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Computational Thinking: Students' Abstraction on the Concepts of Kinematics

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Abstract: Abstraction is the primary key in computational thinking. This study aims to analyze students' computational thinking skills of abstraction on the concept of kinematics. The data were collected through students' project documents and interviews. The data is examined using a content analysis approach that emphasizes writing, verbal, or visual communication. The results revealed that students' abstraction skills were evident in collecting data and analyzing, and recognizing patterns but were less visible in building models or simulations. Abstraction skills can be used as a foundation and framework for viewing a concept in physics not only in mathematics or formulas views but as a data iterative relationship. This research is expected to provide an overview for physics instructors to integrate computational thinking in their learning classroom.

Keywords: Abstraction; Computational Thinking; Kinematics; Physics Learning

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Introduction

Implementing computational thinking in schools is an engaging future vision. Computational thinking is a fundamental thinking skill for students. Wing, (2006) stated that it was necessary to add computational thinking to children to read, write, and do arithmetic. Several definitions of computational thinking have been proposed by researchers, where each researcher has a different way of defining and interpreting it (Barr & Stephenson, 2011; Li, et al., 2020; Orban & Teeling-Smith, 2020; Shute, et al., 2017; Weintrop, et al., 2016; Yin, et al., 2019). Computational thinking involves formulating problems and solutions, where the solutions offered can be represented more effectively and efficiently within processing information (Standl, 2017). This recognition highlights that computational thinking is a way of thinking and acting that can be expressed through particular skills, which can then be used as the base for assessing performance-based computational thinking skills (Li, et al., 2020; Shute, et al., 2017).

Bringing computational thinking and practice in math and science into the classroom will provide students with a more contextual scene and prepare them for their future careers (Jona, et al., 2014; Weintrop, et al., 2016). The pedagogic perspective views that computational thinking skills will expand math and science content (Eisenberg, 2002; Sengupta, et al., 2013; Weintrop, et al., 2016). Computational thinking can be presented as an effective way to learn science and math concepts more challenging (Guzdial, 2008). This means that science and mathematics will be more meaningful by utilizing the computational thinking (Hambrusch, et al., 2009; Lin, et al., 2009). Furthermore, Standl (2017) asserted that computational thinking skills involve understanding the problem, abstraction, decomposition, designing, and testing solutions. Abstraction is the process of making an illustration more apparent to understand by reducing

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elements that are considered unnecessary and inappropriate (Csizmadia, et al., 2015). Shute, et al. (2017) divide abstraction in computational thinking into three subcategories: data collection and analysis, recognizing patterns, and building models. Based on the description, this study aims to analyze students' computational thinking skills, especially the abstraction of kinematics concepts.

Method

This study used a qualitative method. The participants in this study were 35 students of Physics education at the University of Jember who took the introductory physics course (29 female, six male). Data were gathered through interviews and project portfolio documents. Interviews were conducted with ten students openly to explore more in-depth information about student responses. In addition, open interviews were chosen so that participants could tell their experiences as well as possible without being restricted by the researchers' perspective. Available interviews help recognize more detailed and in-depth information about a topic from the source (Creswell, 2012; Johnson & Christensen, 2013). Furthermore, documents are a great source of textual data in the qualitative research field (Creswell, 2012). Documents were collected in this study in student portfolio projects of kinematic concepts.

The data analysis method chosen in this study is content analysis. Content analysis is a systematic and objective method that emphasizes writing, verbal or visual communication analysis (Elo & Kyngäs, 2008). The stages of content analysis are presented in Figure 1.

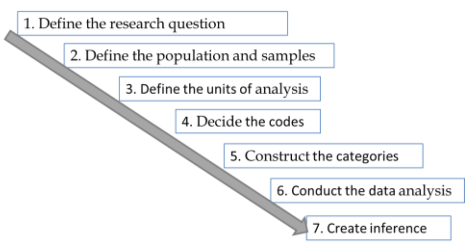

Figure 1. Stages Of Content Analysis Research

The interpretation of evaluation in this study adopts an inductive approach. Students' answers are read and analyzed carefully to answer research questions: how are students' abstractions on the concept of kinematics? During the analysis process, ideas are set about how to describe the participants' conceptions. In this study, researchers tried to understand student answers based on various perspectives

Result and Discussion

Abstraction is a key in computational thinking facets. Abstraction captures general characteristics or actions in a set that can be implemented in other instances. Abstraction includes the ability to identify, organize and use main ideas to find solutions facing complex problems (Ehsan et al., 2020; Grover & Basu, 2017; Wing, 2006. Abstraction in this study is based on Shute et al. (2017), involving collecting data and analysis, recognizing patterns, and building models or simulations.

Data collection and analysis

The results showed that 97% of students were skilled in collecting data. The data collected is distance and time data obtained virtually using an air track simulator. They collect data by iterations so that the data obtained is more precise and accurate. The data is arranged into a table.

> "We collect data carefully and as accurately as possible" (M_2)."
> We repeat data three to five times taken to ensure the accuracy of the data collected" (F_6)
> "Tables are made to ease data organize" (M_3)

(a)

No.	S	t_1	t_2	t_3	t_4	t_5	[illegible]	v	a
1.	50	4,83	4,86	4,87	4,82	4,79	4,83	10,35	2,14
2.	55	5,03	5,09	5,04	5,1	5,1	5,07	10,84	2,13
3.	60	5,26	5,29	5,29	5,33	5,32	5,3	11,33	2,14
4.	65	5,47	5,52	5,54	5,49	5,49	5,5	11,82	2,15
5.	70	5,73	5,78	5,67	5,73	5,7	5,72	12,24	2,14

(b)

Figure 2. (a) Airtrack Simulator Screen Display; (b) Sample Table of Data Collection of Student Answer

The ability to collect data owned by students is outstanding. It shows that they are focused on getting complete information and understanding the scope of the problem of the kinematics concept. The skill to retrieve data accurately trains students to focus on primary variables collected based on observations. The data will be processed to get an essential concept (core idea) of regular linear motion. The skill to retrieve data accurately trains students to focus on primary variables collected based on observations. Data and information gathering skills facilitate knowledge formation (Grover & Pea, 2013).

Pattern recognition

Recognizing patterns is very important in developing abstraction skills. The results showed that

86% of students could identify and recognize patterns of kinematic concepts such as displacement, velocity, and acceleration. The reason is that the subject matter is not a new topic for them and is relatively easy to identify. Regular data through the simulator air tracks makes students have no difficulty in recognizing the patterns.

> "Data through the air track simulator is regular, so it is easy to understand and look for the patterns" (M_1)
> "Data in an organized table makes it easier to look for patterns" (F_5)
> "Kinematics concept has been taught in high school, so it is no difficulty to recognize it" (F_1)

Furthermore, the portfolio project results show that most students look for patterns and regularities in the data collected by sketching a graph such as the constant velocity for linear regular motion concepts. Drawing a chart or a graph gives a more precise and more apparent idea of the relationship between each component or variable, such as displacement and time. Recognizing patterns or characteristics help students in solving problems and is the first step to finding solutions.

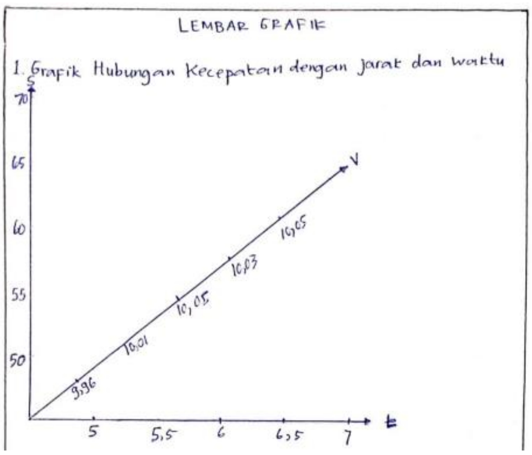

Figure 3. Example of a Graphic Sketch of Students Answers

The ability to recognize student patterns on the kinematics concept is sound. Finding patterns by sketching graphs showed that students have their way of solving problems. The various methods used to search the patterns are part of the abstraction process. Finding patterns helps students develop ideas on how to complete a structure and use it for other things that have the same patterns. In addition, finding and determining patterns to train students to brainstorm ideas is significant as a first step in solving a problem. Recognizing patterns is the key to determining appropriate solutions to problems and knowing how to solve certain types of issues (Özkök, 2021). Identifying patterns strongly supports developing computational thinking skills (Grover & Basu, 2017).

Building model

Building a model is finding and developing various virtual representations to imitate a process. Based on the document analysis results, it is known that only five students (14%) can make models or simulations. It indicated that the ability to build models of students needs to be improved. Based on the interviews, they faced several obstacles: confusion and did not know how to start making models or simulations, did not understand how to convert mathematical expressions into code, thought that simulation was a complicated process and lacked excel skills.

> "We are confused how to start to make the simulation" (F_3)
> "We can only use Microsoft excel for calculating; unfamiliar use it for animation or modeling" (F_5)
> "Simulation is a complicated and difficult process" (M_4)

Figure 4. Example of a student simulation display

Based on the results, the skills to build models or simulations still need to be increased. Modeling or simulation is a practice that is closely related to physics. Simulations and modeling can provide more profound abstraction because they show an understanding of the basic concepts (core ideas). Model building involves complex thought multiple interactions (Orban & Teeling-Smith, 2020). Perspective changes will occur when interest and interaction in interactive simulations that use computational concepts and practices (Brennan & Resnick, 2012).

Abstraction is a crucial ability that must be continually developed for computational thinking. Students' abstraction skills in computational thinking skills can generate ideas and recognize patterns. Computational thinking skills involve mental broadness in thought processes that reflect like computer science and a framework for asking meaningful scientific questions (Xu & Tu, 2011). This is significant capital in solving a problem. Bringing computational thinking and practice in mathematics and science classrooms gives students a more realistic view and better prepared for their future careers (Jona et al., 2014; Weintrop et al., 2016). Yin et al. (2019) also stated that involving computational thinking skills can change approaching subject science in the classroom. Integrating computational thinking in physics will prepare students for their future careers that cover a wide range of physics and outside physics. This research is expected to provide an overview of the integration of computational thinking in physics learning. It is critical to look at physics from a different point of view, not from mathematical formulas but at data patterns.

Conclusion

Computational thinking is an essential thinking skill in solving a complex problem. The abstraction ability of students to collect data and analyze and recognize patterns is evidently good but is less visible in the building models. The abstraction skill can be used as a basis and framework for viewing a concept in physics not only from mathematics views or formulas but as an iterative relationship among data. Abstraction ability makes students able to generate ideas and recognize patterns. It is a significant capital to gain meaningful learning. This research is expected to provide an overview for teachers to integrate computational thinking in learning physics.

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