Prosiding (The analysis of student epistemic games reviewed from physics understanding)

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Submission date: 15-Dec-2021 11:25PM (UTC+1100)
Submission ID: 1731088457
File name: student_epistemic_games_reviewed_from_physics_understanding.pdf (700.07K)
Word count: 2815
Character count: 16073

The Analysis of Student Epistemic Games Reviewed from Physics Understanding

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Abstract. Epistemic game is able to show the relationship of students' understanding concerning problem solving by developing students' intellectual. The aim of the research is to determine epistemic game of high physics-capable students in solving electrical circuit problems. This research is qualitative research. The participant of the research is the students who learn electrical circuit. Test and interview are used by the researcher to collect data. The test is consisted of physics understanding test and electrical circuit test. Physics understanding test is used to determine the level of students' physics understanding, while the electrical circuit test is used to determine students' epistemic game to solve the problems. The research finding showed the epistemic game of high physics-capable students was obtained from analysis result of electrical circuit test and interview. The analysis result of the first test and the third test showed that the game used to solve problems was physical mechanism, mapping meaning to mathematics, and transliteration to mathematics. In the second test, the students used physical mechanism, pictorial analysis, mapping meaning to mathematics, and transliteration to mathematics in solving problems. Meanwhile, the students used mapping mathematics to meaning and pictorial analysis to solve the problems in the fourth test, fifth test, and eighth test. The analysis result of sixth test showed that the students used mapping meaning to mathematics and transliteration to mathematics to solve the problems. Furthermore, the seventh test was completed by transliteration to mathematics, physical mechanism, and recursive plug and chug. Epistemic game of this research can be used to determine learning strategy or model which is compatible with learning material concepts.

INTRODUCTION

Students' understanding and experience have big role in the problem-solving process. Application of problem-solving strategy is not affected by qualitative or quantitative. Besides, the students use conceptual and mathematical reasoning in generating problem solving solutions [1]. Learning development must be based on the cognitive process and description about how to represent knowledge and develop students' competence. The elaboration of cognitive process to solve physics problem needs compatible model. 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 [2]. Meanwhile, the students who have equal ability in organizing information will have an unfavorable achievement. Therefore, it is necessary to create learning environment which is able to make the students balancing their ability. In forming the students' understanding and providing information to solve a problem are depended on the education purposes in articulating the problem selection and design [3].

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 [4]. 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 3rd International Conference on Mathematics and Sciences Education (ICoMSE) 2019
AIP Conf. Proc. 2215, 030012-1–030012-6; https://doi.org/10.1063/5.0000516
Published by AIP Publishing. 978-0-7354-1968-1/$30.00

The relationship of the students' thought and their ability shows that the students have equal understanding concerning problem solving in physics [5]. Epistemic game is able to show the relationship of students understanding about problem solving by developing their intellectual [5]. 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.

There are still many misconceptions and difficulties in understanding electrical circuit. It is showed by the lack of development of the electric circuit concept. Most of the students only used laboratory work which is already ineffective. Forming a discussion team also has positive affect to students' physics ability. Misconceptions and difficulties in learning electrical circuit include the basic concept and the circuit of the electric circuit itself [6]. Hence, the students need learning strategy which is compatible to develop electrical circuit problems completion. Additionally, problem solving strategy (epistemic game) will develop a learning which can stimulate a completion of physics. This case encourages the researcher to determine epistemic game of high physics-capable students in solving electrical circuit problems. The result of the research can be used as a reference in developing method or physics learning strategy in order to ease the misconception of the concept which makes the students bias in understanding the concept.

METHOD

This research is qualitative research. Data collection of qualitative research used interview, electrical circuit tests, and physics understanding test. It was used to determine epistemic game of high physics-capable students in solving electrical circuit problems. Epistemic game was determined by the students' answer to 8 electrical circuit problems which are given to them. Then, it is analyzed using identification rubric of epistemic game.

Research Participants

The participant of the research is the students who learns electrical circuit (consist of 9 students of Electrical Engineering and 4 students of Industrial Engineering), Engineering Faculty of Universitas Nusantara PGRI Kediri. High physics-capable students (8 moderately capable students out of 13 students) based on their physics understanding test results. Students' physics understanding are 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

Technique of Collecting Data

Data collection technique was conducted using two techniques, they are as follow;

Test

The test used in this research was physics understanding test (the problem was consisted of 10 basic physics material questions) and electrical circuit test (the problem was consisted of 8 replacement resistance and electrical circuit questions).

Interview

The interview of this research was based on the test. It was conducted to obtain clear data concerning students' epistemic game in completing electrical circuit test. The interview was provided for all students who have high understanding in completing electrical circuit test.

Technique of Analyzing Data

Data analyzing technique of this research had three stages, they were data reduction, data presentation, and conclusion [7]. The explanations are;

Data Reduction

Reduction of data within this research consist of activities which involve process of selecting data (epistemic game data 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, simplified raw data of epistemic game in the field in the form of game data group, made abstract, and transforms data obtained into general epistemic game data. The activities of the data reduction were started by reading, learning and understanding all of obtained data.

Data Presentation

In this research, data representation consist 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.

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.

Research Roadmap

The research roadmap is presented on the following Fig. 1;

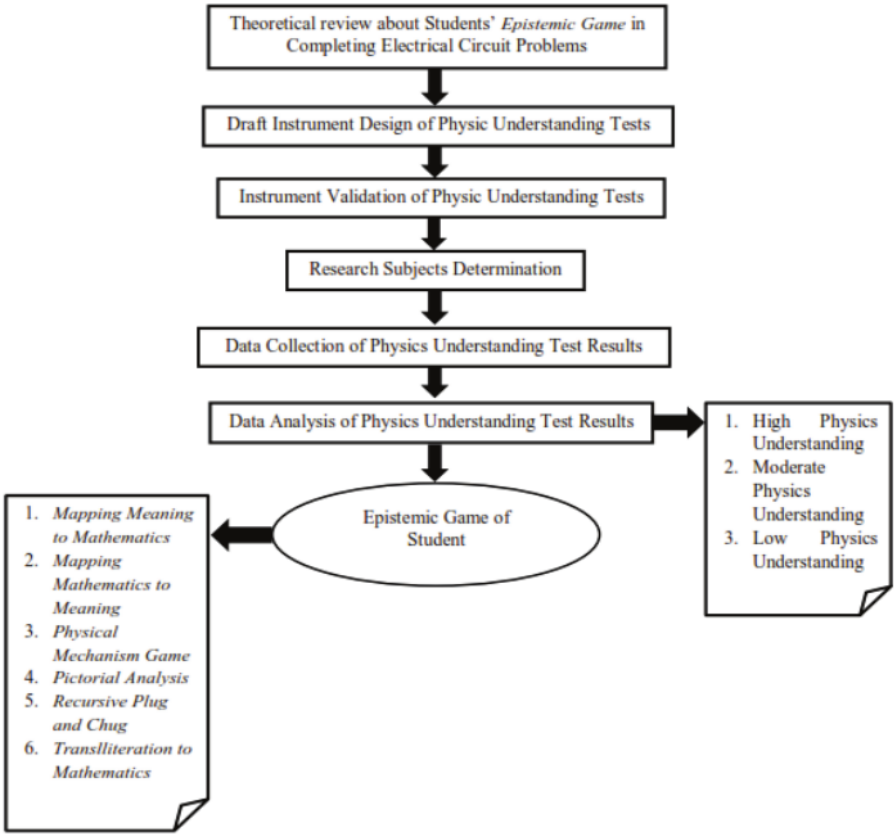

FIGURE 1. Research Roadmap

RESEARCH FINDING AND DISCUSSION

High physics-capable students include eight students. Epistemic game distribution of high physics-capable students in completing electrical circuit problems provided in TABLE 2.

TABLE 2. Epistemic game distribution of high physics-capable students in completing electrical circuit problems

Student	Test							
	1	2	3	4	5	6	7	8
M1	PM	TM	PM	MMM2	MMM2	MMM1	PM	PA
M3	PM	MMM1	PM	MMM2	MMM2	MMM1	TM	PA
M4	MMM1	PM	PM	PA	PA	MMM1	TM	MMM2
M5	MMM1	MMM1	MMM1	PA	MMM2	TM	RPC	PA
M6	PM	PA	PM	MMM2	MMM2	TM	TM	MMM2
M7	PM	MMM1	PM	MMM2	PA	MMM1	TM	PA
M8	TM	PM	TM	MMM2	MMM2	MMM1	TM	PA
M9	TM	TM	PM	MMM2	MMM2	TM	TM	PA

M = The Code of Student
MMM1 = Mapping Meaning to Mathematics
MMM2 = Mapping Mathematics to Meaning
PM = Physical Mechanism
PA = Pictorial Analysis
RPC = Recursive Plug and Chug
TM = Transliteration to Mathematics

High physics-capable students used epistemic game in solving electrical circuit problems. The explanations are; the students used physical mechanism in completing first and third test by drawing the circuits of each completion stage yet did not contain symbol, counting step by step, writing symbols (for determining R series or R parallel only). Other Epistemic games used to complete the first and third 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. Mapping meaning to mathematics was also used to complete the first and third test. In this game, the students drew the circuits of each completion stage yet did not contain symbol, counted concisely, wrote symbols only for determining R series or R parallel.

The implementation of mapping meaning to mathematics as problem solving strategy in this research has not well developed yet. It is corresponding with the result of the research [5] which showed that second and third stage of this game was difficult to be developed. Second stage of this game is translating quantities into mathematical units, while the third stage connects mathematical units according to the physics. Second stage activates intuitive mathematical knowledge, symbolic form and interpretation equipment. Meanwhile, the third stage is depended on the intuitive mathematical knowledge, symbolic form and interpretation equipment. The second and third stages are epistemic form of mapping meaning to mathematics, then the students produce collection of mathematical symbols.

The students completed second test using mapping meaning to mathematics, they drew the circuits of each completion stage yet did not contain symbol, counted step by step, wrote symbols only for determining R series or R parallel. Physical mechanism was used to solve second test within the main circuits drawing yet did not contain symbol, counted concisely, wrote symbols only for determining R series or R parallel. In the transliteration to mathematics, the students counted step by step, wrote the symbols only for determining R series or R parallel. In addition, depiction of each completion stage circuits yet does not contain symbols, counts step by step, writes symbols only for determining R series or R parallel are used to pictorial analysis.

Those research findings can be explained that the students used some games to solve the problems. It was in accordance with the research [5] stating that specific resources and games were not the only way used or played by the students. Based on the research [5], cognitive model in solving problems (epistemic game) increases the understanding concerning problems which are learned by the students.

In the fourth, fifth, and eighth test, the students used mapping mathematics to meaning to solve the problems. In this game, the student counted by writing Kirchoff law in the beginning, gave a name for each loops, conducted substitution and elimination. Pictorial analysis was also used to complete fourth, fifth, and eighth test. It was the test where the students drew the main circuits by drawing the direction of each loop, counting by writing Kirchoff law, conducting substitution and elimination.

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 [3]. The students counted by writing law which was compatible with the problems, gave name to each loop, conducted substitution and elimination. The students developed conceptual story relating to physics equation in the game mapping mathematics to meaning [5]. The students started with a physics equation and developed conceptual story.

Furthermore, the students completed the sixth test using mapping meaning to mathematics. They drew the circuits of each completion stage yet did not contain any symbols, counted in this game. Transliteration to mathematics was used by the students to solve the problems existed within the test by counting step by step, writing symbols only for determining R series or R parallel.

The organized understanding can be used to analyze qualitatively and design a solution which has possibility to monitor advancement of student ability [4]. 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 [5].

In the seventh test, the students, in completing electrical circuit problem, used transliteration to mathematics. In this case, the students did it neatly and in a row yet did not use formulation or equation in solving the problems, they tended to count quickly/concisely, and they did not use Wheatstone bridge equation. The students also used physical mechanism to complete the seventh test in drawing the circuit of Wheatstone bridge, undertake the problems neatly and in a row yet did not use formulation or equation in solving the problems, they tended to count quickly and concisely, they also did not use Wheatstone bridge equation. Meanwhile, the students who used recursive plug and chug to complete seventh test, 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 Wheatstone bridge equation.

Yet, recursive plug and chug is rarely used by the students to solve their physics 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.

CONCLUSIONS

The research can be concluded that epistemic games of high physics-capable students in solving electrical circuit problems are the result of the analysis. The analysis result of the first and the third test showed that the game used in solving the problems was physical mechanism, mapping meaning to mathematics, and transliteration to mathematics. In the second test, the students used physical mechanism, pictorial analysis, mapping meaning to mathematics, and transliteration to mathematics in solving problems. The students used mapping mathematics to meaning and pictorial analysis to solve the problems in the fourth test, fifth test, and eighth test. The analysis result of sixth test showed that the students used mapping meaning to mathematics and transliteration to mathematics to solve the problems. Meanwhile, the seventh test was completed by transliteration to mathematics, physical mechanism, and recursive plug and chug.

Epistemic game 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 in the material concept of electrical circuit. Hence, extended research can be conducted on other material concepts, and learning model can also be applied to support learning material concepts.

ACKNOWLEDGMENT

The researcher is very grateful to Ministry of Research, Technology and Higher Education of the Republic of Indonesia for funding this research.

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FINAL GRADE

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GENERAL COMMENTS

Instructor

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RUBRIC: 6TH-8TH SCIENCE ARGUMENT (CER)

CLAIM

Take an arguable position on the scientific topic and develop the essay around that stance.

ADVANCED	The essay introduces a precise, qualitative and/or quantitative claim based on the scientific topic or text(s), regarding the relationship between dependent and independent variables. The essay develops the claim and counterclaim fairly, distinguishing the claim from alternate or opposing claims.
PROFICIENT	The essay introduces a clear, qualitative and/or quantitative claim based on the scientific topic or text(s), regarding the relationship between dependent and independent variables. The essay effectively acknowledges and distinguishes the claim from alternate or opposing claims.
DEVELOPING	The essay attempts to introduce a qualitative and/or quantitative claim, based on the scientific topic or text(s), but it may be somewhat unclear or not maintained throughout the essay. The essay may not clearly acknowledge or distinguish the claim from alternate or opposing claims.
EMERGING	The essay does not clearly make a claim based on the scientific topic or text(s), or the claim is overly simplistic or vague. The essay does not acknowledge or distinguish counterclaims.

EVIDENCE

Include relevant facts, definitions, and examples to back up the claim.

ADVANCED	The essay supplies sufficient relevant, accurate qualitative and/or quantitative data and evidence related to the scientific topic or text(s) to support its claim and counterclaim.
PROFICIENT	The essay supplies relevant, accurate qualitative and/or quantitative data and evidence related to the scientific topic or text(s) to support its claim and counterclaim.
DEVELOPING	The essay supplies some qualitative and/or quantitative data and evidence, but it may not be closely related to the scientific topic or text(s), or the support that is offered relies mostly on summary of the source(s), thereby not effectively supporting the essay's claim and counterclaim.
EMERGING	The essay supplies very little or no data and evidence to support its claim and counterclaim, or the evidence that is provided is not clear or relevant.

REASONING

Explain how or why each piece of evidence supports the claim.

ADVANCED	The essay effectively applies scientific ideas and principles in order to explain how or why the cited evidence supports the claim. The essay demonstrates consistently logical reasoning and understanding of the scientific topic and/or text(s). The essay's explanations anticipate the audience's knowledge level and concerns about this scientific topic.

PROFICIENT	The essay applies scientific reasoning in order to explain how or why the cited evidence supports the claim. The essay demonstrates logical reasoning and understanding of the scientific topic and/or text(s). The essay's explanations attempt to anticipate the audience's knowledge level and concerns about this scientific topic.
DEVELOPING	The essay includes some reasoning and understanding of the scientific topic and/or text(s), but it does not effectively apply scientific ideas or principles to explain how or why the evidence supports the claim.
EMERGING	The essay does not demonstrate clear or relevant reasoning to support the claim or to demonstrate an understanding of the scientific topic and/or text(s).

FOCUS

Focus your writing on the prompt and task.

ADVANCED	The essay maintains strong focus on the purpose and task, using the whole essay to support and develop the claim and counterclaims evenly while thoroughly addressing the demands of the prompt.
PROFICIENT	The essay addresses the demands of the prompt and is mostly focused on the purpose and task. The essay may not acknowledge the claim and counterclaims evenly throughout.
DEVELOPING	The essay may not fully address the demands of the prompt or stay focused on the purpose and task. The writing may stray significantly off topic at times, and introduce the writer's bias occasionally, making it difficult to follow the central claim at times.
EMERGING	The essay does not maintain focus on purpose or task.

ORGANIZATION

Organize your writing in a logical sequence.

ADVANCED	The essay incorporates an organizational structure throughout that establishes clear relationships among the claim(s), counterclaims, reasons, and evidence. Effective transitional words and phrases are included to clarify the relationships between and among ideas (i.e. claim and reasons, reasons and evidence, claim and counterclaim) in a way that strengthens the argument. The essay includes an introduction and conclusion that effectively follows from and supports the argument presented.
PROFICIENT	The essay incorporates an organizational structure with clear transitional words and phrases that show the relationship between and among ideas. The essay includes a progression of ideas from beginning to end, including an introduction and concluding statement or section that follows from and supports the argument presented.
DEVELOPING	The essay uses a basic organizational structure and minimal transitional words and phrases, though relationships between and among ideas are not consistently

	clear. The essay moves from beginning to end; however, an introduction and/or conclusion may not be clearly evident.
EMERGING	The essay does not have an organizational structure and may simply offer a series of ideas without any clear transitions or connections. An introduction and conclusion are not evident.

LANGUAGE

Pay close attention to your tone, style, word choice, and sentence structure when writing.

ADVANCED	The essay effectively establishes and maintains a formal style and objective tone and incorporates language that anticipates the reader's knowledge level and concerns. The essay consistently demonstrates a clear command of conventions, while also employing discipline-specific word choices and varied sentence structure.
PROFICIENT	The essay generally establishes and maintains a formal style with few possible exceptions and incorporates language that anticipates the reader's knowledge level and concerns. The essay demonstrates a general command of conventions, while also employing discipline-specific word choices and some variety in sentence structure.
DEVELOPING	The essay does not maintain a formal style consistently and incorporates language that may not show an awareness of the reader's knowledge or concerns. The essay may contain errors in conventions that interfere with meaning. Some attempts at discipline-specific word choices are made, and sentence structure may not vary often.
EMERGING	The essay employs language that is inappropriate for the audience and is not formal in style. The essay may contain pervasive errors in conventions that interfere with meaning, word choice is not discipline-specific, and sentence structures are simplistic and unvaried.