3rd WCPE World Conference on Physics Education
Hanoi, Vietnam, 13 - 17 December 2021
3RD WORLD CONFERENCE ON PHYSICS EDUCATION
Innovating physics education: From research to practice

Contribution ID: **57**　　Type: **Presentations in Hanoi**

Survey of Newton Mechanics Conceptual Consistency using Multiple Representations for High School Students

Wednesday 15 December 2021 08:00 (20 minutes)

Survey of Newton Mechanics Conceptual Consistency using Multiple Representations for High School Students

Ryunosuke Ozaki, Tokyo University of Science, Tokyo 162-8601, Japan
Kosuke Nakamura, Tokyo University of Science, Tokyo 162-8601, Japan
Yamato Hasegawa, Tokyo Tech High School of Science and Technology, Tokyo 108-0023, Japan
Fumiko Okiharu, Tokyo University of Science, Tokyo 162-8601, Japan

Abstract. For students who are beginners in physics, it is difficult to understand physics phenomena using highly abstract expression like equations. This is because physics generalizes phenomena by using multiple representations. In this study, we clarify the difficulties that second-year students at high school have in transforming between multiple representations. For this purpose, we conduct a task to represent physical phenomena described by equations in sentences and a survey question based on R-FCI, and describe the results.

`Background and Research Purpose`

For beginners, it is difficult to understand physics phenomena using equations [1]. For example, they can memorize equations and insert them, but they may not be able to explain what the equations and physical quantities mean. In this study, we clarify the difficulties that appear when high school students taking basic physics classes transform between multiple representations to help them understand phenomena using highly abstract equations [2].

`Research Method`

This study targets 102 second-year high school students, where the first author has been teaching basic physics since April 2021. The study was conducted from April to July 2021.
In April, we conducted a preliminary survey on the concept of force, students' attitudes to science, and students' experience with experiments using sensors [3]. In May, a mid-term examination was held, which included questions on reading physics phenomena described in texts and representing them with equations. In addition to the mid-term examination, students were asked to read physics phenomena described in writing and express them using diagrams and physical quantities. In July, we conducted a survey on the concept of force using multiple representations. By examining the correlations between these representations, we examine the changes in students' understanding of physics phenomena as a result of teaching them using multiple representations.

`Results and Discussion`

At the end of the first semester, we conducted a survey on the concept of force using multiple representations of the upward throwing of a ball. The representations used were (1) arrows showing the force working on the ball (multiple choice); (2) a drawing of the force working on a ball after being hit by a bat and a written explanation of the force; and (3) a graph of the relationship between the force acting on the ball and time (multiple choice). The results showed that students' naive concepts were more complex and inconsistent than expected. In (1), students had 24 response patterns, which was quite complex (Fig.1). This was due to a combination of the naive concept that the force is applied to the ball by the hand even after it is thrown, and the naive concept that there is no force acting on the ball at the highest point. In addition, about 99% of the students were inconsistent between these results and the graph they chose in (3).
In (2), about 86% of the students described the force that the ball receives from the bat, and about 43% of the students described the effect of gravity on the ball. Comparing the results of the analysis of (2) and (1), about 93% of the students, in selecting the arrow of force and drawing it, were consistent in expressing the false

concept that the ball receives force from the hand and bat while it is rising. The representation of the correct concept of gravity acting on a ball was consistent for about 86% of the students. Furthermore, comparing the results of (2) and (3), the consistency of the representation of the force versus time graph (F- t graph) and the force diagram was about 48% for the incorrect concept of receiving an upward force and about 56% for the correct concept of gravity acting on the ball. Thus, regardless of the correctness of the students' conception of the force acting on the ball, most of the students were consistent in the representations of the force arrows they drew and the representations of the force arrows they chose, and about half of the students were inconsistent between the representations of the force arrows they drew and the F- t graphs they chose.

`Summary and Future Prospects`

It is said that it is effective to use multiple representations when teaching students to understand a physics phenomenon, but it is necessary to use multiple representations for each event step by step, not to represent a series of phenomena from the beginning. We would like to clarify, from the viewpoint of individual optimization, which scaffolding should be used between expressions when students convert from concrete to abstract representations.

Acknowledgment
This work was supported by JSPS KAKENHI Grant Number JP21K02890.

References

D. F. Treagust, R. Duit and H. E. Fisher, Multiple Representations in Physics Education, Springer, 2017.
P. Nieminen, A. Savinainen and J. Viiri, Force Concept Inventory-based Multiple-Choice Test for Investigating Students' Representational Consistency, Phys. Rev. ST PER 6 (2010) 020109.
D. Hestenes, M. Wells and G. Swackhamer, Force Concept Inventory, Phys. Teach. 30(3) (1992) 141–158.

Author: OZAKI, Ryunosuke (Tokyo University of Science)

Co-authors: NAKAMURA, Kosuke (Tokyo University of Science); HASEGAWA, Yamato (Tokyo Tech High School of Science and Technology); OKIHARU, Fumiko (Tokyo University of Science)

Presenter: OZAKI, Ryunosuke (Tokyo University of Science)

Session Classification: Parallel 6 - Hanoi

Track Classification: 3. Representation in teaching and learning physics