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Epistemic Game on Aplication of Newton's Laws

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Abstract: Epistemic games are a problem-solving strategy used by students in the process of finding solutions to a given problem. This study aims to determine the epistemic game that is owned by students in solving Newton's law application problems. The method used is a qualitative method in which student problem-solving strategies are identified in six games. The research subjects were students taking physics and biology courses. Data collection uses interviews and concept understanding tests about the application of Newton's law. The results showed that students used different games between each other to solve Newton's law application problems. The epistemic games that students have include mapping meaning to mathematics, physical mechanism, pictorial analysis, and transliteration to mathematics. Students use different games with each other to solve Newton's law application problems. The process by which students determine the solution to the problem-solving application of Newton's law is influenced by their' understanding of the material. This research is limited in the form of an epistemic game analysis of the application of Newton's law, so that further research can be carried out on other material concepts.

Keywords: Epistemic Game, Newton's Law, Problem Solving

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INTRODUCTION

Developments in education and technology require students to improve their problem-solving abilities in all aspects of the field of science. This is also a requirement for students who are taking a biology education study program. Problem solving abilities cannot be separated from the strategies students have in solving problems (Czuk & Henderson, 2005). This is indicated by the process carried out by students in solving the given problem. Students have a lot of prior knowledge and ideas that they bring to bear when solving physics problems. In order to understand and talk about what students do, we need a description of the way their resources are organized (Tuminaro & Redish, 2007; Yusuf et al., 2023).

The application of Newton's laws is material that needs to be mastered by students of the biology education study program who are taking physics for biology courses. Material on the application of Newton's laws includes the application of Newton's three laws applied to particle kinematics. The depth of students' understanding and knowledge in the process of solving problems shows the identification of the epistemic game that students have (Hu et al., 2019; Hunter et al., 2021). Characteristics of students' problem-solving solutions can be identified in epistemic games.

The process carried out by students in solving problems can be identified using problem solving strategies. Problem-solving strategies or what can be called epistemic games are problem-solving patterns that are identified as several games. Students have productive resources and approaches to engage in problem solving as shown by their epistemic games (Rodriguez et al., 2020). The epistemic game consists of six games, namely mapping meaning to mathematics, mapping mathematics to meaning, physical mechanisms, pictorial analysis, recursive plug and chug, and transliteration to mathematics.

Epistemic games are the result of research from Tuminaro which shows that problem-solving strategies can be identified in six games and are obtained from the results of students' understanding. Epistemic games are believed to be able to show students' problem-solving strategies in providing solutions to the problems that are given (Shaffer, 2006; Wang & Wang, 2017). Identification of this epistemic game will be used to detect patterns of problem-solving strategies owned by students (Ke, 2019). This pattern of problem-solving strategies can later be used to develop learning models or strategies on the same material or do not demand the possibility of being applied to different materials (Gomes & Mendes, 2007).

In previous studies, researchers have identified epistemic games in students of electronics engineering and mechanical engineering in certain subjects and produced various results. These results indicate that students have a variety of games in solving or solving problems. And not

only that, previous research also shows that one student can use different games when solving or solving different problems even in solving material of the same scope. It is possible that every student has several games and also uses games that are different from one another in the process of solving Newton's law application problems.

METHOD

The research method used in this study is a qualitative one (Creswell, 2012). Data collection uses interviews and concept understanding test about the application of Newton's law. The results of the answers to test, interviews, and discussion activities were analyzed to obtain epistemic game data in this study. The research subjects were students studying physics for biology, which consisted of 30 students of Universitas Nusantara PGRI Kediri. Steps of data collection techniques carried out include data reduction, data presentation and drawing conclusions as in **Figure 1**.

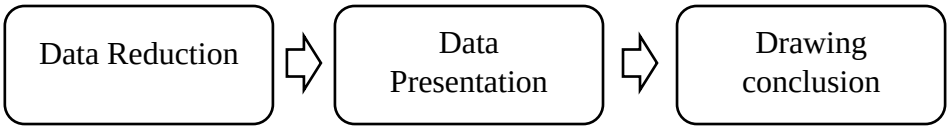

Figure 1. Steps of data collection techniques

FINDING AND DISCUSSION

Epistemic games owned by students in solving Newton's law application material problems include mapping meaning to mathematics, physical mechanisms, pictorial analysis, transliteration to mathematics. The process of solving each student's problem is different depending on the depth of understanding of the application material Newton's laws have. The results showed that students used different games between each student in solving Newton's law application problems. The process of students in determining the solution to the problem-solving application of Newton's law is influenced by students' understanding of the material.

Pictorial analysis is used by students in determining the appropriate concept to the problem. Not only that, students describe the direction of the forces that work in the system. The system in question is seen in object A system or object B system or 1 system as a whole which includes object A, object B and pulleys. Sometimes students only involve one or both of them while the system is related to one another. Students explain and represent problems applying Newton's laws conceptually. Students demonstrate that applying equations is related to problems applying Newton's law.

Physical mechanism develops stories about physical situations and then evaluates the problem stories as in **Figure 2**. The basis of this game is primitive reasoning where students do

not make precise descriptions of concepts and problem equations (Tuminaro, 2004). Students who use physical mechanisms in solving Newton's law application problems only briefly describe and do not write down the equations of the combined system of objects A and objects B viewed in 1 system.

Transliteration to mathematics is used by students in the process of solving Newton's law application problems by identifying the quantities used and related concepts to describe solutions to solving Newton's law application problems. Students who use this game show that using quantities related to concepts but cannot connect between concepts contained in solving Newton's law application problems.

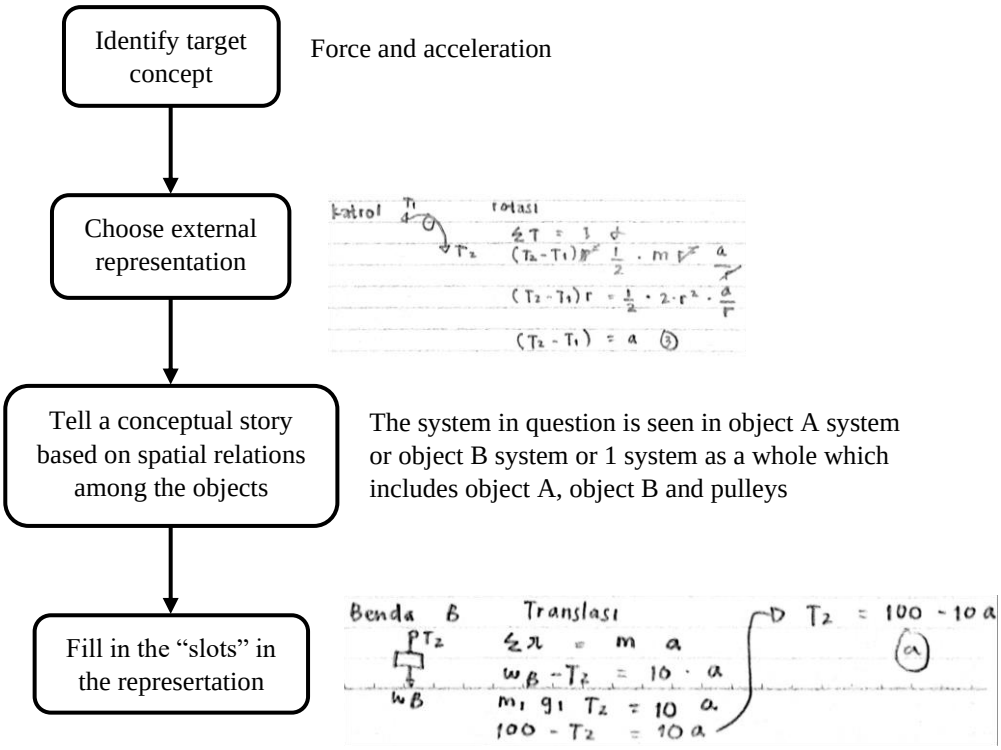

Figure 2. Schematic map within pictorial analysis

Mapping meaning to mathematics was used only by one student. While other students still do not represent the problem-solving process given. So that the games owned by other students have not sufficiently revealed the process of problem-solving strategies in detail. This shows that students' understanding of Newton's law application material has not been fully mastered because it can be seen from the elaboration of the results of solving the problem. In line with research conducted by Bontinge et al. (2021), students who use mapping meaning to mathematics can describe concepts quite well. This is because the initial understanding possessed by these students affects the results of the solutions given in solving the given application of Newton's law problems.

The formation of students' understanding to solve problems depends on the selection of problem designs that are appropriate to the problem being solved (Jonassen, 2000; Teodorescu et al., 2013). In the process of solving problems, students gather initial knowledge frameworks and build explanations (Odden & Russ, 2018). Not only the initial knowledge framework or initial understanding of Newton's application material, the learning environment plays an important role in conditioning students to successfully provide appropriate problem-solving solutions.

This is in line with the results of research which show that not all epistemic games stand out, but only a few (Sevian & Counture, 2018; Siew et al., 2015). This reveals that some games are not commonly used in problem solving. The tendency of students to describe solutions briefly without explaining the magnitudes involved in Newton's application problems resulted in the solutions given not providing proper information. Not only that, some students only involve the concept of 1 small system or 1 whole system from the application of Newton's law (1 whole system in question is a system that includes object A, object B and pulleys and students do not continue the explanation for each system).

Epistemic game clarifies each process of problem-solving strategies that students have. This is in line with the fact that epistemic games reveal students' insights in solving problems involving the integration of mathematics and physics (Hu et al., 2019; Morales, 2017). Epistemic games help teachers to reveal the understanding students have. Disclosure of student understanding is used to identify the general way of student approaches in solving given problems (Lee & Anderson, 2013; Sevian & Counture, 2018). Epistemic games show how students approach a problem and the pattern of strategies taken in getting the right solution to the problem.

CONCLUSION

The results of the analysis are in the form of student epistemic games in solving problems in the application of Newton's law. The epistemic games that students have include mapping meaning to mathematics, physical mechanism, pictorial analysis, transliteration to mathematics. Students use different games between each student in solving Newton's law application problems. The process of students in determining the solution to the problem-solving application of Newton's law is influenced by students' understanding of the material. The epistemic game from this study can be used to determine appropriate learning strategies in understanding Newton's law application material. This research is limited in the form of an

epistemic game analysis of the application of Newton's law, so that further research can be carried out on other material concepts.

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