Analysis of three representations in problem solving on additional relativistic velocities

A Khoiri1, I Kusumawati2, M S Kahar3 and A Mursidi4
1Physics Education Department, Universitas Sains Al-Quran, Wonosobo, Jawa Tengah, Indonesia
2Physics Education Department, STKIP Singkawang, Kalimantan Barat, Indonesia
3Mathematics Education Department, Universitas Muhammadiyah Sorong, Papua Barat, Indonesia
4STKIP Singkawang, Kalimantan Barat, Indonesia
E-mail: akhoiri@unsiq.ac.id

Abstract. In this study is an analysis of three representations in problem-solving on additional relativistic velocities. This research method is descriptive quantitative. Purposive sampling is a technique to get sampling in this research. The sample in this study are students who have studied relativistic speed on three different islands, namely Java Island, Kalimantan, and Papua. The students can be problem-solving in three forms of representation: Verbal (V), Diagrams (D), and Mathematics (M). Three representation skills take some description about representation skills student of physics education. It found that students had difficulty 73% in problem-solving in the form of representation V, 86% difficulties in problem-solving in the form of representation D, and 7% difficulty in problem-solving in the form of representation M. This study should also be implemented on different materials and colleges.

1. Introduction
Representation is something that represents describing or inferring an object [1]. Students have various ways of expressing their ideas from a physical problem-solving in their way in the form of different expressions to other students [2]. Student representation skills classified in the form of Verbal (V), Diagrams (D), Graphics, and Mathematics (M) [3]. The use of representation in physics learning can be used to minimize students' learning difficulties. The difficulty in question is how to solve the problems contained in the test question instrument. The purpose of this study to determine the results of student representation through verbal, diagrams and mathematics on patterns of problem-solving done on the material speed of relativity.

The principle underlying the speed of relativity studied in this study is that the form of problem offered includes abstract concepts that concretized for more natural understanding of the students. Various forms of representation serve as a bridge to explore the expressions that represent thoughts through verbal, diagrammatic and mathematical representations. Representations of the geometric algebra of spacetime, the general problem of the relativistic addition of velocities is addressed [4].
Representations D Relativistic addition of velocities in one dimension, though a mainstay of introductory physics, contributes much less real insight than it could. This one-dimensional relativistic addition velocity formula is:

\[ v_{ac} = v_{ab} + v_{bc} = \frac{v_{ab} + v_{bc}}{1 + \frac{v_{ab} \cdot v_{bc}}{c^2}} \]  

(1)

Where we have taken \( c = 1 \) and subsequently to denote relativistic velocity addition [5]. In explaining problem-solving done mathematically, students also do problem-solving in the form of words or sentences in the form of representation V arranged in such a way as to the concept of relativistic velocity addition. The analysis in this research is expected to provide an overview of the ability of representations of V, D, and M students at the relativity speed of the three islands (Java, Kalimantan, and Papua) for the sake of overcoming the subsequent research.

2. Numerical Methods
This research uses descriptive quantitative research method. Sampling technique with purposive sampling is a sample of individual aims for students who have followed the modern physics course material speed relativity, how the pattern of problem-solving with various representations. The background of the students who sampled was from three different universities located in Java, Kalimantan, and Papua. The research instrument is a matter of essay test containing four questions. Each problem in the test question should be solved using verbal, diagrammatic and mathematical representations. Analysis using percentage data calculation applied to all aspects of verbal, diagrammatic and mathematical representation by presenting the result of the histogram and tabulation of data.

3. Results and Discussion
Recapitulation of problem-solving results in problems with representations V, D and M from different at three college students presented in Figure 1 below.

![Figure 1. Problem Solving on Three Representation](image)

Based on Figure 1 that physics is not only taught by mathematical formulas, but the physical meaning of the formulas expressed through verbal representation and diagrams is necessary. The least understanding of students in representing verbal and diagrams determine the problem-solving patterns in solving the test questions. It was proven from the result of the research that the form of problemsolving is difficulties in the form of representation of V by 73%, the representation of D by 86% and the Representation of M by 7%. Furthermore, the results of representations V, D, and M each item problem or problem presented in Table 1 below.
Table 1. Representation results at three universities in Java, Kalimantan, and Papua

| Problem Solving | Representation of College in Java Island | Kalimantan Island | Papua Island |
|-----------------|----------------------------------------|-------------------|--------------|
|                 | V          | D          | M          | V          | D          | M          | V          | D          | M          |
| 1a               | 34         | 31         | 94         | 33         | 30         | 90         | 23         | 23         | 97         |
| 1b               | 40         | 23         | 86         | 20         | 17         | 93         | 27         | 27         | 87         |
| 2                | 26         | 11         | 86         | 23         | 10         | 100        | 27         | 10         | 83         |
| 3a               | 34         | 11         | 89         | 20         | 13         | 93         | 27         | 6.7        | 90         |
| 3b               | 26         | 11         | 91         | 33         | 6.7        | 87         | 33         | 13         | 97         |
| 3c               | 23         | 14         | 91         | 33         | 13         | 90         | 23         | 13         | 87         |
| 4a               | 31         | 8.6        | 89         | 37         | 6.7        | 80         | 17         | 13         | 93         |
| 4b               | 17         | 5.7        | 83         | 30         | 10         | 80         | 10         | 6.7        | 87         |
| 4c               | 17         | 8.6        | 86         | 23         | 10         | 73         | 13         | 13         | 73         |
| Average          | 28         | 14         | 88         | 28         | 13         | 87         | 22         | 14         | 88         |
| Difficulty       | 72         | 86         | 12         | 72         | 87         | 13         | 78         | 86         | 12         |

Based on Table 1 can be seen the difference of representation results V, D and M for each college presented in Figure 2 below:

![Figure 2. Compare Result Representation V, D, M on Different Colleges](image)

Table 1 and Figure 2 show that problem-solving skills through representations V, D and M have no significant difference in outcomes at different universities. The reason is that the pattern of representation in relativistic speed is not influenced by environmental factors entirely but is more conceptual. Studying theories with various problems that solved with Verbal, Diagram and Mathematical representations are continuously trained both through instructional design, learning styles and media, because M Representation was used for quantitative reasoning in solving typical problems or physics formulas. Representation V helps in defining the concept more clearly through the delivery of the word systematically arranged by way of describing it. While Representation D helps in clarifying abstract concepts to illustrate concepts that are more concrete. So the pattern of students in training represents the speed of relativity can be solved. A more intuitive diagram then represents the abstract verbal description associated with the mathematical representation.
In Table 1 the lower difficulty level shows the pattern of problem-solving done well, vice versa. So the difficulty in solving the problem the less. In the recapitulation result, there is a significant difference in representation ability based on percentage result. The difficulty was solving problems in the form of representation D highest, the reason the students can express the concept through the diagram when it can define the concept through Representation Verbal. When the verb is still having trouble automatically the ability to represent a flow diagram. Students' habits of learning physics concepts with mathematical formulas and student learning patterns are still memorized and understand the formula alone. Identical problems that can be solved by the formula cause the ability of high student mathematical representation means having a low difficulty.

Another factor that affects problem-solving differs in each form of representation is the ability to describe concepts and reasoning differently. Not because students' backgrounds are in different environments or colleges, but the habit of learning shapes the ability to solve problems through representation. The habit of solving problems with mathematical formulas makes the students have no ability in developing the concept they have in the broader field to the verbal form and diagram. To develop multiple representation students by practicing problem-solving which is concrete through picture or diagram which then described thought verbal, so the process of problem-solving students vary not just calculation alone. In this research shows the different result to nonequivalent between M with D and V representation presented one result answer problem-solving skill on cases question 3b in figure 3 below:

This research is also corroborated by [6] that representations greatly assist students in the formation of knowledge and problem-solving. problem-solving as an attempt to find answers based on their understanding depends on the ability to represent concepts. Furthermore, student problem-solving skills developed by [7] are: understanding a problem, planning a solution, implementing a solution plan, and evaluation. The ability to create a representation is closely related to problem-solving. Because both are interdependencies reinforced by [8] suggests that Multiple representations have three main functions namely as a complement to the concept of relativistic velocity lies in the physical meaning of the interpretation barrier, the constructor of student understanding.
4. Conclusion
The conclusion in this research is the ability to solve the problem of speed of relativity have different representation form. Mathematical representation has the highest ability compared to Verbal representation and Diagram. The habit of understanding the problem with symbols and formulas resulted in a good student mathematical representation with a difficulty of only 7%. Limitations of students in the Verbal representation of 73% and representation Diagram of 86% several factors influence it are: less accustomed to solving problems by defining the concept in advance or by clarifying the concept through pictures and diagrams. Identical using the formula for solving the problem becomes the most potent stance student use. Not yet trained to study abstract concepts into concrete through verbal representation and diagrams. Other factors wasn’t found in this study.

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