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DEVELOPING STUDENT ACADEMIC ABILITY USING SCAFFOLDING METHOD IN COGNITIVE APPRENTICESHIP MODEL

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Abstrak: *Tujuan dari penelitian ini adalah untuk menguji bagaimana Model Cognitive Apprenticeship dan Metode Scaffolding digunakan dalam pengajaran matematika dan untuk menilai seberapa baik kinerja pembelajaran matematika ketika kedua pendekatan tersebut digunakan bersama-sama. Teknik penelitian ini adalah penelitian kepustakaan, dan makalah dengan menggunakan Cognitive Apprenticeship Model dan Metode Scaffolding sebagai sumber datanya. Untuk mengetahui apakah metode scaffolding dan teori model cognitive apprenticeship layak digunakan dalam proses pembelajaran matematika, maka pendekatan analisis data menggunakan metode analisis isi. Hasil analisis data menunjukkan bahwa model cognitive apprenticeship yang dikombinasikan dengan metode scaffolding dinilai tidak lebih baik. Hal ini dikarenakan scaffolding yang terdapat pada langkah Cognitive Apprenticeship Model cukup jelas. Tanpa harus menggunakan metode scaffolding, pendampingan dapat diberikan secara bertahap dengan menggunakan komponen sequencing yang terdapat pada model cognitive apprenticeship.*
Kata kunci: proses pembelajaran, model cognitive apprenticeship, metode scaffolding

Abstract: The goal of this study is to examine how the Cognitive Apprenticeship Model and the Scaffolding Method are used in math instruction and to assess how well math instruction performs when the two approaches are used together. This research technique is library research, and the papers using the Cognitive Apprenticeship Model and the Scaffolding Method are the data sources. In order to determine whether the scaffolding method and the theory of the cognitive apprenticeship model are appropriate for use in the process of teaching mathematics, the data analysis approach employs the content analysis method. The results of the data analysis show that the cognitive apprenticeship model combined with the scaffolding method is not perceived to be better. This is because the scaffolding contained in the Cognitive Apprenticeship Model step is quite clear. Without having to use the scaffolding method, assistance can be provided in stages by using the sequencing components contained in the cognitive apprenticeship model.
Keywords: learning process, cognitive apprenticeship model, scaffolding method

Introduction

For the advancement of other sciences, mathematics serves as a fundamental science. As a result, mathematics is a crucial science in many areas of technology and science. Axioms and postulates come first in mathematics, followed by defined elements, undefined elements (basic terms, primal terms), defined elements, and then theorems (Cahyono, 2010). Mathematics is a systematic science that requires people who study it to continue to develop the concepts they already have. The functions of mathematics subjects are tools, mindset, and knowledge. Mathematics can be used as a tool to solve problems related to everyday life. In addition, mathematics is a science that has various kinds of formulas and theorems and also teaches a systematic mindset to solve a problem. Mathematics is a collection of abstract ideas that are given symbols that are clearly arranged. Therefore, mathematics starts from understanding concepts to the complex forms that are used to solve problems (Astuti, 2023).

Given the significance of mathematics for life, it makes sense that mathematics is one of the most significant sciences. Even the National Examination (UN) in Indonesia includes mathematics as one of the courses. According to the National Education Standards Agency, the subject contained in the National Examination at various levels of formal education is mathematics. However, in reality, student learning outcomes in mathematics are still low. Based on data on the average National Examination score, it shows that the math score is still below 50. In addition, in the last three years, the average math score in the National Examination was only in the range of 47.17. The highest average score was achieved with a value of 50.31. Then, it decreased by 6.97, so that the average value was 43.34. In last year, it only increased by 4.53 again, bringing the average value to 47.87. Even though it has increased in last year, the overall average value is still in the lower category. In addition, the magnitude of the standard deviation each year indicates the magnitude of the deviation and the distribution of data. This means that the greater the standard deviation, the more diverse the scores students get. This can be seen from the lowest and highest scores of students each year. In two years ago, students obtained the lowest score of 2.50. This value has a large enough difference from the highest value obtained, which is equal to 100.00. This shows that there are still large inequalities that occur and that students' understanding of mathematics is still low (Candra, 2018).

Seeing the low math scores obtained by students in Indonesia, this needs to be a major concern for all groups, especially teachers. An activity carried out by lecturing (listening) will be remembered by students only 20% of the time; if it is conveyed through sight, it can be remembered by students (listening) will be remembered by students only 20% of the time; if it is conveyed through sight, it can be remembered by students 50% of the time; and if it is carried out by doing, it will be remembered by students rough sight, it can be remembered by students 50% of the time; and if it is carried out by doing, it will be remembered by students 75% of the time. Therefore, students need to be actively involved in building their own knowledge. This is in accordance with the characteristics of constructivism in learning proposed by previous researcher, including (i) students are not seen as something passive but have a purpose; (ii) learning must consider as optimally as possible the process of student involvement; (iii) knowledge is not something that comes from outside but is personally constructed; (iv) learning is not the transmission of knowledge but involves setting the situation of the learning environment; and (v) the curriculum is not just something to be learned but a set of learning materials and resources. The learning environment is also involved in the learning process, according to the features of constructivism in learning. Furthermore, Vygotsky's theory highlights the sociocultural character of learning, which states that pupils learn through interactions with adults and peers. According to Lev Semenovich Vygotsky, pupils developing a concept must be aware of their social surroundings. As a result, it is critical for teachers to build and support the atmosphere for learning activities (Gunawan, 2014).

Article 37 of the Law on the National Education System No. 20 of 2003 specifies that the primary and secondary education curriculum in Indonesia must include mathematics topics, which play a vital role in numerous sciences to progress human thinking. Thinking power is also known as cognitive ability, which is often interpreted as the power or ability of a child to think and observe relationships, an activity that results in a child gaining knowledge that is supported by his ability to explore the environment, the ability to coordinate motor skills, and questioning ability (Hasratudin, 2014). This means that mathematics is more than just arithmetic; it is also a tool for thinking. In other words, a student's mathematical competence is achieved if they are able to think logically, analytically, and systematically (Rohaeti, 2012). Several learning models have been developed to construct knowledge in the learning process (Kamaruddin, 2023). One learning model that focuses on student learning by constructing knowledge in the learning process is cognitive apprenticeship (Santoso, 2010) Cognitive apprenticeship is basically to support learning in the cognitive domain with several methods, including scaffolding, modelling, and fading, which refers to social constructivist learning theory. Cognitive apprenticeship contains four components, one of which is the sociology component, which can support learning through experience. This is in line with the characteristics of constructivism in learning (Nugroho, 2023).

Learning mathematics through experience can help students see mathematics more realistically. Moreover, mathematics is something abstract for students, so they need to be given an overview of the use of mathematics in everyday life (Parinussa, 2023). This is consistent with mathematical traits such as (1) having an abstract object study, (2) relying on agreement, (3) having a deductive mindset, (4) being consistent in the system, (5) having symbols that are empty of meaning, and (6) paying attention to the universe of speech. But sometimes students need help in the process of constructing their understanding of mathematics. Cognitive apprenticeship refers to the process by which a person who is learning gradually gains expertise through interaction with experts (Ramli, 2023). Therefore, the cognitive apprenticeship model can be combined with the scaffolding method. Scaffolding entails offering support to children in their early stages of development, reducing that aid, and allowing them to take on growing tasks as soon as they are able to do so. Students are encouraged to learn by active participation in this strategy (Rachmad, 2023). However, during this learning process, students receive assistance or advice from the teacher to help them focus (Iis, 2007). It is intended that with this aid, students' mathematical competency will improve.

Method

The cognitive apprenticeship model and the scaffolding method were used in this study to examine the process of learning mathematics. The research method employed is library research. So, in this study, library research is a systematic research activity that is carried out by studying books and material, which is then collected and processed to provide answers to the difficulties encountered. This study's data source is a secondary data source. The use of the cognitive apprenticeship model with the scaffolding approach in mathematics learning is the topic of this research. This study focuses on the Cognitive Apprenticeship Model's learning phases using the scaffolding method and its success in applying it to mathematical abilities. Documentation is the data gathering approach employed in this library investigation. The content analysis method was employed in this study to analyse data. Data analysis activities include data reduction, data display, conclusion formulation, and verification.

Findings and Discussion

According to the first source's description of research data, learning mathematics using the Cognitive Apprenticeship model consists of six steps, including modelling, coaching, scaffolding, articulation, reflection, and exploration, which are used to improve students' mathematical representation abilities. The ability of mathematical representation in the first source refers to students' ability to create mathematical models; students' ability to draw graphs or tables to solve systems of two-variable linear equations; students' ability to write stories or written texts based on the representations presented; students' ability to create merchandise from a given graphic; and students' ability to solve and summarize two-variable systems of equation problems with written text. Before beginning the session, the teacher conducts a pre-test to assess students' mathematical representation skills based on their prior understanding of mathematics. This is one of the components of the cognitive apprenticeship paradigm, namely content in the knowledge domain category. The findings of the pre-test revealed that the students' representation abilities fell into three categories: poor, medium, and high. The first source then administered a pre-test to measure students' mathematical representation ability based on school level. The school levels used in the first source are high school and middle school. This school level relates to the sociological component of the cognitive apprenticeship paradigm. According to the results of the two pre-tests, there was no difference in students' mathematical representation ability between the experimental class and the class based on students' prior knowledge of mathematics and school level.

Then, in the learning process, the teacher's modelling stage provides an overview of the material being studied in accordance with the context of everyday life. For example, in building an understanding of gradients, student worksheets present a picture of a person climbing a hill. The slope of a hill can be used as an illustration of a gradient in a real-life context. Then, at the coaching stage, students are given assignments so that the teacher can train them; in this case, the teacher can use student worksheets. While student's complete homework, the teacher continues to pay attention to and promote student progress. According to the indications, pupils are expected to be able to create mathematical models and draw tables or graphs for linear equations with two variables at this stage. Next is the scaffolding stage, where the teacher provides adequate assistance to students. Help at this stage has been significantly reduced so that students are able to complete the task on their own. These tasks include making equations from graphs and solving problems in systems of two-variable linear equations.

Then comes the articulation stage, in which the teacher encourages students to explain knowledge, reasons, and problem-solving strategies. In the first source, students are invited to write back on what they have learnt in their language, using the student worksheet guide as a guide. Students, for example, create stories or written texts based on the images offered. This stage can be utilized to attain representational ability indicators, such as composing stories or written text based on the representations offered and summarizing a two-variable linear equations issue with written language. Then, once in the reflection stage, students compare their problem-solving method to that of a teacher or other students. The last stage, namely exploration, is the stage where students apply what they have learned. At this stage, the sequencing component is included in the student worksheet to assist students in exploring their knowledge. Sequencing categories that can be used include increasing complexity and increasing diversity. This category refers to the increasing complexity of the task and the variety of questions given.

Following the implementation of the cognitive apprenticeship model in the learning process, the first source administers a post-test to assess students' mathematical representation abilities. According to the post-test results, students who got cognitive apprenticeship model learning improved their representation abilities more than students who received conventional learning. This increase occurred in all aspects, namely aspects of the school level and aspects of students' initial knowledge of mathematics. According to the second data source, cognitive apprenticeship includes the following interrelated characteristics of the learning environment: modelling and explaining, diverse views, exploration, self-study, collaboration, social negotiation, and real learning activities. Modelling, coaching, scaffolding, articulation, reflection, and exploration are the six steps employed in the second data source. In student worksheets, two markers of learning achievement will be developed: (1) students can describe the concept of limits using the formal definition of limits, and (2) students can evaluate the limit values of functions using epsilon and delta.

The learning process starts at the modelling stage, where the teacher explains how to formally define and demonstrate problem solving so that students can observe, understand, and build a conceptual modelling process. In the student worksheet, a formal definition chart regarding limits is presented, and students are then asked to fill in the blanks. With this chart, students become more focused on learning the concept of limits. Then the teacher gives an explanation based on the chart, and students observe, understand, and build conceptual understanding. Then, after obtaining an explanation from the teacher, the teacher provides graphic images to help students better understand the concept of limits. From the graph, students can see the position between the epsilon and delta referred to in the limit definition. Next is the coaching stage, where the teacher guides students through coaching activities of gradual direction and assistance, evaluation, diagnosis of difficulties, providing challenges, and providing feedback. At this stage, the task given in the student worksheet has increased in difficulty. Students are trained to work on problems that apply the definition of limits that have been previously obtained from the modelling stage. During this activity, the teacher continues to provide direction and provide feedback, and the teacher can diagnose the location of student difficulties and carry out evaluations.

The teacher trains students, starting with understanding the components in the limit, then defining it according to the formal definition of the limit, and then understanding a graph by completing the blanks. After the process has been carried out gradually, the teacher makes a complete problem along with pictures for students to work on. With these pictures and instructions, it is hoped that students can better understand the concept of the limit of a function. Next is the scaffolding stage, where the support provided by the teacher has begun to decrease along with the increasing complexity of the problem. The teacher provides clear stages for students to demonstrate. After going through modelling and coaching, students are expected to be able to fill in the blanks. At this stage, the teacher only provides assistance as needed, unlike at the previous stages. This is because at this stage, students are expected to be able to complete the task on their own. This stage is the most important because, at this stage, students have begun to gain a complete understanding. Henceforth, students only do articulation and reflection to evaluate their understanding. Then, at the end, students will explore by solving other problems regarding limit functions.

Furthermore, the third source uses the cognitive apprenticeship model to improve students' abstract thinking skills. Indicators of abstract thinking skills in the second source include: (1) the ability to transform problems into symbolic forms; (2) the ability to build equations; (3) the ability to state the relationship between the concept of geometric shapes and linear equations; (4) the ability to make generalizations; and (5) the ability to make equations based on a given situation. Similarly, to the first source, the third source also conducted a pre-test to determine students' abstract thinking skills based on their prior knowledge of mathematics and their school level. The pre-test, which was conducted based on students' prior knowledge, is a component of the cognitive apprenticeship model, namely content in the domain knowledge category. Then the pre-test based on school level refers to the sociology component of the Cognitive Apprenticeship model. Based on the findings of the two pre-tests, it was discovered that there was no difference in students' mathematical abstract thinking skills between the experimental class and the control class based on students' prior knowledge of mathematics and school level.

As for the learning steps, a third source states that learning mathematics using the Cognitive Apprenticeship model consists of six steps, including modelling, coaching, scaffolding, articulation, reflection, and exploration. The ability to translate issues into symbolic forms and to construct equations develops during the coaching and scaffolding stages. Furthermore, at the articulation stage, students are asked to state the relationship between geometric shapes and linear equations and to develop generalizations. After that, students can reflect and compare their work. In the last stage, students are asked to make equations according to the given situation. At this stage, the sequencing component is also included in the student worksheet to assist students in exploring their knowledge. Sequencing categories that can be used include increasing complexity and increasing diversity. This category refers to the increasing complexity of the task and the variety of questions given.

The third source also conducted a post-test to see the increase in students' abstract thinking skills. According to the test results, students who got Cognitive Apprenticeship model learning had greater abstract thinking skills than students who received conventional learning. The fourth data source describes learning by scaffolding conceptual and procedural knowledge. The learning process begins with an explanation of straight-line equation material, including what will be learned and why, when, and how it is used. The teacher provides an outline of the material to be covered at this point. The teacher then encourages student participation in learning by asking questions and completing assignments assigned by the teacher. Throughout the learning process, the teacher monitors and reviews student work. If there are any kids who are struggling, the teacher will offer questions to help them understand. In addition, the teacher can also evaluate students if there are errors in carrying out assignments.

The fourth data source does not use student worksheets in their research, so the teacher directs students through the tasks presented on the blackboard. So that the scaffolding on the fourth data source is only in the form of directing student work, presenting details clearly, and reducing student confusion. Then it can be concluded that the scaffolding applied in the learning process for conceptual and procedural knowledge has not been optimally applied. The fifth data source states that scaffolding entails giving a child a lot of help in the early stages of learning, and then letting the youngster take on more responsibility as soon as he or she is ready. The study's goal is to see how scaffolding affects students' problem-solving ability. The fifth data source conducted an initial ability test on students at the start of the research to determine the extent to which students' abilities were so that the teacher could readily provide support based on the level of the students' first abilities. The results demonstrate that pupils' initial talents range from low to medium to high. Despite this, there was no difference in students' starting ability between the experimental and control groups. Meanwhile, mathematical solving ability is measured at the end of learning by doing a post-test.

In applying scaffolding to learning mathematics, the fifth data source states that the teacher's role is very important. The teacher's role in scaffolding is to assist students in completing assignments or concepts that were initially unable to be obtained independently. This help can take the form of directions, cautions, encouragement, breaking down challenges into learning steps, providing examples, or anything else that allows children to progress autonomously. The assistance provided by the teacher is adjusted to the students' initial abilities. Students with high abilities are given independent study assignments with the help of relevant textbooks. Students with moderate and low abilities are given an explanation of the learning material to build their initial knowledge about it, and they are guided to find answers from the exercises given. Low-ability students are given special treatment, namely re-learning when doing exercises. When doing the exercises, students with low abilities are guided to find answers to more exercises than students with moderate abilities. When students are considered to have been able to complete their assignments, the teacher stops providing assistance so that they can continue their assignments independently.

After seeing the students' initial abilities and applying scaffolding learning, students were directed to solve the problems given in groups. Learning begins with providing motivation to students through instructions, warnings, encouragement, describing problems into learning steps, giving examples, and working on problems. Students are given assistance according to their abilities. Students are also invited to share knowledge in groups and work together to solve problems given with the help of the teacher. Cooperation in groups, motivation, and assistance from the teacher are believed to be able to encourage students to overcome their difficulties in solving problems. After that, the teacher conducted a post-test test, which concluded that there was an average difference in the mathematical problem-solving abilities of students who received learning by scaffolding compared to students who received conventional learning in terms of their initial mathematical abilities.

The sixth data source states that scaffolding is a learning technique in which the teacher invites students to work together to complete tasks that are considered difficult if students complete them alone. In the learning process, the sixth data source uses a scaffolding component consisting of conceptual, metacognitive, procedural, and strategic components for use with learning outside the classroom. Students begin learning by examining items and then selecting the methods that must be used during the learning process. Following that, students debate the mathematical concepts present in the seen object. The final stage is to draw conclusions from the learning experience. The sixth data source attempts to improve students' mathematics communication abilities through scaffolded learning. The indicators of mathematical communication used include: (a) the ability to express mathematical ideas through speech, writing, demonstrating and depicting them visually; (b) the ability to understand, interpret, and evaluate mathematical ideas either orally, in writing, or in other visual forms; and (c) the ability to present ideas and draw relationships with situational models using terms, mathematical notations, and structures. Before beginning the class, the sixth data source administered a pre-test to assess students' mathematical communication ability. Then, at the end, a post-test was administered to assess the improvement in students' mathematical communication skills. The results suggest that students who participate in scaffolding learning have stronger mathematical communication abilities than students who participate in traditional learning.

So, based on the first and third sources, the Cognitive Apprenticeship model has the advantage that the Cognitive Apprenticeship model can be applied to all school levels and can be applied to all categories of students' prior knowledge. Meanwhile, based on the second source, student worksheets play an important role in the learning process with the Cognitive Apprenticeship model. And based on the fourth, fifth, and sixth sources, the scaffolding method has the advantage of being able to make students more active in asking questions, independent in completing assigned tasks, and responsible for their assignments. However, if the cognitive apprenticeship model and the scaffolding method are combined, the learning process is not felt to be better. This is because the scaffolding contained in the steps of the cognitive apprenticeship model is quite clear. Without having to use the scaffolding method, the teacher can still provide gradual assistance to students. By using the sequencing components contained in the Cognitive Apprenticeship model, teachers can provide assistance by guiding students using student worksheets. In accordance with the sequencing principle, namely regarding the sequencing of tasks. So that through the sequencing component, the teacher can sort assignments for students and provide assistance in stages. This can be seen from the second data source, which provides questions gradually in the student worksheet. In addition, seeing the different stages and methods used in the fourth, fifth, and sixth data sources, it is felt that learning will become less effective. Therefore, the cognitive apprenticeship model with its four components is effective enough to improve students' mathematical abilities.

Conclusion

Learning using the cognitive apprenticeship model includes four components: content, method, sequencing, and sociology. In the content component, in the form of students' prior knowledge, learning can be applied to all categories of knowledge. This is because there is an increase in students' mathematical representation and abstraction abilities in each category. The same thing happened to the sociology component, namely at the school level. Learning with the Cognitive Apprenticeship model can be applied at all school levels because there is an increase in students' mathematical representation and abstraction abilities. Then the sequencing components in the category of increasing complexity and increasing diversity can be applied to the use of student worksheets. Therefore, the four components of the cognitive apprenticeship model support learning mathematics. Learning mathematics with the scaffolding method can make students more active in asking questions, independent in completing assigned tasks, and able to be responsible for their assignments. Learning the Cognitive Apprenticeship Model combined with the scaffolding method does not seem to be getting any better. This is because the scaffolding contained in the Cognitive Apprenticeship Model step is quite clear. Without having to use the scaffolding method, assistance can be provided in stages by using the sequencing components contained in the cognitive apprenticeship model.

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