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Epistemic game of moderate physics-capable students' by SOLO taxonomy in completing fluid mechanics problems

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Abstract. The students' thinking process in completing problems is able to show epistemic game. SOLO taxonomy is used to categorize the students' thinking process. The researcher to collect data use test and interview. The test is consisted of fluid mechanics test and physics understanding test. Physics understanding test is used to determine the level of students' physics understanding, while the fluid mechanics test is used to determine students' epistemic game by SOLO taxonomy to solve the problems. The analysis result of the first test showed that the game used to solve problems was mapping mathematics to meaning in relational level and transliteration to mathematics in multistructural level. In the second test, the students used pictorial analysis in extended abstract level and transliteration to mathematics level in relational in solving problems. Meanwhile, the students used mapping mathematics to meaning in relational level, and recursive plug and chug in relational level to solve the problems in the third test. Furthermore, the fourth test was completed by recursive plug and chug in relational level. Epistemic game by SOLO taxonomy of this research can be used to determine learning strategy or model which is compatible with learning material concepts.

1. Introduction

The educational orientation has shifted preparing students to be ready to face and overcome cognitive challenges. This is due to the increasingly diverse needs of the world of work in requiring people who are able to solve problems. In facing the world of work in the future, students are not only equipped with concept understanding but also the ability to think in using their knowledge in solving problems. This also happens to the concept of fluid. The fluid learning process is still informative and lacks real experience for students. One of the results of a study shows that physics learning tends to be informative and does not facilitate students in connecting concepts learned with related phenomena [1]. Students have the direct learning experience and affect the student's understanding.

Students' understanding and experience have big role in the problem-solving process. Qualitative or quantitative did not affect application of problem-solving strategy. Besides, conceptual and mathematical reasoning in generating problem solving solutions are used by the students [2]. Learning development must be based on the cognitive process and description about how to represent knowledge and develop students' competence. Compatible model is needed the elaboration of cognitive process to

solve physics problem. Cognitive process is occurred in students thought when they solve physics problem. The students who have equal ability in managing information will achieve good achievement in learning [3]. Meanwhile, an unfavorable achievement will be had the students who have equal ability in organizing information. Therefore, it is necessary to create learning environment which is able to make the students balancing their ability. In forming a problem are depended on the education purposes in articulating the problem selection and design is solved by the students' understanding and providing information [4].

From the students' point of view, to develop students' ability in solving structural problems, firstly, they have to believe that standard procedural approach will not always enough to solve scientific challenges. Development and strengthening the students' problem-solving ability require approach in the form of compatible challenges. Besides, organized understanding can be used to analyze problems qualitatively and to plan possible solutions to monitor students' ability progress [5]. It shows that problem-solving strategy (epistemic game) of the student is less developed. The development of this strategy requires explicit discussion in the teaching-learning process.

The relationship of the students' thought and their ability shows that the students have equal understanding concerning problem solving in physics [6]. Epistemic game is able to show the relationship of students understanding about problem solving by developing their intellectual [6]. Every student has different epistemic game to solve problems. It is depended on their knowledge and understanding. Besides, the presented problems can also influence the students' thought. When difficult problems were given to the students, presentation of equation is needed to help them in solving presented problems. Therefore, compatible learning strategy is needed to develop problem solving for electrical circuit. Furthermore, problem solving strategy (epistemic game) will develop a learning which can stimulate a completion of physics.

Epistemic game is inseparable from the students' thought process in solving problems. SOLO taxonomy is a tool used to categorize student thinking. This is based on research which showed that the thinking framework is characterized by the SOLO taxonomy [7]. The SOLO taxonomy framework classifies the ability of thought process of an issue. This classifies the level of response for the development of thought processes.

2. Method

This research is qualitative research. Interview, fluid mechanics tests, and physics understanding test are used to collect data of qualitative research. It was used to determine epistemic game of moderate physics-capable students in solving fluid mechanics problems. The students' answer to 4 fluid mechanics problems which are given to them to determine epistemic game. Then, it is analyzed using identification rubric of epistemic game and rubric of SOLO taxonomy.

2.1. Research Participants

The students who learns fluid mechanics (consist of 73 students of Mechanical Engineering), Engineering Faculty of Universitas Nusantara PGRI Kediri is the participant of the research. Moderate physics-capable students (6 moderately capable students out of 73 students) based on their physics understanding test results. Students' physics understanding is grouped based on the criteria listed in Table 1 as follows;

Table 1. Grouping criteria of students' physics understanding

Physics Score (PS)	Understanding Level
$75 \leq PS \leq 100$	High
$60 \leq PS < 75$	Moderate
$0 \leq PS < 60$	Low

Table 1 showed that grouping criteria of students' physics understanding. The criteria is used to determine physics-capable students. The grouping criteria based on the result of physics understanding test of students.

2.2. Technique of Collecting Data

2.2.1. Test. The test of research was physics understanding test (the problem was consisted of 7 basic physics material questions) and electrical circuit test (the problem was consisted of 4 preasure and fluid questions).

2.2.2. Interview. The interview of this research was based on the test. It was conducted to obtain clear data concerning students' epistemic game by SOLO taxonomy in completing electrical circuit test. The interview was provided for all students who have moderate understanding in completing fluid mechanics test.

2.3. Technique of Analyzing Data

Data analyzing technique of this research had three stages, they were data reduction, data presentation, and conclusion [8]. The explanations are;

2.3.1. Data Reduction. Reduction of data within this research consist of activities which involve process of selecting data (epistemic game data by SOLO taxonomy or not) based on the relevance level and its relation with each group of game data. In addition, it focused on the data entered to epistemic game data by SOLO taxonomy, simplified raw data of epistemic game by SOLO taxonomy in the field in the form of game data group, made abstract, and transforms data obtained into general epistemic game data by SOLO taxonomy. The activities of the data reduction were started by reading, learning and understanding all of obtained data.

2.3.2. Data Presentation. In this research, data representation consists of grouping activity based on criteria for grouping students' physics abilities presented in Table 1, and data identification conducted by writing organized and categorized data collection, then it can be possible to make a conclusion. The aimed of data presentation activity is to make conclusion easily.

2.3.3. Conclusion. Conclusion is giving a meaning and explanation to data presentation outcome. Next, conclusion in this research is showed to formulate students' problem-solving strategy in completing electrical circuit. Conclusion is obtained based on the data presentation.

2.4. Research Flowchart

The research flowchart is presented on the following Figure 1:

Figure 1 showed that flow of activities carried out by researchers in conducting this research. The first, the researchers reviewed theory about student's epistemic game by SOLO taxonomy in completing fluid mechanics problems. The second activity was for designing draft instrument of physics understanding tests. The third, the researchers validated instrument of physics understanding tests. The fourth activity, determining the research participants by researcher. The fifth was to collected data of physics understanding test results. The sixth, data analysis of physics understanding test result obtained from grouping criteria based on the students' physics understanding test result. The seventh and the eighth activity, the researchers determined students' epistemic game and SOLO taxonomy level based on data analysis of fluid mechanics test result. The last stage, the researchers obtained students' epistemic game data by SOLO taxonomy.

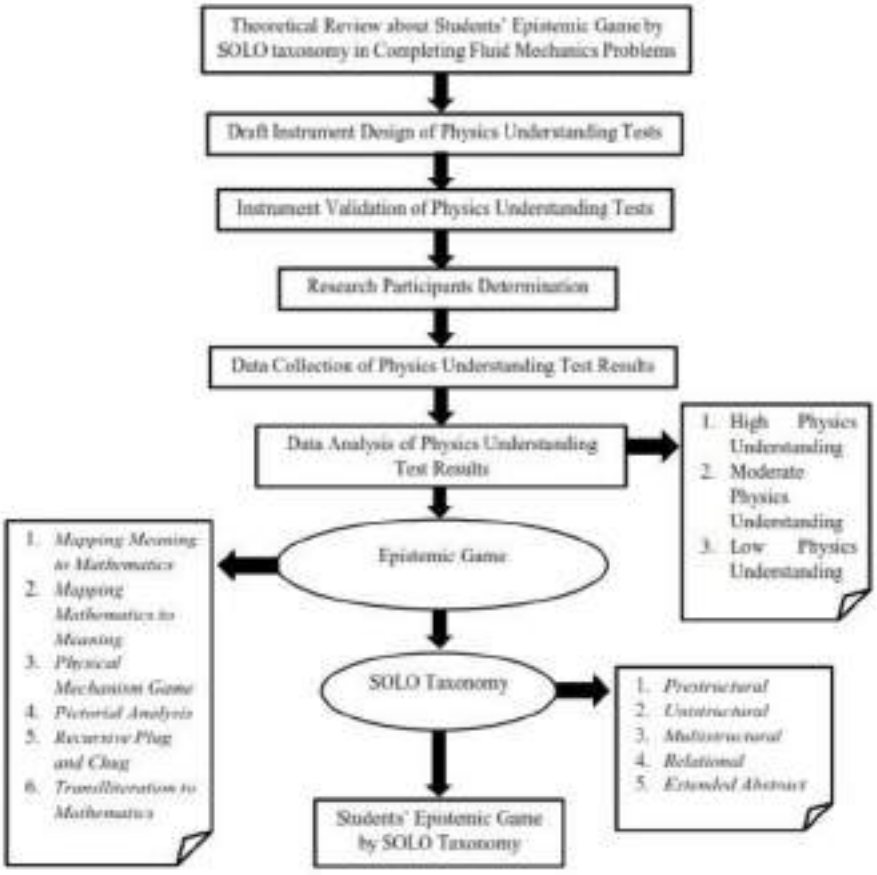

Figure 1. Research Flowchart

3. Result and Discussion

Moderate physics-capable students include six students. Epistemic game by SOLO taxonomy distribution of moderate physics-capable students in completing fluid mechanics problems provided in Table 2.

Table 2. Epistemic game by SOLO taxonomy distribution of moderate physics-capable students in completing fluid mechanics poblems

M	Epistemic Game				SOLO Taxonomy			
	1	2	3	4	1	12	3	4
M003	MMM2	PA	MMM2	RPC	R	EA	R	R
M045	MMM2	PA	RPC	RPC	R	EA	R	R
M048	MMM2	PA	RPC	RPC	R	EA	R	R
M012	TM	TM	RPC	RPC	M	R	R	R
M057	TM	TM	RPC	RPC	M	R	R	R
M066	TM	TM	RPC	RPC	M	R	R	R

Table 2 showed the students' epistemic game by SOLO taxonomy distribution of moderate physics-capable students in completing fluid mechanics problems. M in table was the code of student whereas numeral showed that the student' characteristic. Meanwhile, epistemic game of moderate physics-capable students were mapping mathematics to meaning (MMM2), transliteration to mathematics (TM), pictorial analysis (PA), recursive plug and chug (RPC). And SOLO taxonomy level of student of research result showed that the students used relational (R), multistructural (M) and extended abstract (EA) in completing problems.

Moderate physics-capable students used epistemic game by SOLO taxonomy in solving fluid mechanics problems. The explanations are; the students used mapping mathematics to meaning in completing first test counted by writing fluid concept in the beginning and conducted substitution. This research finding showed that the students completed the test in relational level. They used all of data and connected data and concept. Other Epistemic games used to complete the first test was transliteration to mathematics. The students did the test neatly and straightly yet did not use formula or equation in solving the problems, in the game the students should count step by step. It showed that the students completed the test in multistructural level, they used data without connecting fluid mechanics concepts.

This research finding showed that the students completed the test by following the cognition process in solving the problems. The formation of student understanding and providing information to solve the problems were depended on the purpose of the education in articulating problem selection and design [4]. The students counted by writing law which was compatible with the problems, gave name to each loop, conducted substitution. The students developed conceptual story relating to physics equation in the game mapping mathematics to meaning [6]. The students started with a physics equation and developed conceptual story. The students respond to some data contained in a given problem without connecting between data in multistructural level. The students respond and focus on some data that is relevant to the problem given, and the data is still not integrated [9].

Pictorial analysis was used to complete the second test by the students drew the current by drawing the direction of current, counting step by step, yet do not containing symbol and determining pressure. The students connected data and concepts and applied pressure equation in extended abstract level. In the transliteration to mathematics, the students counted step by step, wrote the symbols only for determining pressure. It showed that the students completed the test in relational level, they used all of data and connected data and concept.

The organized understanding can be used to analyze qualitatively and design a solution which has possibility to monitor advancement of student ability [5]. It shows that problem-solving strategy, i.e. Transliteration to mathematics, uses work sample to produce solutions without developing conceptual understanding. The students counted step by step, wrote symbols only for determining problem solving [6]. Based on the students' response, the students tend to relational level. In the relational level, all aspect of information provided to one another are integrated into a coherent structure [10]. In addition, the studetscan connect between the fact and build the principles/theories in solving the problem given in a short time [11].

In the third test, the students, in completing fluid mechanics problem, used mapping mathematics to meaning. In this case, the students counted by writing fluid concept in the beginning and conducted substitution. The students also used recursive plug and chug to complete the third, they completed the test neatly and in a row, using formulation or equation in solving problems, tended to count step by step, and did not use fluid equation. The students used all of data and connected data and fluid mechanics concepts in relational level in completing the third test.

Those research findings can be explained that the students used some games to solve the problems. It was in accordance with the research [6] stating that specific resources and games were not the only way used or played by the students. Based on the research [6], cognitive model in solving problems (epistemic game) increases the understanding concerning problems which are learned by the students.

The students completed fluid mechanics problems in the fourth test using recursive plug and chug, they completed the test neatly and in a row, using formulation or equation in solving problems, tended

to count step by step, and did not use pressure equation. The students used all of data and connected data and fluid mechanics concepts in relational level in completing the third test.

Recursive plug and chug is used by the students to solve their fluid mechanics problems. In its implementation, the students do not identify and put a quantity into the equation. Epistemic form of recursive plug and chug is identical with mapping meaning to mathematics. Recursive plug and chug relies on syntax understanding of physics symbols without trying to conceptually understand those symbols.

4. Conclusion

The research can be concluded that epistemic games of moderate physics-capable students in solving fluid mechanics problems are the result of the analysis. The analysis result of the first test showed that the game used in solving the problems was mapping mathematics to meaning in relational level and transliteration to mathematics in multistructural level. In the second test, the students used pictorial analysis in extended abstract level and transliteration to mathematics in relational level in solving problems. The students used mapping mathematics to meaning in relational level and recursive plug and chug in relational level to solve the problems in third test. Meanwhile, the fourth test was completed by recursive plug and chug in relational level.

Epistemic game by SOLO taxonomy of this research can be used to determine learning strategy or model which is compatible with learning material concepts. This research is limited to epistemic game by SOLO taxonomy in the material concept of fluid mechanics. Hence, extended research can be conducted on other material concepts, and learning model can also be applied to support learning material concepts.

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