

## **The Study of Conceptual Change using the Worksheet —A Case Study about the Movement of Light—**

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**Abstract:** *It is commonly believed that most children think “Light goes far at night, but light stays on the light source in daylight.” and “Light is its source and its effect”. Both are conceptions of living that children get from experience every day. In contrast, in learning about “Light”, seventh graders are taught to draw a path of light with a straight line, because light is recognized as a distinct entity, located in space between its source and the effects it produces. However, this scientific conception is not accepted by the child who does not consider light as an entity moving in space as I mentioned before.*

*For this problem, as the case study about the conceptions of the junior high student about the movement of light, the purpose of this study is to clarify that the worksheet made for promoting the constitution of the scientific conceptions of the child have an effect. An investigation was carried out on 174 first graders at a public junior high school from October to November, 2015. Before and after learning with the worksheet, the students answered two questions about the distance which light traveled from the candle, and the differences in two results were analyzed. After learning about reflection and refraction of light and about convex lenses, a confirmation test for students was carried out and the result was analyzed.*

*It became clear how children think about “The sight” of an object by their replies to the questions on the worksheet. Most of them think that a smooth surface such as a mirror reflects light, but that a rough surface such as an apple does not reflect light. In addition, they think that they can see an object of which the surface is not smooth like an apple if the object is lit up, though they can’t see the object in complete darkness. Then they noticed these two views contradicting each other, and changed into the view that all objects which they can see reflect light. Also the child found that we could see the object because the reflected light arrived to our eyes. In the investigation after the worksheet, both of the night and day, the number of children who chose “The light from the candle comes out until it hits something”, increased over the same investigation before the worksheet. These observations indicate that most of children came to consider light as an entity moving in space. And then, in learning about reflection and refraction of light and about the convex lens, it followed that the child with scientific conceptions of light, got the result that the confirmation test was enough, in comparison to other children. These findings indicate that learning with the worksheet had a certain effect to promote the constitution of the scientific conceptions.*

**keywords:** *conceptual change, scientific conception, worksheet, teaching and learning, light*

## Introduction

The Teaching Guidelines for Junior High Schools in Japan emphasize that understanding and fixation and inflection of the scientific conceptions are important (Ministry of education, 2008). It would be thought that this view is to change the teaching and learning method to constructivism at school. In contrast, at school, it is a serious problem that young science teachers inexperienced with teaching, are increasing more and more.

## Objectives

The purpose of this study, for this background, is to clarify that the worksheet made for promoting the constitution of the scientific concept without depending on a teaching skill has an effect, and that the student using scientific conceptions could understand the learning contents about light better than the student giving priority to a preconceptions.

## Methods

An investigation was carried out on 174 first graders at a public junior high school from October to November, 2015. Before and after learning with the worksheet (Fig.2), the students answered two of a set of questions (Fig.1), and the differences in two results were analyzed. After learning about reflection and refraction of light and about convex lenses with a science textbook(Keirinkan,2015), a confirmation test (Fig.4) for students was carried out and the result was analyzed .

*Investigation*(Fig.1 ): Two of a set of questions were used to assess that students considered how far light from a candle went. Students were asked to choose the best alternative. 'C' is a physicist's answer(scientific view) with both.

 <p>You are watching a candle burning during the day.</p>	<p><b>The light from the candle :</b></p> <p><b>A: stays on the candle.</b></p> <p><b>B: comes out as far as you but no further.</b></p> <p><b>C: comes out until it hits something.</b></p> <p><b>D: comes out about halfway towards you.</b></p>
 <p>There is a power cut during the night. You are using a candle.</p>	<p><b>The light from the candle :</b></p> <p><b>A: stays on the candle.</b></p> <p><b>B: comes out as far as you but no further.</b></p> <p><b>C: comes out until it hits something.</b></p> <p><b>D: comes out about halfway towards you.</b></p>

Figure 1 (Shinya Morimoto, 1993): Investigation

Worksheet (Fig.2): A worksheet was used to promote that the students change their preconceptions to the scientific conceptions. Before learning with the worksheet, the teacher told the students, when there was no answer in accord with your idea, do not answer. After all students answered question 8, using figure 3, the teacher explained the structure of the human eye and the mechanism by which people see an object. After that, the students restarted answering from question 9.

**Please answer some questions below.**

Q1 Does a smooth surface reflect light ? ( Yes ▪ No )  
Q2 Does a soft surface such as a paper reflect light ? ( Yes ▪ No )  
Q3 Does an apple reflect light ? ( Yes ▪ No )  
Q4 Does a flashlight emit light ? ( Yes ▪ No )  
Q5 Can you see the light of a flashlight ? ( Yes ▪ No )

There is an apple in front of you.

Q6 Does an apple emit light ? ( Yes ▪ No )  
Q7 Can you see an apple in complete darkness ? ( Yes ▪ No )  
Q8 Can you see an apple lit up ? ( Yes ▪ No )  
Q9 This question is for the student who choses "Yes" in Q8.  
Why can you see the apple ?  
A because an apple emits light.  
B because an apple reflects light.

Q10 How far does light from the apple go ?  
A it stays on an apple.  
B it comes out as far as you but no further.  
C it comes out until it hit something.  
D it comes out about halfway toward but no further.

Q11 Have you changed your idea about light ? ( Yes ▪ No )

Please write your idea .

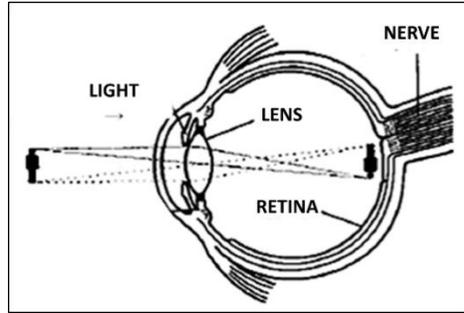
Q12 Have you understood why you can see the object ? ( Yes ▪ No )  
Q13 Why can you see this worksheet ? Please explain the reason why.

Please write your idea .

Figure 2: Worksheet

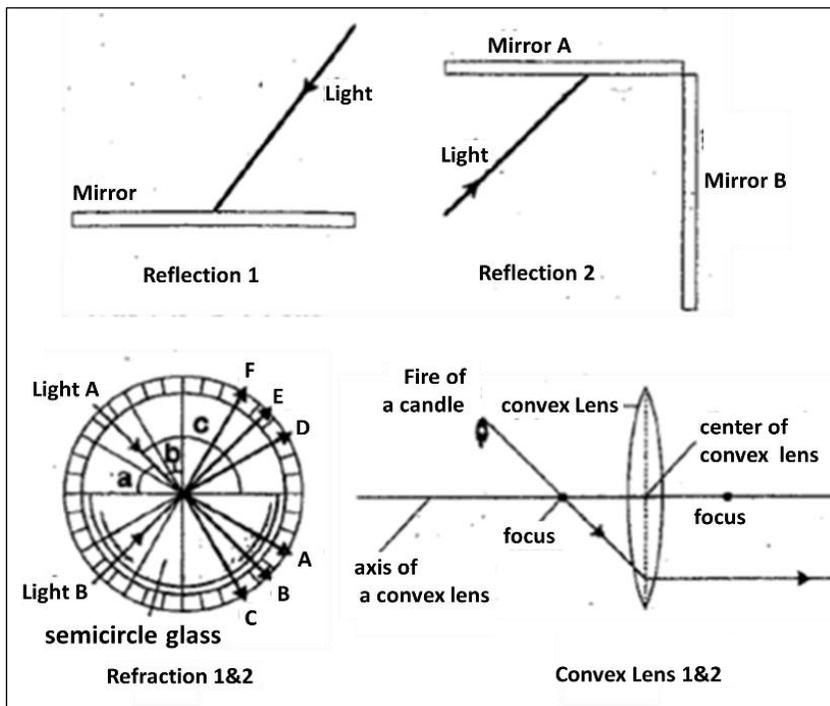
*Human Eye* (Fig.3):

This figure was used to learn the structure of a person's eye and the mechanism by which people see an object.



**Figure 3 : The structure of the human eye**

*Confirmation Test*(Fig.4): This confirmation test was used to assess whether the student would be using a scientific view about the light emitted from a light source, was able to understand the learning contents of the light better than the student not using it. Reflection 1&2 are questions to draw the reflected light with a straight line. Refraction 1&2 are questions to choose the refracted light of the light A&B which goes into the surface of the hemisphere glass. In addition, convex lens 1&2 are questions to draw the candle light which goes into the center of the convex lens and which goes parallel to an optical axis. All these are covered in the science textbook.

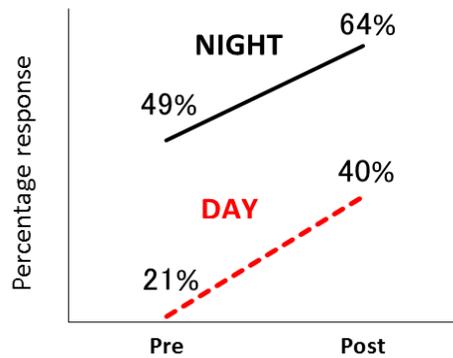


**Figure 4 (Shingakusha, 2015): Confirmation Test**

## Results and Discussion

### Investigation:

In the investigation after learning with the worksheet, as shown in Figure 5, both of the night and day, the number of student who chose “(C): The light from the candle comes out until it hits something”, increased over the same investigation before the worksheet. Many students came to consider that the light emitted from light source goes until it hits something. This view is a scientific view, but because these results also indicate that some students consider that the light goes further at night rather than day, some students would give priority to their own view.



**Figure 5 : Percentage response of ‘C’ for the questions in Figure 1**

### Analysis:

After learning with the worksheet, the students who met the requirement of Figure 6, the number of each their answer was shown in Table 1. Table 2 shows the results, most students answered “NO” for Q3 changed their views. Their view for light phenomena, before Q9, would be changed because of learning the mechanism by which people see an object (for example, see Fig.7 and Fig.8). 14 of 24 students of Group I who had the response of “C” for the both questions of Figure 1, chose “C” for Q10. 17 of 32 students of Group II, on the other hand, had the response of except for “C” for the both questions in Figure 1 after learning with the worksheet, chose “A” for Q10. 14 students of Group I would consider the travel of light with the mechanism by which people see an object, and would change their ideas into “Reflected light goes until it hits something”, but 17 students of Group II would give priority to their own view that the reflected light stayed on the light source. 10 (A3,B7) students of Group I who had the response of “C” for Q10 would consider that the reflected light was weak rather than the light emitted from light source. All students of Group I, therefore, would have the scientific view about the travel of the light emitted from light source. The reason that 6 students of D of Group II who had the response of “C” for Q10 chose except for “C” for the both questions in Figure 1 after learning with the worksheet, would be considered that they prioritize either their own view or the scientific view by the situation. Table 3 shows the results, some of them noticed by themselves that their views changed into scientific. The results of Table 4 suggest that they did not change their pre-conception into the scientific view completely but that they would noticed that they had understood more than before about the travel of the light and the mechanism by which people see the object.

Group I : The students who had the response of “C” for the both questions in Figure 1 after learning with the worksheet.

A: The students who changed to “C” for the both question after learning.

B: The students who changed to “C” for the question only about day.

C: The students who changed to “C” for the question only about night.

Group II : D: The students who had the response of except for “C” for the both questions in Figure 1 after learning with the worksheet.

**Figure 6: Category**

**Table 1: The number of each their answer \*NA...no answer**

	Group I						Group II									
	A		B			C	D									
<b>NO.</b>	24						32									
	7		15			2	32									
	YES	NO	YES	NO	YES	NO	YES	NO								
Q1	7	0	13	2	2	0	26	6								
Q2	2	5	7	8	0	2	6	26								
Q3	3	4	9	6	1	1	20	12								
Q4	5	2	14	1	2	0	28	4								
Q5	6	1	13	2	2	0	25	7								
Q6	0	7	1	14	0	2	1	31								
Q7	1	6	1	14	0	2	4	28								
Q8	7	0	15	0	2	0	32	0								
Q9	A	B	A	B	NA	A	B	A	B	NA						
	1	6	3	11	1	0	2	1	30	1						
Q10	A	B	C	D	A	B	C	D	A	B	C	D	NA			
	1	1	4	1	5	1	8	1	0	0	2	0	17	2	6	6
	YES	NO	YES	NO	YES	NO	YES	NO								
Q11	4	3	10	5	1	1	17	15								
Q12	5	2	13	2	2	0	26	6								

「自分の考えが変わった」ことがあれば書いてみよう。  
 今見える物すべては、光を反射しているから、人が  
 見えたり、物が見えるのは、...と思うようになった。

**Figure 7: Example answer for Q11**  
 “Because all visible objects reflect the light,  
 we can see the persons and we can see the objects, I changed my idea.”

プリントにあたった光が反射してその光が目の  
 に入ったから。

**Figure 8: Example answer for Q13**  
 “Because the light which reflected the worksheet went into my eyes.”

**Table 2: The number of the students who changed their idea;  
 “Does an apple reflect light?”**

		A	B	C	D
Q3	“NO”	4	6	1	12
	↓	↓	↓	↓	↓
Q9	“A(YES)”	3	4	1	11

**Table 3: In the students who answered “C” for Q10, “Light comes out it hits  
 anything.”, the number of the students who answered “YES” for Q11 and Q12.**  
 Q11: “Have you changed your idea about light?”  
 Q12: “Have you understand why you can see the object?”

		A	B	C
Q10	“C”	4	8	2
	↓	↓	↓	↓
Q11	“YES”	2	6	1
	↓	↓	↓	↓
Q12	“YES”	3	7	2

**Table 4: In (a)the number of the students had response except for “C” for Q10 and  
 answered “YES” for Q11, (b)the number of the students answered “YES” for Q12.**

	A	B	D
(a)	3	7	26
	↓	↓	↓
(b)	2	6	20

*Confirmation Test:*

The results of the confirmation test(Fig.4) which was carried out after learning about reflection and refraction of light and about convex lenses with a science textbook, were shown in Figure 10. The correct answer rate for each question was higher in Group I over Group II. These results show that Group I understood about the learning contents of the light more than Group II. It would be considered that the reason for these results was that the students of Group I more easily understood about the travel of light because they experimented on reflection and refraction of light and convex lens using the light emitted from the light source, the same as the candle light.

Refraction 1 and Convex lens 2 have a bigger difference of the correct answer rate than others. The students of Group I having the scientific view about the travel of light emitted from a light source, would have easily understood that the light refracted on the surface of the glass.

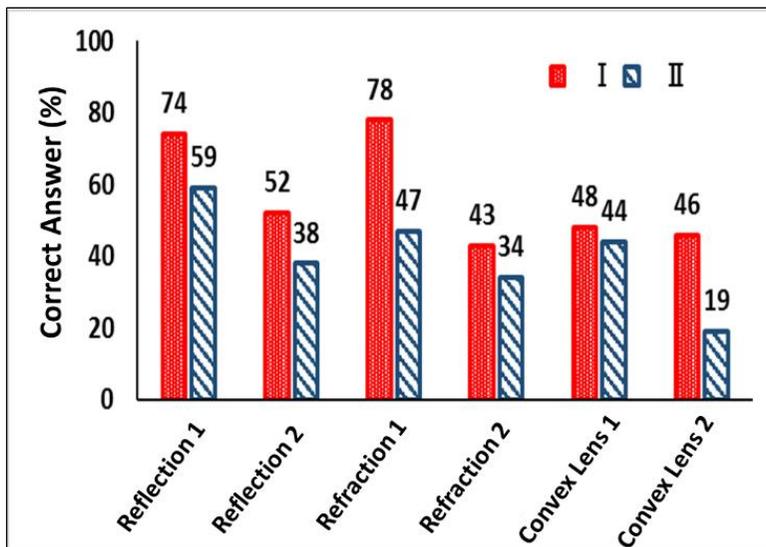


Figure 10 : The results of the Confirmation Test

**Conclusions**

- a. These findings indicate that learning with the worksheet had a certain effect to promote the constitution of the scientific conceptions.
- b. The student using a scientific conceptions could understand the learning contents about light better than the student who gave priority to preconceptions.

**Notes**

This study was written from “A Worksheet that Leads to the Scientific Concept” in the International Conference of East-Asian Association for Science Education (EASE2016). Poster presentation ,Tokyo,Japan. (August 26-28, 2016, Tokyo University of Science, Tokyo, Japan).

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