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The Analysis of the Development Level of Physics Concepts by Students' Proficiency Levels

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Abstract

The purpose of this study is to investigate the differences in the development level of physics concepts by students' proficiency level. The National Assessment of Educational Achievement (NAEA) data set in Korea administered to the 6th and 9th grade students, from 2010 to 2012, were used for analysis. The test items showing significant differences by proficiency levels were extracted and analyzed in two ways. First, the distribution of responses to each distracter of the test items was compared by proficiency levels to identify misconceptions, preconceptions, or the tendency of thinking that students may have. Second, the percentage of correct answers to the test items, particularly developed for the same achievement standard, was compared to identify the degree of achievement by proficiency levels. The findings of this study revealed the specific contents that showed differences in the development of physics concepts by proficiency levels. For example, when comparing the "quickness" of objects whose distance and time are all different, the results showed that the lower level students of the 6th grade tended to consider distance to be an important factor, rather than time.

1. Introduction

Long before attending school, students have been forming their own concepts for nature through the experiences in daily life. The preconceptions of students affect on science learning [1], they interfere the formation of scientific concepts or make often the formation of misconceptions [2]. So, the question, "How can we teach our students to understand science, despite of the preconceptions and misconceptions formed by preconceptions?" is one of the biggest concerns of science educators. Because almost of the subjects in science education research are related with the formation, development, and change of students' concepts, the question is also the common interest of science education researcher.

On the other hand, in order to identify trends in students' concepts, it is efficient to use the student evaluation results conducted on a large scale.

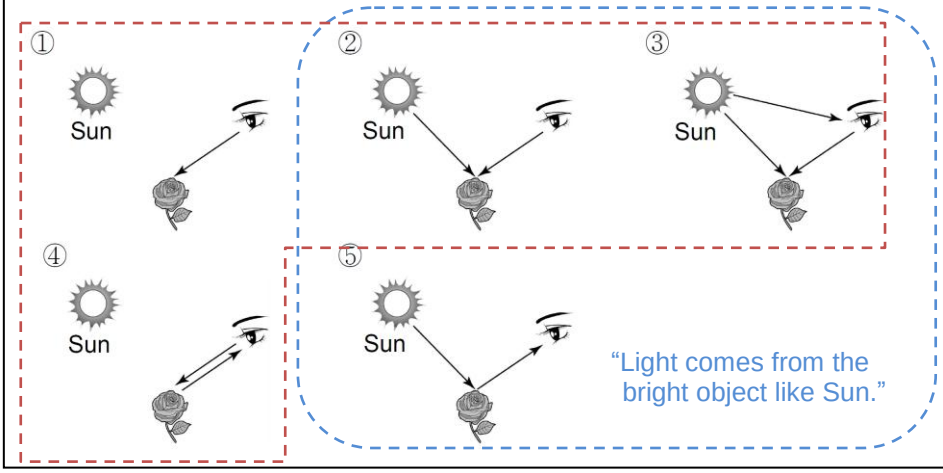
This study is focused on analyzing the level and property of physics concept by proficiency levels, using the data from the Korea National Assessment of Educational Achievement (NAEA) in 2010-2012.

2. Method

In NAEA, Achievement level of students is divided into three stages – Advanced, Proficient, Basic, and there is 'Below Basic' students. In this study, the types of physics concepts or way of thinking of students are analyzed base on the contents and structure of item and the trends or difference of response distribution by proficiency level. Specific analysis method is presented in Fig. 1.

2) Analysis of the contents and structure of item
- Identify the thinking of students for each options
- Find and classify the common elements of options

1. Which of below figures is showing the most appropriate path of the light when a person sees the flower?



"There is the light coming from the eyes."

1) Analysis of the response distribution
- Identify the trends of response rate for each option by achievement level.
- Identify the typical misconceptions for each achievement level.

Achievement Level	Response rate(%)					
	①	②	③	④	⑤	B/D*
Advanced	0.10	1.39	6.77	0.43	91.31	0.00
Proficient	0.70	5.67	23.08	0.91	69.54	0.10
Basic	2.01	12.00	38.93	3.56	43.19	0.31
Below Basic	8.05	19.54	35.63	11.49	24.14	1.15
Total	0.76	5.28	20.07	1.22	72.56	0.11

*Blank or Double check

Although these students recognize light coming from the sun, they think the reason they can see objects is due to the light coming from eyes.

3) Classify and summarize the identified students' physics concepts by achievement level.

Fig. 1. Analyzing method of the students' physics concepts

3. Results

3.1 Grade 6

Forces and Motions

- Almost all students (>90%) have conception the object at the down side of balance is heavier than the object at the opposite side. But more than 20% of students at Proficient level or below consider the object far away from the fulcrum heavier when the balance is in horizontal state.
- More than 65% of students at Proficient level or below don't know how to read the speed, or they didn't reach the level of understanding meaning of speed. Moreover, more than 50% of these students tend to focus on the travel distance of object rather than the elapsed time.

Electricity and Magnetism

- More than 85% of students at Proficient level or above recognize the differences between conductive objects and non-conductive objects.
- About 25% of students at Basic level or below consider the brightness of the light bulb in electric circuit will be changed instead of turning off when the object in circuit is changed to different object.
- More than 20% of students at Proficient level or below have the concept that electric current doesn't flow through the filament of a light bulb is lit.
- More than 80% of students at Proficient level or above think that electric current will not flow if two the same batteries are connected to the same poles facing each other.
- More than 25% of students at Proficient level or below think that electric current will flow if there is another electrical components between two batteries which the same poles are facing each other.

Heat

- More than 75% of students at Proficient level or above are understanding 'convection' by relating the features of convection phenomena.
- More than 70% of students at Basic level or below have no knowledge about the terms of heat transfer like conduction, convection and radiation.

Lights and Waves

- Almost all of students (>95%) recognize that light comes from bright objects such as the sun. But despite of this recognition, about 20% of students consider the reason they can see objects is due to the light coming from the eyes.

3.2 Grade 9

Forces and Motions

- More than 25% of students at Proficient level or below consider the strength of resultant force of two forces acting on an object is constant regardless of the direction of the forces if the strength of the two forces is equal.
- More than 90% of students at Proficient level or above know the kinds of forces and the characteristics of each force.
- More than 10% of students at Basic level or below have no scientific concepts about on the characteristics of 'gravitational force'.
- About 50% of students at Proficient level or below think the object moves to the opposite direction of the force acting on it in the situation related with 'inertia'.
- More than 85% of students at Proficient level or above have the concept that the direction of frictional force acting on the moving object is opposite to the direction of movement.
- More than 25% of entire students consider that the strength of frictional force acting on the object is larger than the external force in order to move the object at the moment of starting to move.

Electricity and Magnetism

- More than 70% of students at Basic level or above have the scientific concept that the electrons can move, so they consider if they rub two object each other, some electrons in an objects would move to the other one.

- More than 80% of Advanced level students have the scientific concept that the direction of electric current is opposite to the direction of the movement of electrons.
- More than 50% of students at Proficient level or below consider nucleus also moves as well as electrons in the wire which electric current is flowing.
- More than 40% of students at Basic level or below think the electric current is consumed.

Heat

- Almost all of students at Proficient level or above (>90%) have concept that the volume of metal object increase if it is heated. These students can identify the phenomena due to the heat expansion of object.

Lights and Waves

- More than 70% of students at Proficient level or above think the light reflected from the mirror proceeds according to the laws of reflection.
- More than 25% of students at Basic level or below consider that the object far from the side of the mirror may not be able to see through the mirror.
- Almost of students at Proficient level or above (>90%) have concept that combining different colours of light makes the lights seen in another colour.
- About 20% of students at Basic level or below consider the 'dispersion' of light as the diffusion of light instead of the separation of light by the wavelength.
- More than 20% of students at Basic level or below consider the 'oscillation' means only the movement of an object at the vibratory level.

4. Discussion and Conclusion

Although there were some previous studies that identified physics concepts that students achieved, there are few studies that compared the concepts by students' proficiency levels. This study has identified physics concepts that are different by students' proficiency levels, and also has investigated the ratios of students for each concept. The results of this study suggest valuable information for personalized education. However, since this study examined rather small number of target items, more research is necessary to compare the results of different assessments by students' proficiency levels. As a matter of fact, many countries conduct large-scale assessments of students' scientific concepts or science literacy both nationally and internationally, such as TIMSS or PISA, and those assessments provide the test results by proficiency levels. The findings of this further research will help us find a way to facilitate our students' understanding of scientific concepts.

References

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