stage, the researcher linked the predictions of student responses with student responses, complemented by didactic anticipation during the implementation of the hypothetical didactic design. The research was conducted at SMA Negeri 1 Parepare, South Sulawesi, Indonesia. The research subject is class XI IPA 1, consisting of 6 students who are the subject of design trials. Topics were chosen randomly by the subject teacher in question.

In addition to the doctrine design, which includes predicting student reactions and doctrine expectations, the main tools of this study are learning barrier test questions, interview guides, final identification tests, and educational video recordings. The data collection method used in this study combines data from the trial, interview, and documentary survey results. The data analysis used in this study is based on the Miles and Huberman model: data reduction, data display, inference drawing/testing (Aini et al., 2019). The implementation of the hypothetical doctrine design in some respondents was validated through a meta-educational doctrine theory and procedure validation process.

RESULT AND DISCUSSION

The VLT is then developed based on learning barrier analysis, learning barrier test results, teacher interviews, and analysis of the textbooks used by the students. Figure 1 below outlines the LDS draft of mathematical materials, especially arithmetic progressions and series materials**.**

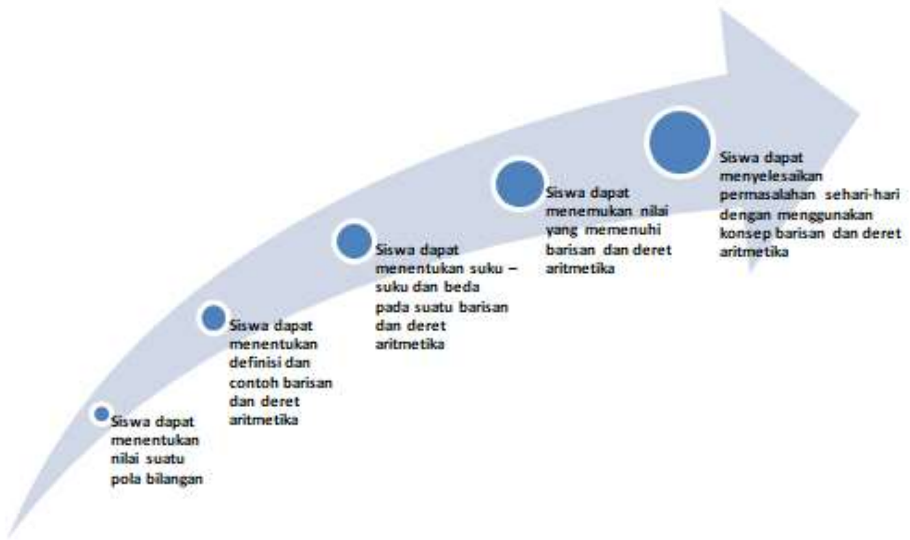


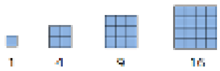
Figure 1. VLT on Arithmetic Sequences and Series Materials

The VLT then evolves into a learning design that includes instructive situations and predictions of the various student reactions that can occur during learning activities. Researchers also predict student reactions that can happen when learning activities take place. Below are examples of learning activities that include didactic expectations in the form of scaffolding.

A. Determining the Value of a Number Pattern

When determining the values corresponding to a number pattern, the learning activity begins with the researcher asking about the number pattern. Students were asked to work on the problem one at a time, and the researchers gave the students time to work on the situation. Students have the following questions.

1. Look at the following picture!



   a. What pattern is formed from the picture above?
   b. Determine the formula for the pattern!
   c. Determine the 5th and 6th patterns from the following picture!
2. It is known that the formula for the nth term of a number pattern is = $10n$ 3. Determine the value of the 21st term is …

Next, the researcher asked the students to work on the questions on the blackboard. However, none of the students came forward, so the teacher gave didactic anticipation with the teacher inviting students to answer the question together. More details on the learning activities can be seen in the following conversation.

T: To work on question number 1. Does anyone want to come forward?
S: (students are silent).
T: OK, if not. Look at the questions from rows 1, 4, 9, and 16 …. In the first pattern, what is formed? What is a square design?
S: Yes, ma'am, square pattern.
T: In the second pattern, does it still form a square?
S: Still, ma'am.
TIn the following pattern, does it still form a square?
S: Still.
T: So, for question a, what pattern is formed from the picture above?
S: Square pattern.

Based on the conversation above, it can be seen that the students were silent when asked by the teacher to work on the questions ahead. Researchers provide didactic anticipation by offering directions to solve the problem. Therefore, the expectation that the researcher gives is one form of scaffolding strategy, namely in the form of complete instructions. Thus, the researcher's anticipation could provide an understanding and make students understand the learning material well. This is reinforced by research by Van Der Stuff (2002) which explains that scaffolding can give students the ability to recall previous knowledge and explore new information.

In order to ensure that the learning objectives are met, the researcher directs students to validate the learning concepts they have acquired by providing a stimulus in the form of questions during class discussions and active interactions between teachers and students.

T: After working on the given problem, what do you know about number patterns?
S: *Can determine the value with the formula mam*
T: Yes, that's right,

S: We can evaluate other terms when we see the formula that applies to a number pattern.
T: So far, do you have any questions?
S: No, ma'am
T: So everyone understands?
S: Understood ma'am

From the conversation above, it can be seen that students understand the learning that has been given. Thus the researcher can continue the explanation for the following material.

At the time of design implementation, several student responses were not following the response that the researcher had predicted. However, as the learning process progressed, the researcher succeeded in anticipating each answer the students gave. Anticipation with scaffolding that researchers provide is based on the opinion of (Alrawili et al., 2020; Andriani, Triyanto, & Nurhasanah, 2021; Milara et al., 2020). Explains that scaffolding allows students to recall previous knowledge and explore new information (Kane, Mishra, & Dutta, 2016; Warner & Kaur, 2017; Widana, 2018). Meanwhile, it explains that scaffolding in learning can be in the form of models, cues, instructions, partial solutions, providing relevant examples, and direct interaction (Sukardjo & Salam, 2020; Surya & Syahputra, 2017).

B. Knowing the Definition and Examples of Mathematics

When defining the phrase, mathematical examples are also used. A ruler is one of the tools used by researchers in the classroom. First, the researcher asked the students to take out the ruler they had, and then the researcher asked them to pay attention to the components contained in the ruler. Next, the researcher asked the students to name the details contained in the ruler. Learning activities can be seen in the following conversation.

T: What components are contained in the ruler that you have?
S: There are numbers, ma'am
T: There's a number line, ma'am.
S: Yes, that's right. What numbers are on the ruler?
T: The numbers 0, 1, 2, 3, 4,... (Researcher writes the numbers mentioned by students on the blackboard) What is the distance or difference from 0 to 1?
S: Yes, mam
T: What is the distance or difference from 1 to 2?
S: Yes, mam
T: Likewise next.
S: One is what forms a pattern in the number sequence.
T: So, does anyone know what a number sequence is?
S: (silence)

From the conversation above, it turns out that students have not understood the concept of an arithmetic sequence which the researcher explained using a ruler. This can be seen from the silent students when the researcher asked the students what an arithmetic sequence was. Therefore, the researcher gave didactic anticipation in the form of another example, still using the existing tools around the class, namely the wall clock. The researcher asked students to name four core numbers from the wall clock, namely 3, 6, 9, and 12. Next, the researcher explained the relationship between these numbers and arithmetic sequences, making students understand better. The ongoing learning activities can be seen in the following conversation.

T: Could you take a look around us? What other examples form a pattern? (Students

searched around the room and did not find such examples.)
S: Another example is a wall clock. There are four main numbers on a wall --=clock, namely 3, then what number?
S: Number 6, Ma'am. (Researcher writes down the number mentioned by the student) What's the following number?
S: Numbers 9 and 12, Ma'am.
T: Yes, numbers 3, 6, 9, and 12. Look at the numbers, so what is the difference?
S: Three, ma'am.
T: Likewise, so on. This constant difference or difference characterizes that this number is an arithmetic sequence. So an arithmetic sequence is a sequence of numbers composed of terms with a continuous difference or difference.
S: (Students listen to the teacher's explanation)
T: From the definition of an arithmetic sequence, try to give another example of an arithmetic sequence. Try S1 to mention examples of arithmetic sequences!
S: 5, 9, 13, 17…
T: The example mentioned by S1 is an arithmetic sequence?
S: Yes, ma'am.
T: Yes, exactly. How about the others, do you understand?
S: Already, ma'am.

Based on the conversation above, the doctrine expectations of researchers by providing other examples in the form of sequences helped students better understand what they are learning. Lesson expectations are also a form of scaffolding that provides more educationally relevant examples. Another example of arithmetic progressions researchers use is the four main numbers on wall clocks.

At the scaffolding stage in mathematics learning, the teacher can give some questions or statements that encourage students to represent what they see, repeat the instructions, or verbally re-express what they have observed (Glynn & Winter, 2004). This can be seen during the design trial. It can be seen that the anticipation given by the teacher is mainly carried out through the scaffolding process, especially during the formulation and validation actions.

Some of the scaffolding strategy expectations provided by the researchers were: 1) If a learner is unable to answer the question offered while determining a value that matches a pattern of numbers on their own, the researcher has provided instructions on how to do so.. 2) In determining the definition and example of arithmetic progressions, the researchers' expectations by providing another example of the sequence format will help students better understand what they are learning. 3) When determining the value of the nth term and the sum of the first n math terms, the expectation is to go to each shirt, review their work and interact directly. Various related examples should also be provided to help students better understand (Pemahaman et al., 2020). Another relevant example is the form of scaffolding (Sinha & Kapur, 2021; Wales, Kraus, Filser, Stöckmann, & Covin, 2021).

C. Determining Terms and Differences and General Mathematical Formulas

The next lesson will determine the terms and differences and general mathematical formulas. They are still using the context of numbers on the wall clock. The researcher asked the students to pick in advance what they could know from the numbers on the wall clock. After they determine what is known from the numbers on the wall clock, the researcher invites students to check the correctness of their work. The snippet of the learning activities can be seen in the following conversation.

T: Look again at the numbers 3, 6, 9, and 12. These numbers are the terms in the arithmetic sequence. So the number 3 in the series is what term?

S: 1st Tribe Mom

T: The number 3 is the 1st or first term, and the 1st term is denoted by U_1 or a.

S: Then the number 6 is the number to what? 2nd tribe

T: Yes, that's right; what is the 2nd term symbolized by?

S: 2 Mom

T: So to find the difference or the difference is…

S: $U_2 - U_1$

Based on the conversation, it can be seen that students have started to understand ethnicity and difference in mathematics. Several help questions were given to students to validate the concept so that they finally came to a conclusion that $U_1 = a,\ U_2 = a + b, U_3 = a + 2b,\ U_n = a + b$ and the formula for the arithmetic sequence is $U_n = a + (n - 1)b$.

Furthermore, the researchers distributed questions in the form of practice questions that were done individually and collected on the same day. Researchers use the results of working on this question as a reference to whether they have understood or not the material presented. Overall, students understood the material presented. The following are examples of student answers that can be seen in Figure 2 below.

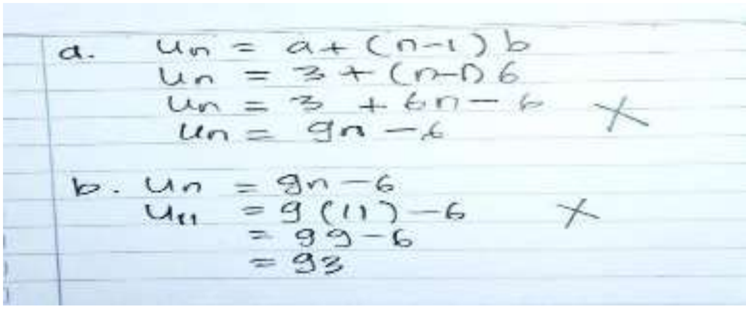


Figure 2. Answers S3

Figure 2 shows that there are still student errors in determining the formula that applies to an arithmetic sequence. The mistake made by the student was in the addition of numbers that had a variable. Namely, that is $3 + 6n - 6 = 9n - 6$, and it should be $6n - 3$. To overcome this, the researcher would remind students of material that students had not understood so that the same mistakes will not happen again in the next meeting. In general, students seem to be able to work on the given practice questions, but there are still students who are less careful in working on the questions given. Figure 3 below is one of the results of student work.

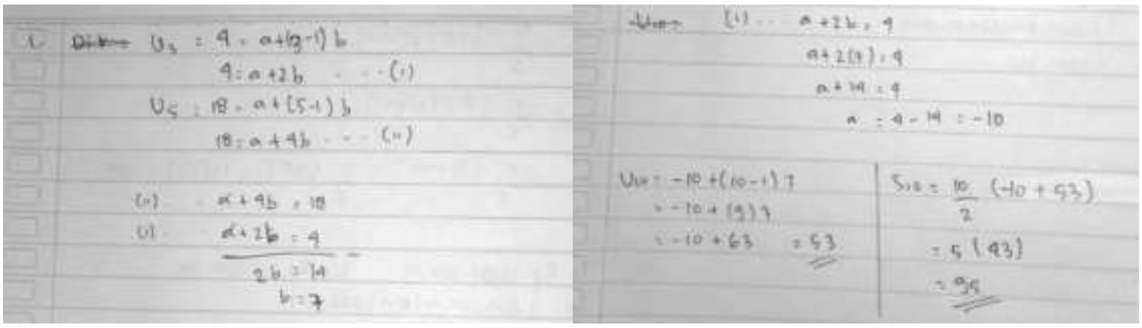


Figure 3. Example of S4 Work Results

From Figure 3 above, it can be seen that students are less careful in working on the given problem, namely the multiplication of integers. For example, the error experienced by the student was multiplying the number 5 (43) = 95, and the result should be 5 (43) = 215. However, procedurally this student was able to work on the given problem, only experiencing an error when multiplying the final result.

The researcher's prediction is also supported by the belief that if the desired mental action is not achieved, as evidenced by students' inability to comprehend how related objects relate to problems that arise, the teacher can indirectly intervene by using the scaffolding technique (didactic action) and designing a task that promotes student interaction (pedagogical action). This behavior is further supported by the belief that the teacher's didactic efforts will help to foster the conditions necessary for learning to take place (Laruelle & Pagès, 2019; Miranda, Angelin, Silva, & Dos Santos, 2019).

Although the intended didactic situation does not actually cause the learning process to occur, conditioning can be done, for example, through the use of a scaffolding strategy, making the learning process possible (Diana, Marethi, & Pamungkas, 2020). Once the learning process occurs, new situations arise that can be singular or varied depending on the environment or learning activities the teacher has designed (Doo, Bonk, & Heo, 2020; Pathoni et al., 2020). The learning process becomes more difficult as the environment becomes more varied and situations get more variable.

CONCLUCISION

This study aims to clarify the requirements of the doctrine on learning mathematics. Through testing, interviews, and documentation, data was gathered. Based on an analysis of the challenges students encounter when studying mathematics, researchers have created a virtual learning trajectory (VLT). Then, using VLT, a didactic design was created. The scaffolding strategy doctrine was found to be the scenario of the three principles that the researchers had anticipated, according to the outcomes of the application of the doctrine technique. Researchers seek to acquire lessons and offer guidance in the form of education when calculating values that correlate to a pattern of numbers. Students are better able to appreciate collaborative learning when they are aware of the researcher's expectation that other instances of arithmetic progressions would be provided when choosing a definition. To verify the work and interact directly, the value of the nth term and the sum of the first n math terms are communicated to each shirt.

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Scaffolding Pada Pembelajaran Barisan Dan Deret Untuk Antisipasi Didaktik

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Abstrak

Penelitian ini menjelaskan antisipasi didaktis pembelajaran matematika. Pengumpulan data dilakukan melalui tes, wawancara, dan dokumentasi. Dari virtual learning trajectory (VLT) di rancang pemeriksaan didaktis yang dihadapi siswa saat belajar matematika. Dengan demikian, desain didaktis dikembangkan dari VLT. Metode didaktis diimplementasikan, dan hasilnya menunjukkan bahwa terdapat tiga situasi didaktis yang peneliti antisipasi dengan strategi scaffolding. Saat menentukan definisi dan contoh barisan bilangan aritmatika. Pemberian contoh lain sebagai langkah antisipasi didaktis peneliti yang membuat siswa memahami pelajaran. Selanjutnya menentukan nilai suku ke_n dan jumlah n suku pertama, sebagai langkah antisipasi didaktis dengan cara mengecek pekerjaan mereka di meja masing-masing dan melakukan interaksi secara langsung. Antisipasi didaktis peneliti berikan disesuaikan dengan situasi dan kondisi siswa di kelas.

KataKunci: Scaffolding; Pembelajaran; Mathematika; Didaktik; Antisipasi.

Diterima: 29 Oktober 2022
Direvisi: 15 Desember 2022
Disetujui: 26 Januari 2023