Case study: investigating of eleventh graders’ translating among modes of representation ability on linear motion

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Abstract. The purpose of this study is to describe the profile of students’ translating among modes of representation ability on physics. The ability to represent information into verbal, graphical, picture, table and mathematical representations in order to help students define suited physics’ concepts on solving physics problems. Participants included 28 11th grade students in a senior high school in Bandung. The sampling technique is random sampling. This study used description method to describe the profile of students’ translating among modes of representation ability. The findings showed that students’ translating among modes of representation ability were classified in medium category with 54.44% of mastery. The highest average score on students’ ability to represent picture representations into mathematical format was 69.60% from its ideal maximum score. Whilst students’ ability to represent pictorial format into graphical reached 25%. It can be concluded that students’ translating among modes of representation ability is insufficient category.

1. Introduction

Physics is a subject that is considered difficult by high school students. This opinion is the same as e.g. Abdurrahman et al [1] which states that physics still gets a bad reputation as a subject in school because it feels difficult to learn so that many students are not interested to learn physics. Students assume that in the process for problem solving of physics subject requires the involvement of many concepts. Whereas, there are many physics concepts that have solved many human problems in everyday activities, but students are still reluctant to learn it because of those reasons. Physics concepts are used to study and solve problems about nature and their symptoms in human’s everyday life.

But in fact, in the learning process in the classroom, there are still many physics teachers who use problem solving training or exercises methods after delivering teaching material, this type of learning is a content-based learning. Content-based learning that prioritizes students' cognitive, where students are expected to become reliable memorizers if the students were asked about the lessons received. Whereas according to [2] the example and practice method has several weaknesses, namely that there is very little to reveal the process of occurrence of physical phenomena because the settlement process is oriented to the results of calculations. In addition to learning activities that are less supportive, students’ understanding of abstract concept on physics that is scary thing for student. Activities that can support the development of students' understanding of the material learned in addition to the experimental activities in the classroom, are the elaboration of representative from the problems faced by students.
The description of the representative in question is an activity representing understanding from one form to another or translating among modes of representation, for example representing representative from a graphical form to a verbal form. e.g. Angell’s research results [3] state students' views on physical difficulties because they have to deal with experiments, formulas and calculations, graphs, conceptual explanations at the same time, and also require translation between representations. So that it takes the ability to represent representative from one form to another to help facilitate the absorption of representative and build students' understanding of the material being studied [4]. From empirical evidence in the form of research conducted by experts, the use of multiple-representation helps students understand the problem of physics in problem solving process. But in reality, the use of multiple-representation in the physics problem solving process is still little used by students. The habit of problem solving that are generally presented in verbal or table form, then directly using mathematical representations in solving the questions asked. Whereas in physics, presenting to tables, graphs or diagrams is often used. Whereas in the process, the translation of representative into several other forms of representation can show students' understanding of the problems at hand. e.g. Abdurrahman et al [1]; Andromeda et al [5]; Treagust et al [6]; Opfermann et al [7]; argued that the need for different representations to help the students understand the concepts that being studied. So that the use multiple-representation in the problem-solving process cannot be ignored in order to increase students' understanding of the physical problems that faced by them. According to [2]; Vrain and Waldrip [8], [9] there are several ways to represent representative such as verbal, mathematical, pictures or diagrams (pictorial), table representations and graphical representations. e.g Rizky, G [10] also said that the form of representation in physics, especially in Newton's law; requires verbal, mathematical, drawing, physical or free object motion diagrams and object motion diagrams. Verbal representation is a description of representative described in the form of words. A pictorial representation that can be in the form of a picture/sketch of an object or diagram in the form of a bar chart, circle diagram, free object diagram or tree diagram. Table representation is the form of representative that containing information from more than one variable in table form. While graphical representation describes representative in the form of line diagrams and mathematical representation describe information in math equation. The use of multiple-representation can help to elaborate representative that is difficult to understand to the other forms that are easy to understand, for example abstract physical concepts in speed and acceleration. So, the ability to represent those kinds of representations, need to be honed in order to make the understanding of students in learning the concepts of physics easier for example in linear motion.

Based on the background that has been described, the purpose of this study is used for a preliminary study to describe students' basic skill on translating among modes of representation in verbal, pictorial (picture/diagram), mathematical, graphical and table forms. So that it can be explored for more especially in parts that are difficult in representing the representative obtained and an appropriate action to build students' translating among modes of representation ability.

2. Methods
The research flow that this study used is the first finding study literature about students’ low understanding ability, then suspecting the low use of representations in the learning process; designing instrument of translating among modes of representation ability; then testing the instrument to students and finally feasible to be used to draw conclusions about translating among modes of representation ability.
Figure 1. Research Flow.

The research method used in this paper is descriptive method, which describes the profile of translating among modes of representation ability of students in the field of physics subject that have received straight motion material in the sub-material distance, displacement, velocity, speed and acceleration. The translating among modes of representation ability that being studied is the ability to change the representation between verbal, mathematical, diagrams or graphical. The study was conducted to 28 students of class XI at senior high school in Bandung with accreditation in A category. The sampling technique is random sampling. According to e.g. Yusup, M [11] assessment of learning outcomes that use multiple-representation can be in the form of asking students to make equal representation; asking students to test the equality between two or more given representations; or ask students to choose the right representation from the multiple choices. The assessment used is to ask students to represent to other equivalent forms or translating among modes of representation. The instrument used are 6 items of problems consist of representation from verbal to pictures and mathematical; table to mathematical and verbal; pictures to mathematical and verbal; pictures to verbal and graphical; pictures to mathematical and verbal; and verbal to mathematics and graphical. The distribution of questions is 4 items for each format of verbal, mathematical, pictorial in the form of sketches, and graphical representations. Here are two examples of test questions for changing representative from picture to mathematical and verbal forms and changing representative from table to mathematical and verbal at table 1.

Table 1. Guidelines for Scoring Translating Among Modes of Representation Ability.

| Changing Representative from Picture to Mathematical and Verbal | Changing Representative from Table to Mathematical and Verbal |
|---------------------------------------------------------------|--------------------------------------------------------------|
| See the following route sketch for the route of Idzwan's house to the school! | Pay attention to the mileage table of the moving vehicles simultaneously on the straight track! |

If Idzwan's house is in Q position and school is in U position, specify 4 the travel route that Idzwan can use with its mathematical equations! Which is the closest route if he can use QU route? Give your reason!

Based on information on the table, how is the speed, acceleration and type of motion that each vehicle does?
Guidelines for scoring translating among modes of representation ability refer to e.g. Etkina [12] is shown in the table 2.

| Score (missing) | Criteria |
|----------------|----------|
| 0              | Score is given if there is no representation that build by the student or there is no answer |
| 1 (inadequate) | Score shows some important representative are not showing in the representation made by student or having a big mistake |
| 2 (need improvement) | Score shows representation made by student already represented a big part or the whole information’s but still unclear. |
| 3 (adequate)   | Score shows all important representatives were clearly stated and organized in the representation. |

Classification of the representation ability of students will be categorized into 3 parts, namely high, medium and low criteria based on the results of test. Translating among modes of representation ability data will be described statistically including frequency, mean, percentage, and standard deviation of the score.

3. Results and Discussion

From the results of test, statistical data from the translating among modes of representation test is available in table 3.

| Data                | Statistic |
|---------------------|-----------|
| Ideal Maximum Score | 36        |
| Biggest data        | 26        |
| Smallest data       | 7         |
| Range               | 19        |
| Mean                | 19.60     |
| Median              | 21        |
| Modus               | 25        |
| SD                  | 5.29      |
| Variant             | 28        |

From table 3, the data obtained from the students' lowest translating among modes of representation ability test score is 7 and the biggest score is 26 from the Ideal Maximum Score 36. The median and mode for data of the test scores are 21 and 25, and the standard deviation is 5.29. The mean scores the students' translating among modes of representation ability tests is 19.60. Thus, the mastery of the students' translating among modes of representation ability in the class is 54.44% or in the medium category. The categorization is also carried out on every aspect of change in representation as shown in the table 4.

| Verb-Graph | Verb-Math | Table-Math | Table-Verb | Picture-Math | Picture-Verb | Picture-Graph |
|------------|-----------|------------|------------|--------------|--------------|---------------|
| N          | 28        | 28         | 28         | 28           | 28           | 28            |
| Mean       | 1.18      | 1.80       | 1.32       | 1.68         | 2.09         | 1.93          | .75           |
| Percentage | 39.29     | 60.10      | 44.10      | 55.95        | 69.60        | 64.29         | 25            |
| M_i        | 2         | 2          | 1.50       | 1.50         | 2            | 1.50          | .50           |
| S_b        | .33       | .33        | .50        | .33          | .33          | .50           | .17           |
| SD         | .79       | 1.00       | .94        | .67          | .67          | .95           | .44           |
| Category   | Low       | Medium     | Medium     | Medium       | Medium       | Medium        | Low           |
From table 4, it’s known that the highest average of representation ability is to represent representative from the form of a picture or picture to a mathematical form at the amount of 2.09. This is in line with e.g.Ormrod's findings in [10] that students prefer to use mathematical formulas when solving physics problems because they are considered to be easier to remember. Then it is followed by representing representative from the form of a picture or picture to verbal form at the amount of 1.93. So, students answer more correctly when representing representative into a mathematical form. While the ability to represent representative with the lowest average is from the shape of the picture to graphical of 0.75. Similarly, e.g.Ormrod's findings concluded that only a few students included the pictures and diagrams in explaining what was presented in the problem. While the results of Parlindungan, Suhandi, Liliasari [13] research showed the lowest results are representing from graph domain.

![Figure 2. Comparison of Score Percentages per Translating Among Modes of Representation](image)

The findings didn’t show the ability of representation in high category. Changes in the form of representations in the medium category include changes in representation from verbal to mathematical, tables to mathematical, tables to verbal, pictures to mathematics and pictures to verbal. While the changes in the form of representation in the low category include, changes in representation from verbal forms to graphics and pictures to graphics.

From Figure 2, the ability to represent representative from pictures to mathematical has the highest mastery percentage at the amount of 69.60% followed by changes in representation from pictures to mathematical, verbal to mathematical, tables to verbal, tables to mathematical and verbal to graphs with percentages respectively 64.29%, 60.10%, 55.95%, 44.10%, and 29.19%. While the lowest mastery percentage is 25% which is the change in picture representation to the graphical form.

| Representation Changes | Item No. | Score (%) |
|------------------------|---------|-----------|
|                        |         | 0 | 1 | 2 | 3 |
| Verb-Graph             | 1       | 0 | 67.86 | 7.14 | 25 |
|                        | 6       | 21.43 | 78.57 | 0 | 0 |
| Verb-Math              | 1       | 0 | 17.86 | 21.43 | 60.71 |
|                        | 6       | 14.29 | 60.71 | 17.86 | 7.14 |
| Tab-Math               | 2       | 10.71 | 67.86 | 0 | 21.43 |
| Tab-Verb               | 2       | 0 | 42.86 | 46.43 | 10.71 |
|                        | 3       | 0 | 21.43 | 42.86 | 35.71 |
| Picture-Math           | 5       | 0 | 14.29 | 67.86 | 17.86 |
|                        | 3       | 0 | 42.86 | 14.29 | 42.86 |
| Picture-Verb           | 4       | 7.14 | 46.43 | 46.43 | 0 |
|                        | 5       | 10.71 | 3.57 | 21.43 | 64.29 |
| Picture-Graph          | 4       | 25 | 75 | 0 | 0 |
From table 5, the highest percentage for the zero score is at problem number 4 with a change in the form of picture representation to the graphical representation. 25% of students, cannot describe verbal problems as much as graphs and the remaining 75% of students display graphs only the Cartesian axis without drawing the line diagram (students get only one score). One of the causes that might be the reason is the lackness of information provided in the problem. It could make students are confuse to represent graphs. So, problem number 4 on changing representations from verbal forms to graphs becomes aspects of representation change with the lowest percentage of mastery. In [10] findings, representing the form of diagrams and graphs is the least chosen representation by students. In e.g. Siswanto, et.al finding [14] also said that the use of tables and images helps students understand build an understanding of the situation deeply. The following is an example of the results of the work of the student who obtained a one score for verbal representation to the graph in question number 6.

Figure 3. Example Answer for Score One, (b and (b) for Score Two), (c) for Score Three.

The same thing happens in problem number 4 on changing the of picture representation to the graph. Low mastery percentage is indicated by the distribution of the score for students' answers which are at scores 0 and 1. Students are still lacking in changing representative into graphic form, whereas according to e.g. Arifyanti, F, et [15], graphics or pictures can provide clear boundary between the actual situation and the situation according to the theory. Even though, based on e.g. D. Rosengrant’s findings [16] when asked one of participant to clarify, drawing a picture form of the problem made it is much easier for him to digest. Most students with score two still lack in completing representative requested, such as mathematical acceleration calculation representative or less representative about RO and QU length. Even though many students obtained a score 2 for translating the mathematical form picture and score 3 for translating the mathematical form of verbal form on the concept of distance and displacement calculations, translating to mathematical form from other form still under 50% of mastery. Low category of level of difficulty of translating picture to mathematical form test may have caused high presentation of student mastery. According to e.g. Rizky, G's findings [10], students often use language in representing representative. Likewise, the findings in this study, the third largest percentage score is representing representative to verbal form from pictures with a percentage of 64.29%. Many of the students have been able to make representations from the form of pictures or pictures to verbal by delivering complete representative according to what is provided in the form of pictures.

4. Conclusions
As is indicated above, this study is a part of a research that will be conducted about students’ translating among modes of representation ability using multi representation. The ability of students to translate representation to more than one representation is still in the medium category with the average of each aspect being dominant in medium or mediocre value. In the change of representative into a graphical form in a low category. It is still necessary to familiarize students to translate representations from various forms into graphical forms, this is considered necessary because graphical forms are often used in physics questions. So that students can understand physics questions if they are presented in graphical form or have to present them in graphical form. It is because of e.g. Kurnaz’s finding [17], it is observed that multiple-representations (as like concept network, data-
meaning tables, conceptual change texts, analogies and pictorial representations) are used in some studies especially in problem solving.

This finding can be used as a preliminary study in order to follow up the problem of mastery of students' translating among modes of representation ability that still mediocre in physics subjects. Subsequent development of this finding is the selection of appropriate teaching methods to train translating among modes of representation ability of students, one of which is to familiarize students in representing representative to from various forms contextually with a problem-based learning model assisted by the use of worksheet based on multiple-representation. This was supported by the findings of e.g Hasanah H, et al [18]; Parlindungan, Suhandi, Liliasari [19] who developed an worksheet with multiple-representation-based to train students' ability in presenting representative to verbal, picture, graphic and mathematical forms in problems solving. Thus, students can train their multi-functional abilities while understanding the concept of physics more concretely because it is based on everyday problems presented by the teacher. The selection of problem-based learning model usage in the development of this study refers to the findings of e.g. Arifiyanti, F, et al [15] which shows the decreasing of student difficulties who use problem-based learning model with a multiple-representation approach of 41.59%. This is enough to show the influence of problem-based learning model usage on the translating among modes of representation ability of students.

In addition to the selection of teaching methods that can train students' translating among modes of representation ability, the development of this study is the use of other representations that are not only in verbal form, pictures, graphs, tables and mathematically on test. Development of test instruments for translating among representation ability with a better level of difficulty and various modes of representation need to be considered in next preliminary studies. So that the findings obtained will be described in more detail.

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