

The Profile of Problem-solving in Algebra based on Solo Taxonomy in Terms of Cognitive Style

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Abstract—The study is descriptive research with a qualitative approach, aimed to describe the mathematics problem-solving the problem based on SOLO taxonomy in terms of cognitive style. The instruments used in this study were researcher themselves, GEFT and Super-item test and interview schedule. The subjects of the study were grade VII students of SMPN 3 Makale, consisting of 2 fields dependent and 2 independent field students. The data were collected through job analysis and interview. Data analysis indicates that; (1) subject 1 with field independent shows that (a) at the unistructural level, the subject provided a fact based on the solution of the problems, (b) at the multi-structural level, subject used several parts of information and focused thinking on some aspects of the solutions, (c) at the relational level, the subject answered the problem by linking some previously known concepts and (d) at the extended abstract level, the subject could not find the formula without applying principle or pattern that has been formed; (2) subject 2 with field-independent cognitive style shows that (a) at the unistructural level, the subject provided a fact based on solutions of the problems, (b) at the multi-structural level, the subject used several parts of information and focused thinking on some aspect of the solution, (c) at the rational level, the subject answered the problems by linking some previously known concepts, (d) at the extended abstract level, the subject could find the formula without applying principles or patterns that have been formed; (3) subject 3 with dependent cognitive style shows (a) at the unistructural level, the subject used error information to answer the problems, (b) at the multi-structural level, the subject used several parts of information and focused thinking on some aspects of the solutions, (c) at the relational level, the subject could solve the problems, (d) at the extended abstract level, the subject could not solve problems; (4) subject 4 with dependent cognitive style shows (a) at the unistructural level, the subject provided a fact based on the solutions of the problems, (b) at the multi-structural level, the subject used some parts of information and focused thinking on some aspects of the solutions, (c) at the relational level, the subject could solve the problems, (d) at the extended abstract level, the subject could solve the problems.

Keywords—*SOLO taxonomy, algebra, cognitive style*

I. INTRODUCTION

The purposes of education in Indonesia is to develop the potential of students to be religious, and piety to God, morality, healthy, knowledgeable, capable, creative, independent, and become citizens of a democratic and responsible [1]. Besides, Depdiknas [2] mentioned that the purposes of learning mathematics are that students are able to solve mathematics problems. This statement is reinforced

by Widjajanti [3]. The purpose of teaching mathematics is to prepare students to use mathematics and mathematical thinking in daily life. Mathematical problem solving is not only the ability to solve problems that are required by the students but also the need for good student thinking processes [4].

Researchers adopt and modify the Bigg and Collis theory to determine the ability of students in responding to mathematical problems which are given because this theory explained that students' responses to similar tasks are various. Bigg and Collis also designed SOLO Taxonomy, in which the learning outcomes observed are used as evaluation tools to measure the quality of students' responses about a SOLO Taxonomy task. This theory became the grand theory of this essay.

The application of the SOLO Taxonomy to know the quality of student responses and fault analysis in accordance with Collis with several advantages of the SOLO Taxonomy are as follows; (a) easy and simple tool to determine the student's response levels in math questions; (b) easy and simple tool for categorizing errors in solving mathematics problems; (c) easy and simple tool to prepare and determine the level of difficulty or complexity of mathematics problems [5].

SOLO Taxonomy classifies student's abilities in responding mathematics problem into five different levels and hierarchies, such as *pre-structural*, *unistructural*, *multi-structural*, *relational* and *extended abstract* [6]. The descriptions of the SOLO Taxonomy can illustrate the development of thinking skills [7]. The descriptions of each level are as follows:

A. *Pre-structural Level*

At this stage, students cannot do the task given correctly. It means that students do not have skills that can be used to solve the problems, totally do not understand what they should do. One of the things that can be seen is the absence of problems solving given to students.

B. *Unistructural level*

At this level, there is a clear and simple relationship between one concept and the other, but the core of the concept is not widely understood. Students try to answer the question in a limited way by selecting one of the information in the given question. The student's response focuses only on one relevant aspect.

C. Multi-structural Level

Some simple connections have been established, but metacognition capabilities have not yet appeared. This level includes: sorting or chopping, sorting, classifying, explaining, creating lists, combining and performing algorithms.

D. Relational Level

At this stage, students are able to integrate fragments of relevant information apart, provide more than one interpretation of an argument, provide some solutions to a divergent problem, link the relationship between facts and theories and actions and objectives and build Conceptual understanding belonging to the relational level.

E. Extended Abstract Level

Students at this level may produce general principles of unified data that can be applied to new situations with more than one interpretation of an argument, may provide some solutions to a problem, may present a link between concepts Material, and form a new idea.

The process of thinking cannot be separated from the principle of learning [1]. A person with a cognitive style in one type is not a problem either bad, but each type has advantages in the field. Witkin [8] argued that students with FI cognitive style tend to choose individual learning, respond well, and freely (not dependent on others). Whereas, students with field-dependent cognitive style tend to choose to study in groups and as often as possible interact with other students or teachers, requiring extrinsic rewards or reinforcement [9].

II. RESEARCH METHODOLOGY

This study is Descriptive research with a qualitative approach. The focus of this research is to describe the students' problem-solving abilities based on SOLO Taxonomy with field independent and field dependent cognitive styles. This study was conducted at SMP Negeri 3 Makale on grade VIII. The subjects were according to their learning experiences on the topic of Algebra. The subjects consist of two subjects with field-independent cognitive style and two subjects with cognitive style field dependent as presented in Table 1.

TABLE I. THE SUBJECT OF THE STUDY

Subject Initials	Category	Code
DK (subject-1)	Field independent 1	FI-1
ST (subject-2)	Field independent 2	FI-2
TLC subject-3)	Field dependent 1	FD-1

J (subject-4)	Field dependent 2	FD-2
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A. Research Instruments

The instrument used to collect data in this study were the researchers themselves, *GEFT (Group Embedded Figures Test)* to categorize the students' cognitive styles, as well as achievement test and interview schedule to know the reflective thinking process of students in solving mathematics problems.

B. Research Procedure

The research procedures are as follow; 1) the planning stage was done by preparing the learning packages instrument, performing expert validation, and analyzing and revising the validation result. 2) the implementation stage was done by giving *GEFT*, and mathematics achievement test, determining the appropriate subject categories, conducting interviews regarding tests, performing triangulation by giving tests at different times to the subject along with an interview. 3) data analysis phase is done by data reduction, data exposure, and conclusion. 4) the result of the study is reported. For data exposure, the coding of the characteristic reflective indicator used by the researcher is detailed as table 2.

TABLE II. AN INDICATOR OF SOLO TAXONOMY LEVEL

SOLO Taxonomic Level	Indicator
Unistructural	1) Using one aspect of the information
Multi-structural	1) Ability to use existing information to perform calculations 2) Ability to use available information to find the value of output involving more than one concept
Relational	1) symbolic Generalization 2) Ability to combine all available information to produce an algebraic equation
Extended Abstract	1) Establish an abstract principle that represents the form of a general formula 2) Analyze the formulas that are formed to determine the general formula 3) Make allegations to the formulas created

III. RESULTS AND DISCUSSION

A. Subject with Field Independent Cognitive Style

The following is a description of the relation between the research indicators and the test results of the subject with a field-independent cognitive style (Table 3).

B. Subject with Field Dependent Cognitive Style

The following is a description of the relation between the research indicators and test results of the subject with field-dependent cognitive style (Table 4).

TABLE III. THE RELATION BETWEEN THE RESEARCH INDICATORS AND THE TEST RESULTS OF THE SUBJECT WITH FIELD-INDEPENDENT COGNITIVE STYLE

Level	Subject	
	FI-1	FI-2
Unistructural	At this level, subject give the correct answer	At this level, subject give correct answers
Multi-structural	At this level, the subject answers that the information he gets from part a plus part b, the information is interconnected	At this level, the subject answers that the information he gets from part a plus part b, the information is interconnected
Relational	At this level, the subjects answered that the first step he takes to answer this question by using an analogy, and this equation by means of factoring	At this level, the subject responds to the first step used to describe the subject using the formula of the rectangular area
Extended abstract	At this level, the subject is not able to answer the question	At this level, the subject explains that the way is used to answer by factoring

TABLE IV. THE RELATION BETWEEN THE RESEARCH INDICATORS AND THE TEST RESULTS OF THE SUBJECT WITH FIELD-DEPENDENT COGNITIVE STYLE

Level	Subject	
	FD-1	FD-2
Unistructural	At this level, the subject gives a wrong answer	At this level, the subject gives the correct answer
Multi-structural	At this level, the subject answers that the information he gets from part a plus part b, the information is interconnected	At this level, the subject answers that the information he gets from part a plus part b, the information is interconnected
Relational	At this level, the subjects answer the first step is used describe	At this level, the subject explains the information that is known and asked, but the subject can not solve the problem
Extended abstract	At this level, the subject does not know the answer to this question	At this level, the subject is not able to solve the given problem

Subjects with Field Independent cognitive style shows the following indicators for SOLO Taxonomy, especially on:

1) *Unistructural*

Subjects solved the problems by drawing existing information. Before doing this, the subjects must understand the goal of the questions correctly. The correct understanding certainly will facilitate in tracing any information needed to provide the right answer as well. This is in accordance with the characteristics of the Independent cognitive style of the ability to organize objects that have not been organized and reorganize the objects that have been organized.

2) *Multi-structural*

At this level, the subject uses several pieces of information to produce correct answers and focuses thoughts on some aspects of strategy and solutions, the subject can group some pieces of information but have not been able to establish a clear relationship, and the subject performs calculations based on an algorithm. This is in accordance with the characteristics of the Independent cognitive style that processes the information by recalling the knowledge possessed based on the learning experience stored in its long-term memory, prior knowledge possessed in relation to the problems encountered.

3) *Relational*

Subjects can provide correct answers based on information that has been combined. The ability of the subjects in building relationships between information, indicating that the subjects have a conceptual ability, able to build the concept through a number of examples, perform procedural operations and look at the nature of order that is formed. This is consistent with the characteristics of the FI cognitive style that focuses on one aspect and analyzes patterns into different parts and also corresponds to subjects who have been able to think flexibly where there is a strong urge to do it smoothly;

4) *Abstract expanded*

The subjects understood that a problem situation in mathematics could be presented in various forms, whether in words, tables, diagrams, drawings, or formulas. The ability to construct a formula based on a problem situation is not an easy task. In this study, the subject can answer this question correctly.

To compare and contrast to the subjects with Field Dependent cognitive style, then the troubleshooting of the subjects with field-dependent cognitive style are; (a) *Unistructural*. The first subject wrongly took the information used to answer the question. This is in accordance with the characteristics of cognitive style dependent that tends to think globally; the subject views the object as a unity with the environment so that its perceptions easily affected by changes in the environment; (b) *Multi-structural*. The subjects use several pieces of information to produce correct answers and focus thinking on some aspects of strategy and solutions. This fits the characteristics of the cognitive style of filed dependent using some information to solve the problem, work algorithmically by planning solutions using thought formation process and formation of understanding; (c) *Relational*. The subject cannot solve the problem because it does not understand the problem. Based on the results of the interview the subjects did not understand the problem and also did not know the connection between algebraic form and algebraic operations. This is consistent with the characteristics of cognitive styles that tend to accept existing structures due to lack of restructuring capability; (d) *Abstract expanded*. The subjects cannot solve the problem because it does not understand the problem, in particular, does not understand in addition the subject does not correct the patterns that have been formed in the previous answer. Based on the characteristics of the cognitive style that the subjects have not been able to find concepts based on his own thoughts. This is seen where the subjects have not been able to find or create a pattern that has been formed from the previous answer.

Profile of mathematical problem solving of the subject with field-independent cognitive style are; (a) in answering the unistructural question, subject gave a solution based on the facts on the matter. Subject understand the problem using the process of thinking and organize the objects that have not been organized and reorganized the objects that have been organized to focus on one aspect or one strategy or one solution, (b) in answering the multi-structural question, subject used some information and solutions to resolve the issue, worked algorithmically by planning solutions and used forming opinions processes and understanding of the formation; (c) in answering the relational question, subjects are able to think flexibly, able to build conceptual relationship by combining some of the information in the matter of a separate relevantly, able to give more than one interpretation of an argument, d apart provide some solutions to the problem of divergent, and able to make connections between facts to construct a theory. In searching for a solution of the subject matter of using the thought process and the formation of the decision forming conclusions; (d) in answering the abstract expanded question, the subject has a better multi-representation ability.

Profile of mathematical problem solving of the subject with field-independent cognitive style second are; (a) in answering the unistructural question, subject gave a solution based on the facts on the matter. subject understood the problem by using the thought process of organizing and was able to organize objects that have not been organized and reorganized the objects that have been organized to focus on one aspect or one strategy or one solution; (b) in answering the multi-structural question, subject used some information and solutions to resolve the issue, worked algorithmically by planning solutions and used thought processes forming opinions and understanding of the formation; (c) in answering relational problem, the subject has not been able to think flexibly, was able to build conceptual relationships by combining some of the information in question in the relevant separate, and in looking for solution, the subject has not used the decision formation process of the conclusion formation; (d) in answering the abstract expanded question, subject has a better multi-representation ability, namely the ability to change the situation in the form of a general formula.

Profile of mathematical problem solving of the subject with field-dependent cognitive style is; (a) in answering the unistructural question, in the field of cognitive style dependent objects subject more global look and blends in with the surrounding environment. That causes the subject to answer the question of where the element of the problem is not the answer to the question because the complete subject of the subject; (b) in answering the multi-structural question, the subject used some information and solutions to resolve the issue, worked algorithmically by planning solutions. The characteristic cognitive style of FD is that it tends only to receive information, so that it is unable to organize the information back to be disclosed to others. But the subject shows that for this stage is different because the subject is able to solve the problem well and can organize the information back; (c) in answering the relational question, subject was able to think flexibly, built conceptual relationship by combining some of the information in the matter of a separate relevantly, give more than one interpretation of an argument, provide some solutions to the

problem of divergent, and make connections between facts to construct a theory. FD cognitive style characteristics that tend to receive the existing structure because of the lack the ability to restructure. But in the answer above the subject can solve it with a good structure; (d) in answering the expanded abstract question, the subject did not have better representation ability, namely the ability to change the situation matter in the form of a general formula. Subjects did not have full knowledge, either conceptually or procedurally and able to use the process of thinking decision-making and formation of conclusions in finding formulas or patterns. Based on cognitive style characteristics that the subject has not been able to find a concept based on his own thoughts.

Profile of mathematical problem solving of the subject with field-dependent cognitive style are; (a) in answering the unistructural question, subject gave a solution based on the facts on the matter. The subject understood the problem using the formation of understanding and was able to look globally and blended with the surrounding environment; (b) in answering the multi-structural question, the subject used some information and solutions to resolve the issue, worked algorithmically by planning solutions and used thought processes forming opinions and understanding of the formation. In FD cognitive style that is likely only to receive information, so it is not able to organize the return of information to be disclosed to others. But the answer to the above problem shows that for this stage is different because the subject is able to solve the problem well and can organize the information back; (c) in answering the relational question, subject was able to think flexibly, built conceptual relationship by combining some of the information in the matter of a separate relevantly, give more than one interpretation of an argument, provide some solutions to the problem of divergent, and make connections between facts to construct a theory. FD cognitive style characteristics that tend to receive the existing structure because of the lack the ability to restructure. But in the answer above the subject can solve it with a good structure; (d) in answering the abstract expanded question, the subject can solve problems, have to better multi-representation ability, namely the ability to change the situation matter, subject have complete knowledge, both conceptually and procedurally. Based on cognitive style characteristics, the subject has not been able to find a concept based on his own thoughts.

IV. CONCLUSION

The profile of problem-solving in Algebra based on SOLO taxonomy intent of cognitive style is good to be implemented.

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