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Epistemic Games of Moderate Physics-Capable Students in Completing Electrical Circuit Problems

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Abstract

The students need a learning strategy that is compatible to develop electrical circuit problems completion. Additionally, problem-solving strategy (epistemic game) will develop a learning process that can stimulate the completion of physics. This case encourages the researcher to determine the epistemic game of moderate physics-capable students in solving electrical circuit problems. Moreover, it is qualitative research, and the participant of the research is the students who learn the electrical circuit. Moderate physics-capable students (4 moderately capable students out of 13 students) based on their physics understanding test results. Test and interview were used by the researcher to collect data. The test consists of a physics understanding test and an electrical circuit test. The physics understanding test is used to determine the level of students' physics understanding, while the electrical circuit test is used to determine students' epistemic games to solve the problems. The research finding showed the epistemic game of moderate physics-capable students was obtained from the analysis result of the electrical circuit test and interview. The analysis result of the first test, the second test, the third test, and the seventh test showed that the game used to solve problems was transliteration to mathematics. Meanwhile, the students used mapping mathematics to meaning and transliteration to mathematics to solve the problems in the fourth test. The analysis result of the fifth test and the eight test showed that the students used mapping mathematics to meaning to solve the problems. Furthermore, the sixth test was completed by mapping meaning to mathematics.

Keywords: electrical circuit, epistemic game

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INTRODUCTION

Students' understanding and experiencing have a big role in the problem-solving process. The application of problem-solving strategy is not affected by qualitative or quantitative. Besides, students use conceptual and mathematical reasoning in generating problem-solving solutions (Chen, Irving, & Sayre, 2013). Learning development must be based on the cognitive process and description of how to represent knowledge and develop students' competence. The elaboration of the cognitive process to solve the physics problem needs a compatible model. The cognitive process occurs in students' thoughts when they solve physics problems. According to Bancong & Subaer (2013) the students who have equal ability in managing information will achieve good achievement in learning. Meanwhile, the students who have equal ability in organizing information will have an unfavorable achievement. Therefore, it is necessary to create a learning environment which can make the students balancing their ability. To form the students' of understanding and providing information to solve some problems are depended on the educational purposes in articulating the problem selection and design (Teodorescu & etal, 2013). Implementation of a model can improve the students' critical thinking, concept understanding, and problem-solving process (Fitriyani, Supeno, & Maryani, 2019; Hidayat, Hakim, & Lia, 2019; Pratiwi, Ain, & Igut, 2019). A model as well as the long-term impacts of instructional development on teaching (Ibrahim, Clark, Reese, & Shingles, 2020). Besides, it can change students' thinking pattern in solving problem (Puspitasari & Munawi, 2018).

From the students' point of view, to develop students' ability in solving structural problems, firstly, they have to believe that the standard procedural approach will not always enough to solve scientific challenges (Ogilvie, 2009). Development and strengthening the students' problem-solving ability require an 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 to progress (Ogilvie, 2009). It shows that the 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 between the students' thought and their ability shows that the students have an equal understanding regarding problem-solving in physics (Tuminaro & Redish, 2007). The epistemic game can show the relationship of students' understanding of problem-solving by developing their intellectual (Hu, Chen, Leak, Young, Santangelo, Zwickl, & Martin, 2019; Mason & Bertram, 2016; Toharudin, Hendrawan, & Rustaman, 2011; Tuminaro & Redish, 2007). Every student has a different epistemic game to solve the problems.s It is depended on their knowledge and understanding. Besides, the presented problems can also influence students' thoughts. When difficult problems were given to the students, the presentation of the equation is needed to help them in solving presented problems.

There are still many misconceptions and difficulties in understanding the electrical circuit. It is occurred due to the lack of development of the electrical circuit concept. Most of the students only used laboratory work which is already ineffective. Meanwhile, physics learning is a unity of concept and experience. Besides, forming a discussion team also has a positive effect on students' physics understanding. The difficulties and the misconceptions in learning electrical circuits. It included the basic concept and the circuit of the electrical circuit itself (Papadimitriou, 2012). Hence, the students need a learning strategy that is compatible to develop electrical circuit problems completion. Additionally, problem-solving strategy (epistemic game) will develop a learning process that can stimulate a completion of physics. This case encourages the researcher to determine the epistemic game of moderate physics-capable students in solving electrical circuit problems.

METHOD

This is qualitative research. Data collection of qualitative research used interview, electrical circuit test, and physics understanding test. It was used to determine the epistemic game of moderate physics-capable students in solving electrical circuit problems.

The epistemic game was determined by the students' answers to 8 electrical circuit problems that are given to them. Then, it is analyzed using the identification rubric of the epistemic game (mapping meaning to mathematics, mapping mathematics to meaning, physical mechanism, pictorial analysis, recursive plug and chug, transliteration to mathematics). The instrument correlation coefficient of 0.509 was greater than the correlation coefficient of r-table so that the instrument is valid. And the instrument reliability coefficient was 0.60 which is greater than 0.50 so the instrument was reliable.

The participant of this research were the students who learn the electrical circuit. They are the students of Engineering Faculty of Universitas Nusantara PGRI Kediri (consists of 9 students of Electrical Engineering and 4 students of Industrial Engineering). Moderate physics-capable students (4 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 follow.

Table 1 Grouping Criteria of Students' Physics Understanding

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

(Ratumanan & Laurens, 2011)

The technique of collecting data was conducted using two techniques, they are as follow: (1) Test : the test was the physics understanding test (the problem consisted of 10 basic physics material questions) and the electrical circuit test (the problem consisted of 8 replacement resistance and electrical circuit), and (2) Interview; The interview was based on the test. It was conducted to obtain clear data concerning students' epistemic game in completing the electrical circuit test. The interview was provided for all students who have a moderate understanding of completing the electrical circuit test. The interview rubric are as follow; (1) Responses to completing electrical circuit problem, (2) The students' explanation in choosing the flow of completing electrical circuit problem, (3) The students' explanation in using symbols to complete electrical circuit problem, (4) The students' explanation in drawing the electrical circuit complete electrical circuit problem.

The technique of analyzing data of this research was based on Mile & Huberman (1994) stages. They were data reduction, data presentation, and conclusion. The explanations of those stages are as follow: (1) Data reduction; Data reduction within this research consist of activities involves the process of selecting data (epistemic game data or not) based on the relevance level and its relation with each group of game data.

Besides, it focused on the data entered into 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. (2) Data presentation; Data presentation of this research consists of grouping activity based on criteria for grouping students' physics understanding presented in Table 1. Furthermore, the data identification conducted by writing organized and categorized data collection, to it can be possible to conclude. Therefore, the aimed of data presentation activity is to conclude easily, and (3) Conclusion; the conclusion is giving meaning and explanation of the data presentation outcome. It is showed to formulate students' problem-solving strategies in completing the electrical circuit. The conclusion is obtained based on the data presentation.

RESULT AND DISCUSSION

Moderate physics-capable students used the epistemic game in completing the electrical circuit problem. The explanation is; the students used physical mechanisms in completing the first, second, third, and sixth test by drawing the circuit of each completion stage yet did not involve any symbols, calculated step by step, writing symbols (for determining R series or R parallel only). Another epistemic game which was used to complete first, second, third, and sixth test was transliteration to mathematics. In this game, the students did the test neatly and straightly yet did not use any formulas or equations in solving the problems, and the students should calculate step by step in the game. The example of problem-solving was completed by moderate physics-capable students to use transliteration to mathematics was presented in Figure 1.

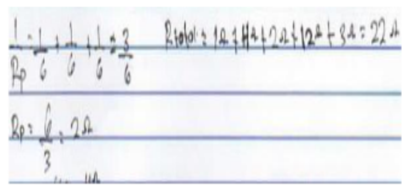

Figure 1 Using Transliteration to Mathematics in Completing Problems

Mapping meaning to mathematics was also used to complete the first, second, third, and sixth test. In conducting the game, the students drew the circuit of each completion stage but did not use any symbols, calculated concisely, and wrote the symbols (for determining R series or R parallel only). The example of problem-solving was completed by moderate physics-capable students to use mapping meaning to mathematics was presented in Figure 2.

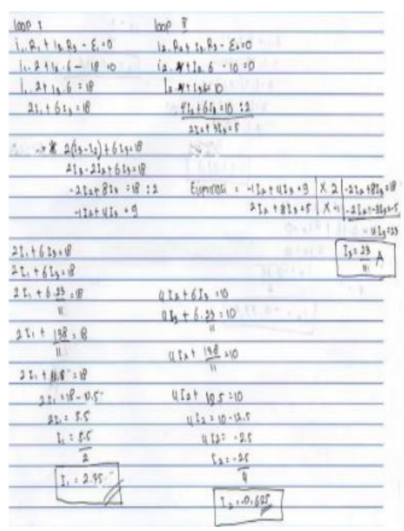

Figure 2 Using Mapping Meaning to Mathematics in Completing Problems

Then, the students who used pictorial analysis completed the first, second, third, and sixth test by drawing the circuit of each completion stages. In this game, they also did not use any symbols, calculated step by step, and wrote symbols (for determining R series or R parallel only).

Moreover, in the fourth, fifth, and eighth test the students used mapping mathematics to meaning in completing the problem. In this game, the students calculated by writing down Kirchoff law at the beginning, labeling each loop, conducting substitution and elimination. The example of problem-solving was completed by moderate physics-capable students to use mapping mathematics to meaning was presented in Figure 3.

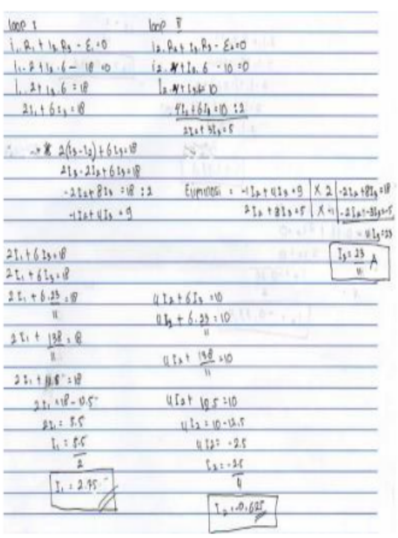

Figure 3 Using Mapping Mathematics to Meaning in Completing Problems

The pictorial analysis was also used to complete the fourth, fifth, and eighth test where the students drew the main circuit by drawing the direction of each loop, calculating by writing down Kirchoff law at the beginning, conducting substitution and elimination. The students used transliteration to mathematics to solve the problems by calculating step by step, writing symbols only for determining R series or R parallel.

In the seventh test, the students used transliteration to mathematics to solve electrical circuit problems. In this case, the student did the test neatly and straightly yet did not use any formulas or equations in solving the problems, they tended to calculate quickly/concisely, and they did not use the Wheatstone bridge equation. Physical mechanism was also used by the students to complete the seventh test in drawing the circuit of the Wheatstone bridge, undertaking the problems neatly and consecutively, they also did not use formulation or equation. They also tended to calculate quickly and concisely and did not use the Wheatstone bridge equation. Meanwhile, the students who used recursive plug and chug to complete the seventh test, they completed it neatly and consecutively, used formulation/equation, tended to count step by step, and did not use Wheatstone bridge equation.

Moderate physics-capable students include four students. Epistemic game distribution of moderate physics-capable students in completing electrical circuit problems is provided in Table 2.

Table 2 Epistemic Game Distribution of Moderate Physics-Capable Students in Completing Electrical Circuit Problems

Student	**Test**							
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**
M10	TM	TM	TM	TM	MMM2	MMM1	TM	MMM2
M11	TM	TM	TM	MMM2	MMM2	MMM1	TM	MMM2

M12	TM	TM	TM	MMM2	MMM2	MMM1	TM	MMM2
M13	TM	TM	TM	MMM2	MMM2	MMM1	TM	MMM2

Note:M = The Code of Student; MMM1 = Mapping Meaning to Mathematics; MMM2= Mapping Mathematics to Meaning; TM = Transliteration to Mathematics

The research finding showed that the students solved the test by following the cognition process. Formation of understanding and providing information to solve some problems are depended on the educational purposes in articulating the problem selection and design (Teodorescu & etal, 2013). The students calculated by writing down the appropriate law at the beginning, labeled each loop and conducted substitution and elimination. The students develop a conceptual story relating to the physics equation in mapping mathematics to meaning games (Tuminaro & Redish, 2007). First, the students start the game with physics equation, and then they develop the conceptual story. Steps of the game are: (1) Identifying the concept, (2) Figuring out the equation to solve the problems, (3) Combining the concepts, (4) Evaluating the problems.

Organized understanding can be used to analyze problems qualitatively and expected to have possible solutions to monitor the progress of the students' abilities (Ogilvie, 2009). It is showed that problem-solving strategy, for instance, transliteration to mathematics, used a profession as an example to get solutions without developing conceptual understanding. The students calculated step by step wrote down the symbols only for determining problem-solving. (Tuminaro & Redish, 2007) had identified four steps of the game, as follows; (1) Identifying quantities, (2) Figuring out solution pattern, (3) Mapping quantities, (4) Evaluating mapping.

Meanwhile, the students did not identify and apply the quantities into the equation in recursive plug and chug implementation. The identifications of this game are (Tuminaro & Redish, 2007); (1) Identifying quantity, (2) Figuring out the equation which correlates with the problems, (3) Determining other quantity, (4) Identifying new quantity (if needed), (5) Calculating quantity.

CONCLUSION

The research can be concluded that epistemic games of moderate physics-capable students in solving electrical circuit problems are the results of the analysis. The epistemic game which was used by moderate physic-capable students to complete the first, second, third, and seventh test of electrical circuit was transliteration to mathematics. In the fourth test, the students used mapping mathematics to meaning and transliteration to mathematics in solving problems. The students used mapping mathematics to meaning to solve the problems in the fifth and eighth test. Meanwhile, the sixth test was completed by mapping meaning to mathematics.

The epistemic game of this research can be used to determine a learning strategy or model which is compatible with learning material concepts. This research is limited to the epistemic game of the electrical circuit concept. Hence, extended research on other concepts and learning models can also be applied to support the mentioned learning material concepts. 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.

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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.