Profile of creative thinking abilities of students measured by multi representation-based creative thinking assessment

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Profile of creative thinking abilities of students measured by multi representation-based creative thinking assessment

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Abstract. This study aims to describe the profile of students' creative thinking abilities. This research is a mixed study using the method of embedded experimental model. Quantitative data in the form of test results become the main data which is then triangulated with qualitative data from collected through classroom observation activities, asking students to fill out questionnaires, and conducting interviews. The subjects of this study are high school students who have studied the topic of linear motion. This topic was chosen because it has a characteristic that is the scope that can be presented with a variety of representations that can reveal students' creative thinking abilities. The selected school is a state high school with accreditation A with the assumption that students have received education with national standards. This means that it can be a benchmark for the success of a learning program in training students' creative thinking skills. Based on the results of data collection obtained information that the stimulation to encourage students to solve problems with a variety of display representation is still in the category of less creative. This is supported by field observation data that the one-way learning model, the conclusion of the questionnaire data confirmed from the results of the interview that students lack the opportunity to answer in creative ways.

1. Introduction

Assessment is an important component in the learning process. Improving the quality of education can be done by improving the quality of learning and assessment processes. A good learning system will produce good quality of learning, and the quality of learning can be seen from the results of the assessment [1]. In this regard, the government has issued Minister of National Education Regulation No. 16 of 2007 concerning Academic Qualification Standards and Teacher Competencies. This regulation states that teachers must have competence, one of which is to develop instruments for assessment and evaluation of learning processes and outcomes. The regulation applies to all subject teachers including physics teachers.

Physics is one branch of science that studies about natural phenomena caused by the interaction of various physical quantities. To be able to understand physics properly it is necessary to be able to master various forms of representation of physics concepts [2]. Cognitive instruments that are dominated by one form of representation are less able to measure the real cognitive abilities of students. This is because the intelligence of each individual is so diverse. In fact, students who have image intelligence are less able to state the answer in verbal, graphics, or mathematical representations. On the other hand, these students will provide optimal answers to questions that accommodate their intelligence. Therefore it is important for teachers to implement an assessment system that can explore the optimal abilities of the various intelligences of the students they teach.

The results of observations made indicate that the cognitive instruments provided by physics teachers in several high schools in Semarang City, Indonesia were dominated by mathematical representation. Unfortunately, it turns out that many students have difficulty in working on mathematical problems. Surely this is one of the causes of suboptimal achievement in physics learning outcomes. To further investigate fact about representation abilities of students, preliminary research has been conducted in small samples on four kinds of representations, namely mathematical, image, graphics, and verbal. The results of this study indicate that the distribution of student representation on the topic of linear motion consists of verbal representations of 07.19%, mathematical representations of 26.14%, representation of images 53.92%, and graphical representations of 12.75%. This finding is in line with research which shows that representational transitions which include a formula prove to be significantly more difficult; in particular for the directly proportional function type, the transition to a formula stands out from the analysis [3]. The results indicate the low ability of multi representation of students as seen from the distribution of the diversity of their intelligence. Interestingly, there is a tendency for students to more easily answer the questions presented by attaching images or illustrations.

Representation is a restatement of the same concept in a different format or form. Representation is a process of forming, abstraction, and demonstration of physical knowledge [4]. Physics is a subject that requires different understanding and ability of representation for the same concept. Therefore, in understanding physics the use of inaccurate representations becomes an obstacle to their understanding [5]. A problem that is considered difficult and complex can be simplified if the strategy and use of physical representations are used in these problems [6]. The use of representation models in conducting assessments is one of the solutions to overcome the difficulties of learning physics and helps improve the understanding of students [7]. In addition, multi-representation based assessment can measure the ability of students in solving physics problems. The topic of linear motion in the 2013 curriculum is one of the high school physics learning materials for grade X. The linear motion discussed is kinematics in one dimension. To improve the mastery of the concept of kinematics, it is not enough for students to understand the concept of kinematics with only one form of representation, but students must be able to master a variety of representations [8]. Besides, representational construction of students supports their learning in science [9]. Moreover, the 2013 curriculum demands to integrate 21st century skills. The main goal of learning in the 21st century is to develop and improve High Order Thinking Skills (HOTS) of students [10]. One of HOTS criteria is creative thinking. This implies that in understanding physics the use of inaccurate representations can be a barrier for students to be able to think creatively [11]. Therefore, research needs to be done on the pattern of mastery of the concept of linear motion of students based on the mode of representation. One effort that can be done is to use a multi-representation based creative thinking assessment instrument. This effort is expected to assist teachers in determining the most appropriate patterns of representation for students to practice their creative thinking skills in learning the concept of linear motion.

2. Method

The population of this study were students who had obtained the concept of linear motion in A-accredited high schools. Samples were selected by purposive sampling technique. Consideration in determining the sample of schools is from the average results of the 2018 Physics National Examination in Central Java, Indonesia. The study is a descriptive qualitative research. The test contain 36 items consisting of 9 mathematical representation items, 9 item image representation questions, 9 verbal representation items, and 9 graphics representation items.

Empirical test was taken in two accredited A High Schools with almost the same value in the National Examination (UN) Physics, namely SMA Negeri 9 Semarang and SMA Negeri 7 Semarang. Trials at SMA Negeri 9 Semarang were conducted in Class X MIPA 6 and X MIPA 7 with a total of 30 students. Trials at SMA Negeri 7 Semarang were conducted in Class X MIPA 1 and X MIPA 4 with a total of 30 students. The product trial was aimed at to find out the validity, reliability, level of

difficulty, and distinguish power of items on the assessment of creative thinking based on multi representations compiled.

3. Results and Discussion

There are differences in mastery of student concepts based on the mode of representation. Understanding the concept of linear motion of students based on the mode of representation starts from the most difficult to the easier one is the problem of graphical representation, verbal, mathematical, and images. The difference in understanding of concepts based on the mode of representation also shows the diversity of students' intelligence. It emphasizes that all intelligence possessed by humans is not exactly the same level [12]. The data of students' multi representation abilities is presented as in Figure 1.

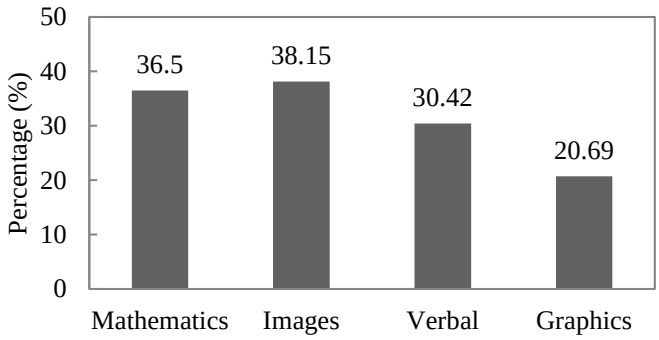


Figure 1. Bar Charts of Students' Concept Mastery in Representations of Mathematics, Images, Verbal, and Graphics

The images representation ability possessed by students shows the highest percentage among other representations. This is consistent with the results of preliminary observations which show that students are better at mastering images problems and is the highest percentage among other representations. In addition, questions with images representation are often given by teachers which make them already trained in working on images problems.

Graphic representation ability is at the lowest percentage. Based on the results of the analysis of the documentation of the test questions given by the teacher shows that graphic questions are rarely given. In addition, students also admitted that if they were rarely given questions with graphics, even if there were graphics problems, they were usually only presented with graphics, not instructed to make graphs. They also said that the questions given tended to be a matter of mathematical type and images. They would rather calculate with formulas than interpret a graph. For verbal representations, they admit that they are rarely given, but if verbal questions are related to their daily lives they are easier to understand. This makes verbal problems a greater percentage than graphics problems.

The presentation of learning material with a variety of representations would certainly make it easier for students to understand the concept in accordance with the ability of representation [13]. Every student has different intelligence so students will learn in different ways according to the type intelligence. The application of diverse modes of representation will provide optimal learning opportunities for each student's intelligence. There is an effect of the representation format on students' physics problem solving abilities [6, 14, 15]. However, the analysis of the data obtained shows low results for the mastery of the concept of linear motion topics in each mode of representation. The understanding of student representation concepts in linear motion topic through verbal, mathematical formats, and images is still low. Therefore, in learning physics students need to be trained to develop multi-representation abilities. Meanwhile, based on the results of the student response questionnaire found that the student participants were not accustomed to working on multi-representation problems.

The instrument of assessment of creative thinking based on multi representations on linear motion topics can motivate and measure students' creative thinking abilities. The instrument of assessment of creative thinking based on multi representations on linear motion topics that is prepared is appropriate to be used as an instrument of assessment of student learning outcomes, but requires more time in preparation because it requires a deeper understanding of concepts, in addition students must first be accustomed to creative thinking and introduced with various representations. Analysis of students' creative thinking abilities can also be analyzed by looking at the proportion of indicators of creative thinking abilities in the instruments arranged. In more detailed results of the analysis as in Figure 2.

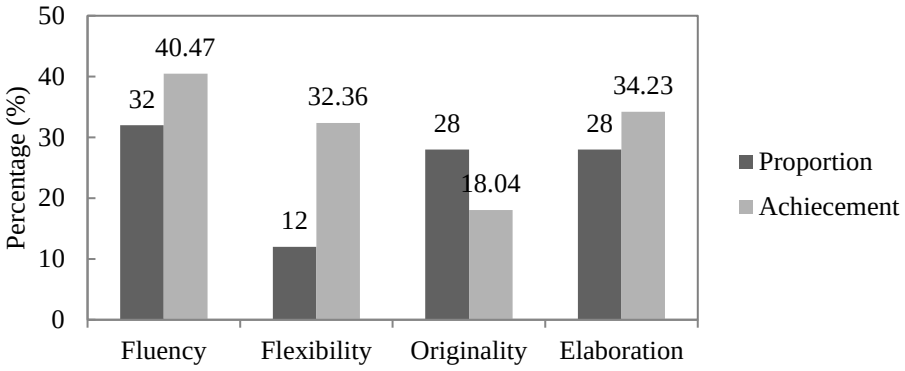


Figure 2. Students' Creative Thinking Abilities based on the Indicators

3.1. Verbal Representation

The verbal representation problem is about the motion of an aircraft from taking off to stopping. In this problem the elaboration aspect (thinking in detail), students are required to be able to provide detailed information in the text. Examples of student answers can be seen in Figure 3a and Figure 3b. In Figure 3a students answer in detail all types of motion that are informed in the text. Such student responses reflect the profile of creative thinking. In Figure 3b students tend not to understand the purpose of the problem. Students answer the questions with the habits taught by the teacher, namely writing what is known. Such student responses reflect the profile of less creative thinking.

(a) (b)

Figure 3. Samples of students' answers which is creative (a) and less creative (b)

3.2. Images Representation

Problem representation of the images is about the motion of a car from at rest position to move with acceleration of $\vec{a}$. In this problem the original aspect of thinking is more dominant. Students are required to be able to give answers that are not as usual or unique. In Figure 4a students draw a

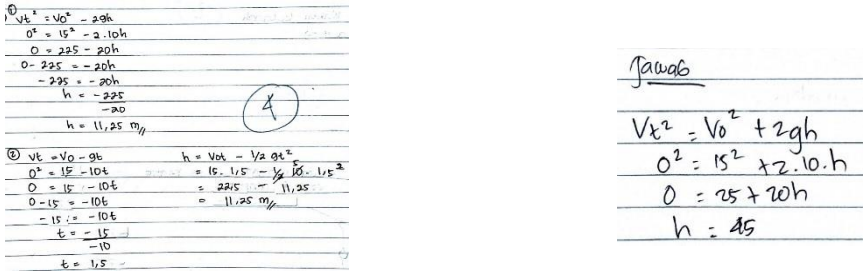
continuation of the car's motion with t = 3 s. In fact, the answer that is commonly provided is drawing continued motion with t = 2 s or in sequence. These unusual student answers reflect the profile of creative thinking. Figure 3b students tend not to understand the purpose of the problem. Students answer the questions by just drawing without being given detailed pictures related to time and speed. Such student responses reflect the profile of less creative thinking.

(a) (b)

Figure 4. Samples of students answer for creative (a) and less creative creteria.

3.3. Mathematical Representation

The mathematical representation of student answers in determining the highest position can be reached by a ball with initial velocity of 15 m/s upward can be seen in Figure 5a and Figure 5b. In Figure 5a shows students answer in fluency aspect by doing the test in two different ways and correctly. This reflects the profile of creative thinking, while in Figure 5c students answer the questions with only in single approach and was wrong. Such student responses reflect the profile of less creative thinking.

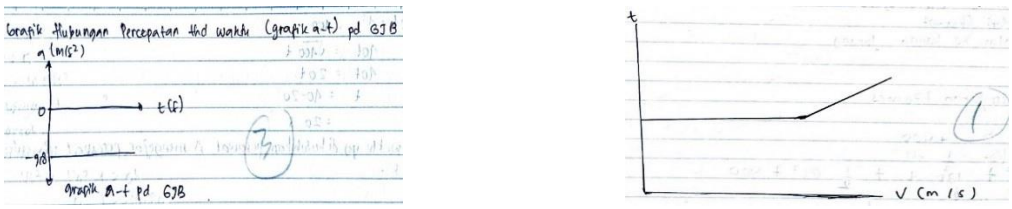


(a) b)

Figure 5. Samples of students answer for creative (a) and les creative criteria.

3.4. Graphics Representation

The student ability on graphical representation is shown in Figure 6a and Figure 6b. The problem is about free fall motion of a fruit drop by a monkey in graphics of time vs distance. Students are required to be able to provide answers with a variety of perspectives (flexibility aspects). Figure 6a shows that student draw a complete graph from his perspective starting with the magnitude on each axis which is equipped with the appropriate units, the magnitude and direction of the acceleration added to the picture according to the magnitude and direction of the acceleration of gravity, and the graph drawn correctly. Such student responses reflect the profile of creative thinking. As for Figure 6b, student tends to have tried to draw in accordance with the perspectives he understand, but not according to the concept. The graph is also made without details such as units of time magnitude and acceleration that are not in the graph. Such student responses reflect the profile of less creative thinking.



(a) (b)

Figure 6. Samples of students aswer with creative (a) and less creative (b) criteria.

3.5. Triangulation Analysis

The ability to represent students' images showed the highest percentage among other representations. This is consistent with the results of preliminary observations which show that students are better at mastering picture problems as evidenced by the percentage of the ability of image representation by 38.15% and is the highest percentage among other representations. In addition, questions with image representation have often been given by teachers which makes them already trained in working on picture problems. The ability of graph representation is at the lowest percentage. Documentation of the questions given by the teacher shows that graphic questions are rarely given. In addition, students also admitted that if graph problems were rarely given, even if there were graph problems, they were usually only presented with graphs, not instructed to make graphs. They also said that the questions given tended to be a matter of type of calculation and drawing. They would rather calculate with formulas than interpret a graph. For verbal representations, they admit that they are rarely given, but if verbal questions are related to their daily lives they are easier to understand. This makes the verbal problems bigger than the graph problems.

The application of diverse modes of representation will provide optimal learning opportunities for each student's intelligence. However, the analysis of the data obtained shows low results for the mastery of the concept of straight motion material in each mode of representation. Meanwhile, based on the results of the student response questionnaire found that the student participants were not accustomed to working on multi-representation problems.

4. Conclusion

The creative thinking assessment with the representation pattern approach developed has been able to identify students' thinking skills on the concept of linear motion. The pattern of students' mastery of the concept of linear motion based on the mode of representation starting from the most difficult to the easier is a matter of representation in the form of graphics, verbal, mathematical, and images. Based on the results of this research, there are still wide opportunities to develop creative thinking assessments with a multi-representation approach to other concepts so that more opportunities for students to practice their creative thinking skills.

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