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## A Proposed Process of Algebra Problem-Solving in Learners

### Abstract

*The aim of this study is to describe the formal thinking process of students in solving algebraic problems. This study is descriptive qualitative, with two 8th grade subjects taken using a purposive sampling technique. The main instrument in this study is the researchers own judgment, Test of Logical Operations instruments, and algebraic problem-solving tests. The data were collected from various sources using the think-aloud approach. Data were analysed, classified based on students' cognitive development types (concrete, transitional, and formal) and transcribed into data presentation. The study found that, at the stages of understanding the problem and implementing the plan to solve the problem, the subjects successfully carried out the process of thinking assimilation and abstraction. On the other hand, at the stages of planning and re-examining answers, the subjects able to perform the assimilation process of thinking.*

### ORIGINAL ARTICLE



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### Key Words

*Mathematics, Logic, Algebra, analysis.*

### Introduction

Mathematics is important to learn in school because it is needed not only for natural science, but also other sciences in undergraduate programs, such as engineering, psychology, politics, and social sciences. According to Government Regulation No. 19 of 2005 concerning national education standards in the second part, shows that at every level of education, starting from primary, secondary and higher education are required to contain mathematics as one of the subjects so that every student cannot avoid learning mathematics. Many people think that mathematics is a collection of numbers, calculations, statistics, opportunities, forms of objects that require abstraction. This makes many students think mathematics is difficult. The difficulties in learning mathematics are essentially a phenomenon that appears in various types of behavior manifestations. Although avoiding learning difficulties, including learning mathematics, is only for pragmatic purposes, seeking convenience, so that it can fall into ignorance and will face greater difficulties in the future. Mathematics is a universal science that underlies the development of modern technology. That is, mathematics has a very important role in various scientific disciplines as well as advancing human thinking power. The rapid development in the field of technology today is based on the development of mathematics in the fields of numbers, algebra, analysis, opportunity theory. To be able to master and create technology in the future requires a strong mastery of mathematics. This fact is the reason why mathematics is still given up to the level of higher education.

Basic objects in mathematics in the form of facts, concepts, relations, or operations and principles that are all in the form of abstract so that to understand this not only memorize the material but also the thought process is needed. Teachers, by guessing the thought processes carried out by students can be used as a material for consideration in determining values in cognitive abilities. Cognitive ability is the process of processing information that reaches cognitive activities, such as the ability to remember, symbolize, categorize, solve problems, create and fantasize.

Facts in the field show that mathematics learning is only seen as a monotonous and procedural activity. In other words, the teacher does the mechanistic learning process, that is, the teacher explains the material, gives examples, assigns students to do exercises, checks students' answers, at a glance discuss problem-solving which is then imitated by students. Many ways are done by teachers of Mathematics learning such as using unusual learning strategies such as problem-based learning, ethnic-based learning. The purpose of this unusual learning is to use so that students do not have negative perceptions of Mathematics, learning motivation in Mathematics increases, and cognitive abilities possessed by students can increase. The emphasis of students in solving problems must be correct in the final results without seeing the process of solving problems also become another problem that must be resolved immediately. The use of multiple-choice instruments leaves the questions in the form of stories or descriptions that make students think that the final results in completing Mathematics are important compared to the problem-solving process, the ability to connect between mathematical information, and communication skills. The most important aspect of Mathematics learning is the thinking process of students, as if neglected, even though one of the main tasks in mathematics learning includes explaining students' thinking processes in learning mathematics to improve mathematics teaching in schools. This condition results in many students not being able to understand mathematical concepts properly so that the tendency of learning outcomes or mathematical problem-solving abilities becomes unsatisfactory.

By knowing the thinking process of students in solving mathematical problems can help teachers to know mathematics learning can be better, make it easier for teachers to understand students' mindsets in dealing with problems. Also, by knowing the thinking process of students, teachers can prepare learning methods, learning models, and learning tools so that Mathematics learning becomes more effective. In this regard, the purpose of this study is to find out the formal thinking processes of students in solving algebraic problems.

## **Method**

The study was conducted at SMP 2 Yogyakarta. The research subjects were taken from 2 students in class VII-E with a purposive sampling technique. This technique is a sampling technique that is carefully selected according to certain considerations of the researcher so that it is relevant to the research design used. The main considerations used in the sampling of this study are (1) the subject must have Piaget's cognitive development in the formal phase, (2) the subject can communicate mathematically well, and (3) the subject has good problem-solving abilities, in terms of ability to solve mathematical problems.

Following the problems to be studied, this type of research is included in qualitative research which intends to express in-depth the formal thinking processes of students in solving algebraic problems. Solving mathematical problems refer to the steps to understanding the problem, making a plan, implementing the plan, and checking the answers. Because this research is qualitative, the researcher acts as the main instrument in collecting data, assisted by supporting instruments, namely Test of Logical Operations (TLO) and algebra problem-solving test instrument. The Test of Logical Operations is structured to classify students at the sublevel of concrete and formal cognitive development. The Test of Logical Operations consists of 21 items that refer to indicators of classification, sequence patterns, doubling logic, compensation, proportional thinking, opportunities, and relationships. The description of each indicator can be seen in Table 1, while algebraic problem-solving tests that have been previously validated by experts in the field of mathematical and mathematical language content.

**Table 1:** Indicator Test of Logical Operations

S. No.	Indicator's	Description
01	Classification	The systematic arrangement in groups or categories according to established criteria. It is one of the first logical operations that an individual is expected to develop.
02	Seriation	Arrangement in series or succession.
03	Logical Multiplication	Multiplication operations related to, involving, or following the logic.
04	Compensation	It is about counter-balancing, making an appropriate or supplying equivalence. This may refer to the additive compensation or the compensating effects of variables that describe a physical system like the balance beam.
05	Proportional Thinking	It is the establishment of relations of one part to another or of a whole concerning magnitude, quantity or degree.
06	Probability	It is the establishment of a logical relation statement such that evidence conforming to one conforms to the other to some degree.
07	Co-relational Thinking	It is the establishment of a correlation or causal relationship. It may also refer to the presentation or setting forth to show relationships.

Students are asked to convey what they think when solving problems and are interviewed (if needed) to obtain data. Data obtained during the interview was recorded using a camcorder. In this case, the method used to collect data is Think Out Louds (TOL). TOL is a method of retrieving data, where the subject is asked to voice his mind during resolving the problem and asks him to repeat it if there is something to be said during the problem-solving process, in this case allowing the subject to say something or what he is thinking.

The analysis was carried out to find out the students' formal thinking process. Stages of analysis are:

- Checking all data that has been collected from various sources,
  - Categorizing the types of cognitive development of students, namely concrete, transition, and formal,
  - Determining formal students to be used as research subjects,
  - Review the results of formal student work in solving mathematical problem-solving questions,
  - Verifying data and data sources that have been classified and transcribed in the presentation of data.
- The data verification technique is based on the level of trust using observer diligence in this case, researchers, and triangulation techniques.

## Result and Discussion

Before subjects are given an algebraic problem-solving test, students are given a TLO first to confirm their cognitive development. The results of TLO show that class VII-E SMP 2 Yogyakarta consists of 28 students in the transition phase from concrete to abstract and three students in the formal phase. By using the consideration that students can communicate mathematically and solve good problems, two students are taken as research subjects. Furthermore, both subjects are called F1 and F2. By knowing the formal thinking process, it can make it easier for teachers to develop mathematics learning tools, at least to compile mathematics learning media so that students' thinking processes in solving mathematical problems become more clear and systematic. So, the ability of mathematical problem solving is better.

The process that occurs in learning activities involves mental processes that occur in the brain of students, so learning is an activity that is always related to the thought process. Thinking is an information process. When children feel, encode, represent, and store information from the world around them, then they are doing the process of thinking. The process of thinking is an activity that occurs in the human brain. Because it occurs in the human brain, it is difficult to observe how a person's thinking processes directly. The thinking process

requires two main components, namely the incoming information and the scheme that has been formed and stored in the mind of each. In general, the thought process consists of assimilation, equilibration, accommodation, and abstraction. To be able to stimulate and train these thinking skills, mathematics learning requires appropriate methods or techniques so that stimuli aimed at students can use all their potential. Mathematical problem solving is one of the right ways of learning to train students to think. Solving mathematical problems, in this case, algebraic material refers to the steps to understanding the problem, making a plan, implementing a plan, and rechecking the answers.

The stage of understanding the problem refers to understanding what is known, what is asked, or whether the conditions are sufficient, insufficient, excessive, or contradictory to find the question. To believe or understand a problem can be done in several ways, including repeatedly reading, asking your-self what knew, what is unknown, and asking the purpose of the mathematical problem. In understanding algebra problems, F1 and F2 can write down what is known and what is asked. Both subjects can integrate old knowledge or schemes with new knowledge or schemes. Between old knowledge and new knowledge, and subjects do not experience cognitive conflict, so they do not experience any obstacles in identifying the problem at hand. In this regard, the two subjects did the assimilation process of thinking in understanding algebraic problems. Assimilation is the process by which new stimuli from the environment are integrated into existing schemes. Assimilation is an individual process in adapting and organizing itself with a new environment or challenge so that the understanding of students develops. Assimilation does not produce development or schema, but only supports the growth of the schema.

Furthermore, F1 in understanding the first algebraic problem uses the JS symbol as a substitute for actual distance and JP as the distance on the map, in the third problem, TB is used as a change in height. Likewise in the F2 subject on the problem JS symbols are used for actual distance, JD for distance on the map or floor plan, S for scale; and the third problem is used the front letter symbol instead of names like H for Hanifa and A for Arifa. In this regard, F1 can construct a symbol as a substitute for distance so that the problem-solving process is not too long. The subject can describe a certain situation into a thinkable concept through construction, so the student performs the process of thinking abstraction. Like using JS as the actual distance, JP or JD as the distance on the map, TB as changing height, H for Hanifa, and A for Arifa. The process of constructing the use of symbols is one indicator of students doing the process of thinking abstraction.

Based on this, the formal subjects carry out the assimilation process of thinking because they can adapt and organize old schemes with new schemes so that students' knowledge develops. Also, the subject performs the process of thinking abstraction in understanding the problem because the subject constructs the information that exists in the algebraic problem into the symbol. The stage of making a plan refers to how related resolution strategies are related. A problem cannot be solved properly without good planning. Planning to solve problems is very dependent on the experience of students who are creative in arranging a problem solving, the more varied their experiences are, there is a tendency for students to be more creative in preparing a problem-solving plan.

At this stage students can do this by searching for the relationship between known and unknown data, it is possible at this stage to calculate the unknown variable, so that it will get the question of how information that is already known will be interconnected to get things that are not known, or students do self-question like has there been a problem before? Alternatively, has there been a question that is the same or similar in another form? Do you know a question similar to this? Which theory can be used in this problem? Pay attention to the question! Think about a problem that was once known by a similar question! If there is a problem similar to a problem that has been solved, can that experience be used in the current problem? Can the results and methods use here be used? Do you have to look for other elements to be able to take advantage of the original question? Can you repeat the question? Can it be stated in other forms? Return to definition! If the new problem cannot be resolved, try to think of the same problem and finish it.

In planning to solve the problem, F1 and F2 subjects did not write anything in the answersheet. However, students in planning to solve problems immediately pour or write what is on their minds on the student's answer sheet at the stage of implementing the plan. This is by the results of interviews conducted in F1 and F2.

R : Why is there no writing on your answer sheet at the stage of making a plan?

F1 : I did not write at the stage of writing the plan because I did not know what to write at this stage, but I can solve the problem that I am facing.

R : what does it mean?

F1 : I mean this one sir (Sambal refers to the stages of implementing the plan on the student answer sheet)

R : If you are F2?

F2 : I am not used to this step in solving problems.

R : What does it mean?

F2 : I am used to solving problems using known steps, being asked, answered, and finally concluded.

Based on the results of the interviews with the two subjects, it can be concluded that in general the sub-projects are not used to using the second step of this policy. So they do not write anything out of the information on algebraic problems. In this regard, formal subjects carry out a process of thinking assimilation in planning to solve problems. This is because the new stimulus from the environment has been integrated by the subject in the existing scheme (old scheme) so that the subjects adapt and organize themselves with a new scheme. The impact of this thinking process will only strengthen the old scheme on the subject.

The implementation phase of the plan is that the subject is ready to do calculations with all kinds of data needed including concepts and formulas or equations that are appropriate. At this stage students will examine each step contained in the plan and write it in detail to ensure that each step is correct, students must be able to form a more systematic systematics question, in the sense that the formulas to be used have already been prepared to be used following what is used in the problem, then students begin to enter the data until they reach the solution plan after that students implement the plan steps so that the questions will be expected to be proven or resolved [66,68]. Besides, students can question themselves about how to carry out the completion plan, and examine each step, check that each step is correct? Moreover, how to prove that the steps are chosen are correct?.

At this stage, subjects F1 and F2 can solve problems in the comparison questions correctly and smoothly. The subject did not find difficulty in solving the problem. This means that the subject can integrate old knowledge and new knowledge to solve this problem. The process of integration between old knowledge and new knowledge does not experience cognitive conflict or differences in understanding so that subjects experience strengthening cognitive schemes. In connection with this matter, the subject performs the assimilation process of thinking in carrying out the plan to solve the algebraic problem. Related to the process of thinking abstraction carried out at the stage of understanding the problem, the subject still uses symbols that have been raised in the previous stages such as using JS as actual distance, JP or JD as the distance on the map, TB as changing height, H for Hanif and A for Arif. The process of constructing the use of symbols is one indicator of students doing the process of thinking abstraction. In connection with this matter, the subject besides doing the assimilation process of thinking also performs the process of thinking abstraction.

At the stage of re-examining the answers, students will look back at the answers to make sure that the answers to the problems are correct. This step is important to do to check whether the results obtained are by the provisions and there is no contradiction with the questioned person. Steps that can be used by students to carry out the re-examination phase include matching the results obtained with the things being asked, interpreting the answers obtained, identifying are there other ways to get the problem resolved, and identifying are there other answers or results that meet.

F1 and F2 subjects in looking back at the answers made did not write anything down. As expressed at the stage of planning to solve a problem, the subject is not used to correcting the answers that have been written. However, subjects can interpret the answers that have been obtained in the form of inference from an answer. In connection with this, the formal subject conducts the assimilation process of thinking in re-examining the answers that have been made. This is because the new scheme faced by students reinforces the old scheme that is in the brain of formal subjects.

## Conclusion

From the results of the research and discussion that has been described, it can be concluded that the subjects of class VII-E Yogyakarta 2 formal cognitive development carry out the process of thinking assimilation and abstraction for the stages of understanding the problem and implementing the plan to solve the problem. At the stage of planning and re-examining answers, the subject performs the assimilation process of thinking. In this regard, learning devices such as learning media and worksheets are needed to bridge the thinking processes of other students.

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