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Study Notes

A Preliminary Study of Junior High School Students' Naive Knowledge of Light in the Real Science Classes

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The present study aimed to investigate whether the questions or situations used in the precedent researches on naive knowledge appeared in the real science classes. 8 out of 15 lessons about light were recorded and observed, and the teacher's and students' activities were analyzed in detail. According to the results, the incorrect naive knowledge was introduced in the non-standard textbook, though the questions or situations did not appear. In addition, both the teacher and students hardly referred to everyday phenomena related light. Thus, it seems difficult to identify students' naive knowledge from their spontaneous behaviors in the real science class. The idea similar to the naive knowledge of light incidentally emerged in the lesson about refraction of light. For a problem to draw a refracted path of light, one student drew an arrow from an eye to a coin at the bottom of a container. This incorrect direction of ray, similar to those reported by the precedent studies, was described in the textbook and the students had actually read the sentences about it. Thus, some students may consider that people can see objects by emitting something like a beam from their eyes and catching them.

Key words：naive knowledge, light, science education, junior high school student, Introduction

Introduction

People acquire rich knowledge through various experiences in everyday life (e.g., Clement, 1982; McCloskey, 1983). This knowledge has been called intuitive or naive knowledge especially in physics domain since people construct it by themselves before formal learning at school. Many researchers have reported that naive knowledge is quite useful for explaining phenomena or solving problems encountered in the real life, and thus is repeatedly applied (e.g., Osborn & Freyberg, 1985). When students' naive knowledge of a certain subject matter is consistent with the scientific knowledge, it would be quite easy for students to follow classes and understand the scientific conceptions. According to Vosniadou (1994) and Chi and Roscoe (2002), however, it is often inconsistent with scientific knowledge and even hinders students from learning and achieving a deep understanding. Therefore, it is necessary to explore what knowledge students acquire before formal learning and bring into their classes.

Researches on Naive Knowledge

Students' naive knowledge has been observed in various science domains, such as Newtonian mechanics (Clement, 1982; McCloskey, 1983), electricity (Cohen, Eylon, & Ganiel, 1983), sound (Linder & Erickson, 1989) and so on. Most of these researchers applied mainly two types of techniques; Open Questionnaire (OQ) and Forced Choice Questionnaire (FCQ).

In the OQ, students are asked to predict what will happen next and explain why they think so. In this case, participants can response uninhibitedly to the questions presented by the interviewer, and thus their answers do not likely to involve experimenters' predictions or expectations. At the same time, however, in the case of younger children or novices of the domain, their responses are limited due to their immature linguistic ability, and we may not figure out their real thinking. Add to this, researchers sometimes repeat questioning to confirm subjects' idea, which makes them change their previous responses and say something just to suit the occasion. In the FCQ, participants are usually asked to choose one of the alternatives presented by the experimenter. Contrary to the OQ, participants' responses in the FCQ are not constrained by their verbal level. By using FCQ, researchers can cover much younger children because what participants have to do is only to choose from several alternatives. Yet, the FCQ also has some problems. One of them is that it has the potential of biasing subjects towards scientifically correct responses which they may not fully understand. This is because the alternatives may not involve the answer that subjects do not really think. In that case, they may choose irresponsibly the closest answer. When there is no alternative showing them and they have to explain verbally by themselves, then the problem of their linguistic ability would arise again.

Although both of the two techniques have several problems, they are still quite useful and convenient methods (see also, Vosniadou, Skopeliti, & Ikospentaki, 2004). It is even possible to compensate the shortcomings of each other by combining the both. However, most of the questions or situations set in the researches using these methods are unlikely to appear in the textbooks or teacher's instructions. Therefore, using these conventional methods, what knowledge students have in that science domain could be extracted, while it seems difficult to examine when and how their naive knowledge emerges and facilitates or hinders the achievement of a deep understanding during science classes.

The Present Study

To date, only a few studies (e.g., Verschaffel & De Corte, 1997) analyzing the real classroom situations have been reported. Thus, the first purpose of the present study was to examine whether the questions or situations used in the precedent researches on naive knowledge were treated in the real science classes. The second purpose of the present study was to suggest any possibility that naive knowledge of light would appear in the science classes and influence on their learning. Thus, the teacher's instructions and students' behaviors were videotaped and observed.

The theme of the science classes observed in the present study was light. According to the course of study for junior high school (MEXT, 2007), light are included in "Familiar physical phenomena" as well as sound, force, and pressure. The goals are to understand the regularities of light and sound, and properties of force through observation and experiments of familiar physical objects or phenomena, and to cultivate the ability to think or view them in scientific way as being related to everyday life.

Although there have been many researches on light conception (e.g., Galili & Hazan, 2000; Guesne, 1985), there are only one or two types of naive knowledge have been found. The first is that people tend to think that they can see objects by emitting something like a beam from their eyes and catching them, although, in reality, the objects reflected the light from the light source such the sun or a fluor lamp and the reflected ray enters their eyes. The second is that something like a beam from their eyes is reflected to objects and the reflected thing returns to their eyes (Fig. 1).

Many researchers used almost the same questions or situations to investigate people's naive knowledge of light. For example, Galili and Hazan (2000) asked participants to answer 13 questions addressing conceptual understanding of the act of vision, general properties of light, shadow formation, imagery in reflection and refraction, and color resulting from colored radiation and from reflection, using paper-and-pencil tests. The main point of these questions was to explain the role of light and eyes in visual perception. For example, participants were presented several pictures of a light source, a person, and an object and asked to explain each role and draw a path of light.

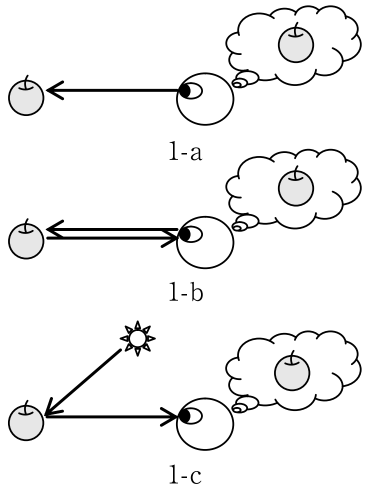

Fig. 1. Processes of visual perception. 1-a and 1-b show incorrect naive knowledge. In 1-a, something like a beam is emitted from eyes and catches an object. In 1-b, something like a beam is emitted from eyes and it is refracted to an object and the refracted ray comes back to eyes. In 1-c, which shows scientifically correct knowledge, a ray from the light source collides against an object, and the refracted ray comes

Method

Participants

One class (41 students and one science teacher) of a private junior high school in Shiga prefecture participated in the present study. There were 18 male and 23 female first grade junior high school students (12 to 13 years old).

Period of observation

The science classes (each class has 50 minutes) from April 23rd to June 6th in 2008 were observed. There were two science classes a week, unless some school events were scheduled. The unit of light consisted of

14 lessons (Table 1). The main topics were (1) the path light goes (light travels in straight line, reflection and refraction), (2) the way shadows or images are formed, (3) properties and constructions of convex or concave lens, and (4) the types of light and its energy. Eight classes were observed in total. Recorded lessons were lesson 3-4, 6-7, 9-10, 12, 13. For lesson 1-2, 5, 8, 11, 14, the contents of learning and students' activities were investigated by interviewing the teacher. All the science classes were taught by one teacher.

Table 1. Contents of each lesson about light

Lesson	Contents
1	Familiar phenomena related to light
2	The way light goes
3	Reflection of light
4	Refraction of light I
5	Refraction of light II
6	Total reflection
7	Shadows and images
8	Properties of convex lens
9	Images by convex lens
10	Construction images by convex lens
11	Properties of concave lens
12	Construction images by concave lens
13	Types of light and its energy
14	Integration

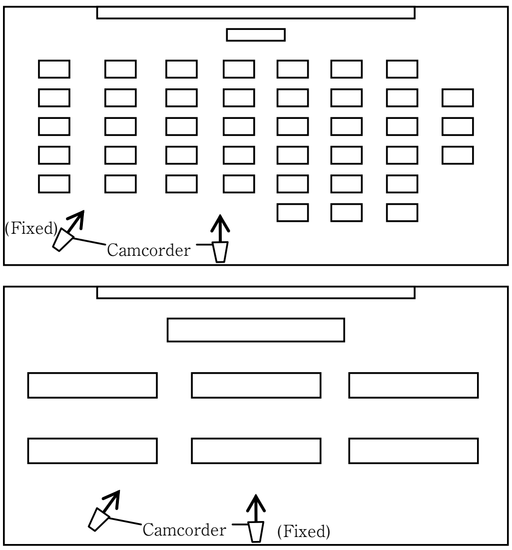

Fig. 2. Arrangements of the classroom (top) and science laboratory (bottom).

Equipments and procedure

Two camcorders (Panasonic DVD camcorder VDR-M95) were used. The one was set at the back of the classroom or science laboratory to record the whole class activities, and the other was appropriately moved around to record notes on a board, instructions by the teacher, comments or activities of students. Fig. 2 shows the arrangement of the classroom and the science laboratory. The experimenter was basically not involved in the lessons

Results and Discussion

Results of the observations were analyzed, based on the videotaped lessons. To examine whether the questions or situations used in the precedent researches on naive knowledge were treated in the real science classes, the science teacher's instructions were analyzed first. Then, students' activities during classes were analyzed, in order to examine any possibilities that they possessed naive knowledge of light.

Teacher's instructions

The teacher's behaviors during lessons were roughly classified into the following three categories: (1) explanation of contents of learning and writing notes on the whiteboard, (2) presentation and exposition of problems, (3) demonstration of experiments.

For explanations of contents of learning the teacher hardly used the textbook, and wrote detailed notes on the whiteboard. Although he used the textbook only to show the pictures which could not easily write on the whiteboard or explain only verbally, most of his explanations were based on the textbook and few examples of everyday life were explained. Instead of using the textbooks, he tried to make students to pay attention to him and his notes on the whiteboard. He allowed some time for students to copy the notes and made sure that all students were ready, before moving on to the next contents of learning. Although the junior high school applied the non-standard textbook (Tokyo Syoseki, 2004), its contents were almost the same as standard one, except for some topics to motivate students. One of the topics was about how humans visually perceive objects, which related to the incorrect naive knowledge of light. Both of the two types of incorrect naive knowledge of light described above (Fig. 1) were illustrated with their academic histories. This topic was treated in lesson 1. According to the teacher, when he asked the students to read that part of the textbook, they commented, for example, "Such views are nonsense," "It is impossible to emit a beam from my eyes," or "It is obvious that the reflected light comes into our eyes." These responses by the students showed that they seemed to know the scientifically accepted process of visual perception, and at least they did not have the naive knowledge described above. In addition, the teacher repeatedly explained in lesson 2, 3, and 4 that light directly from source of light or reflected light from objects comes into person's eyes.

The ways of presenting problems appeared quite simple; that is, after the teacher asked only verbally or with notes on the whiteboard, students raised their hands up and one of them was named and answered the question. However, the teacher seemed to facilitate as more students to raise their hands as possible. He never named a student immediately and waited until more than about half of the students raised their hands. Thus, all students could have an opportunity to answer the question and different opinions from different students came out. And when most students did not raise their hands, or when the first student did not answer correctly, the teacher gave some hints. Almost all of the questions were explained in the previous lesson or wrote on the textbook, and there was no question related to everyday life.

There were four experiments during the observations. In each case, small groups of 6 to 7 students were generated. When he demonstrated the experiments, he made sure that all students could understand how to manipulate the tools by explaining and showing repeatedly. Also, he asked them to take turns conducting an experiment since limited laboratory instruments were available. This instruction seemed to make a partial success. That is, all students could actually experience an experiment and observe a phenomenon which occurred by themselves, while some of those who had already finished their turn did not observe other students' experiment nor take a note about the results on their notebooks, but whispering with each other or play with tools unrelated to the experiment.

Thus, in the science class observed, the questions or situations used in the precedent studies of naive knowledge did not appear. However, incorrect naive knowledge itself was introduced in the textbook. In addition, there were few examples of everyday phenomena related to light.

Students' activities during lessons

The students' activities were classified into the following three categories: (1) listening to teachers' instruction and copying notes on the whiteboard, (2) answering to problems, (3) conducting experiments.

When they were listening or copying notes, students who whispered meaningless topics with each other were hardly observed, and most of them seemed to concentrate on the lessons very much. One of the reasons for this is that junior high school is a private school which administers an entrance examination and the students were a diligent learner from the beginning. Another reason is that the teacher took enough air time to think about the contents of learning or copying notes as described above. However, there were only a few students who took extra notes of the teacher's explanations.

For answering to problems during lessons, most students positively raised their hands. Again, this would be due to the teacher's behavior to wait for a relatively long time until most students were ready for answering to the question.

In small group activities where several experiments were conducted, all students took part in and became both an experimenter and an observer by rotation. However, as described above, some of the students who had already conducted an experiment did not observe the others' experiment and whispered meaningless topics with each other. Furthermore, even the students who seriously observed the others' experiment took an extra note unless the teacher instructed so.

Possibility of naive knowledge

In lesson 1, when the students read the topic about incorrect naive knowledge of light, they made remarks which they did not have such knowledge reported in the precedent studies. In addition, both the teacher and students hardly refer to everyday phenomena related to light, and thus it is likely that students did not possess a prior knowledge hindering from learning, at a glance. However, in lesson 5, one student showed a possible sign of incorrect naive knowledge.

In lesson 4 and 5, the main goal was to understand the property of light to be refracted when a ray travels into a medium with a different density, and to construct its path. In lesson 4, the students conducted several experiments using a prism spectrograph, and observed the phenomena where a ray going straight was refracted when it collided against the prism. And in lesson 5 at the experimental laboratory, the students reviewed the outline of the properties of fraction of light, were presented a demonstration of the fraction of light with another medium, and learned how to draw a path when a ray travels into a medium with a different density. The teacher showed an example where a coin at the bottom of a container, which was without range of vision as it was, came into sight when some water was poured into the container (Fig. 3).

After the demonstration of pouring some water and confirming that all students could see the coin, the teacher drew a simplified picture of the coin, container, and the imaginary eye on

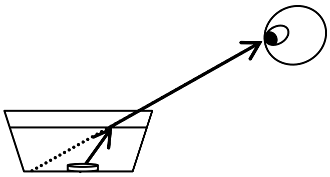

Fig. 3. Correct path of a ray going out of water in the container and to an eye. The broken line shows a path when there is no water in the container.

the whiteboard. And then, he asked students to draw a path of light when the eye could see the coin. About half of the students raised their hands, and one of them named by the teacher stepped forward and completed the drawing. Fig. 4 shows a path of light illustrated by the student.

As shown in Fig. 4, the student could assume some light source which did not appear in the original picture, but in his drawing, a ray from the source reflected by the surface of water and went into the eye, and again, it reflected by the eye and went into the water. The drawing seems to show that this student could not understand correct paths of light and had incorrect knowledge similar to the naive knowledge, that people can see objects by emitting something like a beam from their eyes and catching them. Even when the teacher explained that the eye could not emit a beam, the student did not notice his mistake of the direction of arrows.

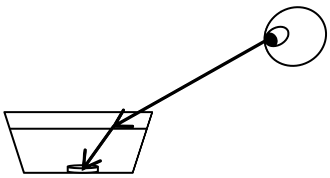

Fig. 4. Incorrect path of a ray by a student. Something like a beam is emitted from an eye into the water. The direction of arrows are opposite to those in Fig. 3.

The teacher named another student to draw a path, and this time she could draw a correct path from the coin to the eye, though the ray started from the coin, not from the source of light. Here, the teacher drew a correct path starting from the blank area of the whiteboard to the coin at the bottom of the container, and, in turn, from the coin to the eye. Even after this presentation of the correct answer, however, many students seemed to wonder why it was correct, but the student's was wrong. The students' speeches or drawings observed in lesson 4-5 would suggest that they seemed to have some incorrect naive knowledge of light.

Conclusion

The present study observed the real science classes, in order to describe teacher's and students' behaviors during lessons and to examine whether questions or situations used in the precedent studies appeared in the real classes.

The results showed that in the science classes the present study observed, both the teacher and students referred neither questions nor situations used in the precedent studies, though the incorrect naive knowledge itself was introduced in the textbook. Thus, it seems difficult to identify students' naive knowledge from their spontaneous behaviors in the real science class. However, the junior high school in the present study is a private school and applied a non-standard textbook, which explicitly introduce the incorrect naive knowledge of light. Thus, further researches to investigate the other public school applying a standard textbook (e.g., Dainippon Tosyo (2006), which just refers the scientific correct visual perception but not incorrect knowledge) should be needed.

The similar idea to those reported by many researchers (e.g., Galili & Hazan, 2000; Guesne, 1985) was observed in the lesson 5 about the fraction of light. Even though when the students first read the topic about the incorrect naive knowledge and the teacher explained it several times, it incidentally emerged in student's construction of a path of light. Also, after the presentation of the correct path, it seemed difficult for some students to realize what was problematic by themselves. However, some problems still remain. First, there was only one student observed, who showed the incorrect path of light from an eye to an object. It is possible that only a small minority of junior high school students has this idea and most of them actually understand the correct process of visual perception. And secondly, it is possible that the student's path from an eye to an object was not due to his incorrect naive knowledge of light, but he drew it simply because it was easier than that from an object to an eye. Further research using interviews or questionnaire by pencil-and-paper format should be needed to examine whether junior high school students have incorrect naive knowledge of light

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