ATLANTIS PRESS

Advances in Social Science, Education and Humanities Research, volume 173

1st International Conference on Education Innovation (ICEI 2017)

A Profile of Student's Scheme Activation based on Theory of Constructive Operators in Problem Solving Reviewed from The High Mathematics Ability

Suroso
Universitas Negeri Surabaya
Surabaya, Indonesia
surosoae@gmail.com

***Abstract* — The purpose of this study is to get a profile of student's scheme activation based on Theory of Constructive Operators (TCO) in solving a mathematical problem of students with high mathematics ability. The descriptive-explorative method with the qualitative approach is used in this study. The subject is students of grade XI in Science major of SMAN 1 Ponorogo. The data is collected using task-based interview and is validated using time triangulation. Then, it is analyzed using categorization, reduction, explanation, interpretation and conclusion making. The results are: (1) in Understanding Problem: The students do operator C, L, incomplete I, M, and F; (2) in Devising a Plan: they do operator C, L, incomplete I, M, and F; (3) in Carrying Out the Plan: they do operator C, L, I, M, and F; then (4) in Looking Back: they do operator C, L, I, M, and F.**

Keywords— student's scheme activation, constructive operators

I. INTRODUCTION

Schema is a general term in Psychology for a mental structure. It is not only about a complex mathematical structure, but it is also associated with a simple structure coordinating activities of human's five senses. This is in accordance with [1, 2] that the general psychological term for a mental structure is a schema. The term includes not only the complex conceptual structures of mathematics but also relatively simple structures which coordinate sensory-motor activity.

One of the neo-Piaget theories is Theory of Constructive Operators (TCO) which combines the Piaget theory about cognitive improvement and the Witkin theory about environmental dependence. [3] said that: "this theory explains human psychological functioning as the product of a dynamic combination of schemes (the brain's software, information/action bearing functional-system processes, embodied by cell assemblies or network), and "hidden hardware" operators of the brain. Operators acting on schemes generate thoughts, actions, and learning. Hidden operators are brain-resources mechanisms that regulate the functioning of (and can change) schemes. Piaget left these resources unexplained and often referred to them as principles like "regulation", "accommodation" and "equilibrium". Operators intervene in all neuropsychological processes that are emergent and not automatized or overlearned: M-operator (mental-attentional capacity, which explains the innate-developmental basis of working memory), I-operator (attentional inhibition mechanisms causing attentional interruption), L-operator (i.e, logical-structural capability), C-operator, (content-learning capability), F-operator (i.e., the Neo Gestalt "field effects" or " minimum Principle" or "S-R compatibility"), etc.

Some hidden operators in TCO are C, L, M, I, A, and F. Operator C (content learning) is relevant with assimilation and accommodation of Piaget schema. Operator L (structural learning) is a process in forming the higher schema (superordinate), it is not a modification of existing schema, but it is a coordination of two or more schemas activated simultaneously. Operator M (mental energy), which metaphorically refers to central computing space, is used to activate schema which is relevant to the task (mechanism), but it is not activated by the perceptual input or another operator. Operator I (interrupt) is used to helping operator M; i.e. a central attentional mechanism; which discards (deactivated) the irrelevant schema. Operators observed in this research are operator C, L, I, M and F when students solve mathematical problems. Description of the operators is shown in table 1.1 below.

Student schema will be improved if the activation is done continuously in having problems. The problem in Mathematics is a conscious situation or condition (which can be an issue, question, or problem) and it needs a solution, and the way to resolve it is not available immediately. The words "not available immediately" stated here refer to an effort to get the way to solve the problem which is needed when the situation arises. Problem-solving is a process to resolve a problem, and the problem-solving model used in this research is Polya model. According to [4] activities in every phase of problem-solving are understanding the problem, devising a plan, carrying out the plan, and looking back.

TABLE I. DESCRIPTION OF TCO OPERATORS

Operator	Description
C	Operator C (Content learning) corresponds to Piaget's assimilation or accommodation of schemes.
L	Operator L (Structural learning) provides an account of another Learning type that involves the formation of a superordinate scheme. In these cases, the formation of the new scheme is not derived from the modification of an existing scheme, but from the coordination of two or more schemes activated simultaneously.
I	Operator I (Interrupt) carries out functions which are complementary to the Operator M; i.e. it is a central attentional mechanism that inhibits (deactivates) irrelevant schemes.
M	Operator M (Mental energy), also metaphorically called "central computing space," has the function of incrementing activation of schemes that are relevant to a task.
F	Operator F (Field) is the organism's tendency to simplify the pattern of activated figurative schemes and to structure its operative processes in such a way as to make them congruent with this simplified organization of the figurative schemes.

Sources: [3]

This research focuses on the schema activation profile of Senior High School students based on TCO in solving a problem. Activation is observed at the time and after the students solve mathematical problems using Polya model and they will be described using operator C, L, I, M and F based on TCO. This research question is "how is the schema activation profile of students with high Mathematics skills based on TCO in solving mathematical problems?"

II. METHOD

Based on the purpose of this research, i.e. to find a description of student scheme activation in solving mathematical problems based on Theory of Constructive Operators (TCO), the type of this research is qualitative which has explorative characteristics. Qualitative research is one of which procedures result in descriptive data in the form of written and verbal words that can be observed. It is explorative because this research investigates schema activation of students in solving mathematical problems based on TCO.

Triangulation is done to test the validity and credibility of data because triangulation is a qualitative cross-validation which does the comparison to get credible data [5]. The credible data based on triangulation is consistent data or frequently named as saturated data. Triangulation in this research is a time triangulation comparing data from the first and second interviews. If data from the first and second interviews is consistent, then the process stops because the data is considered to be saturated and the data from both interviews is valid. If data from the first and second interviews are not consistent, then the third interview is done. Data from the third interview is compared to data from the other two interviews. If data from the first and third interviews are consistent, then the data from both interviews are considered to be rated so that the data is valid. If it is not, then data from the second interview is compared to data from the third interview using the same procedures.

Data in this research is not only collected from the interviews, but also from the test done by the subjects to support the analysis of interview data.

III. RESULTS AND DISCUSSION

This part elaborates the research results of subjects who have the high mathematical skill level. The profile is obtained from schema activation based on TCO of subjects who have high mathematical skill level in understanding, planning solutions, executing solution plans, and rechecking stages. In every stage, the processes of operators C, L, I, M and F are observed from the understanding stage until rechecking stage.

The operator series are also observed at every stage of problem-solving and they are expected to appear in every stage. Operator C, L, M, and F are implemented by students in solving mathematical problems from understanding until rechecking stage. Operator, I is not fully implemented by students in stages of executing plans and rechecking. Students activate the irrelevant operative schema in the form of arithmetic and geometry sequences simultaneously at problem understanding and solution planning stages. The processes in changing and choosing are in accordance with a research [6] where subject implements dynamic synthesis in information processing by executing of procedure and plan activations, in-formation of choosing as well as final result performance.

When students do operator L, they do coordination and modification dynamically and systematically. The dynamic one is done by changing suitable formulas and the systematic one is done using the right sequence formula and transformation. This is in accordance with [6, 7] about meta-subjective dimensional analysis.

When students solve a mathematical problem, they connect or combine some operators. Relationship of operator M and L, or LM is implemented simultaneously by the student in solving the problem at every stage. By doing this operator LM, students can solve the problems quickly as in the plan, it is in accordance with [3]. Interesting relationship between operators that are usually applied by the students is between operator M and I. At the beginning of problem understanding stage, operator I interferes students' thought particularly in operative schema preparation (arithmetic sequence), but at solution planning stage, students have presumed the irrelevant arithmetic sequence but do not sure about the end, so that they confirm at the beginning that this obstacle plan is discarded and the relevant one is geometry sequence. The power of connection between M and I is implemented by students in the form of M > I where it means that students apply operator M strongly than operator I in problem-solving. It is in accordance with [3, 8], although M works in synergy with I, but some students discard I faster, then M replaces it.

But there are little different findings of pulling inter relevant schemas, so that subject needs to discard the unsuitable although actually they can be used, and this makes the finishing process becomes longer.

Students also make another combination between operator L, I, M and F. Subject performs operator L by the influence of operator M and I in synergy (pulling inter M>I), then it is

helped by operator F using pictures, after that it is simplified and structured (operator F), in accordance with [3, 6].

IV. CONCLUSION

Based on the results of data analysis and discussion, the research results can be concluded as follows.

1) Schema activation profile of student with high mathematical skill level based on TCO in solving the mathematical problem at the understanding stage is as follows.

a) Implementing operator C through the content process by knowing what has been known, what has been asked, about the current concept of problem and its type, performing operator L, implementing operator I completely, performing operator M, and implementing operator F.

b) Student performs operator series of L1→M1→F1→C2→F3→M2 which means that they coordinate and modify relevant figurative schema which has a simple pattern, then they present the solution order by structuring a relevant operative scheme.

2) Schema activation profile of student with high mathematical skill level based on TCO in solving mathematical problem at solution planning stage is as follows.

a) Students implement operator C through content process by identifying between things which are known and asked, they perform operator L because they coordinate and modify two or more figurative and operative schemas in discovering between known and asked and in finding reasons from one step to the next step, they implement operator I uncompletely because they do not deactivate irrelevant operative schema, i.e. arithmetic sequence, they perform operator M because they activate rel-evant figurative schema of what known and asked, activate relevant operative schema from one step to the next, activate figurative and operative schemas simultaneously from one step to the next as well as mention two finish-ing methods, then they implement operator F because they simplify the pattern of figurative schema and make the structure of operative schema from one step to the next as well as make the congruence between simple pattern of figurative schema and the structure of oper-ative schema.

b) Students perform operator series of L1→M1→F1→C2→F3→M2 which means that they coordinate and modify relevant figurative scheme which has a simple pattern, then they present the solution order by structuring a relevant operative scheme.

3) Schema activation profile of students with high mathematical skill level based on TCO in solving the mathematical problem at solution plan executing stage is as follows.

a) Students implement operator C, L, I, M and F.

b) Students perform operator series of C1→L1→M1→F1→M1→F1 which means that they check the steps by coordinating relevant figurative scheme, check by using pictures, and take one of the suitable formulas in order to not spend much time.

4) Schema activation profile of student with high mathematical skill level based on TCO in solving mathematical problem at rechecking stage is as follows.

a) Students implement operators C, L, I, M, and F.

b) Student performs operator series of C1→C2→L2→C3→L1→L2→F1→F2→C4→L1 which means that they change the strategy but the pattern is fixed, find the result, explain the whole process using two ways with the same results, then they repeat all the process.

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