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The Effect of Learning to Incorporate Instruction on Formulation of Consideration Description Under Peer Evaluation Activity on Scientific Expression

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Abstract

The purpose of this study was to implement a junior high school science class that incorporates the instruction on formulation of consideration description under the peer evaluation activity, and to examine the effects of such instruction, focusing on the scientific expression of consideration description. The peer evaluation activity is a learning activity in which learners use Goto's (2013) mutual evaluation sheet to exchange opinions with others about their considerations in observations and experiments, using the evaluation criteria to conduct self-assessment and peer evaluation, and then revise and improve their consideration based on the mutual evaluation sheet that shows their score evaluation and comment evaluation [1]. In previous studies on the peer evaluation activity, it has been found that they are effective in increasing the awareness of explaining one's own considerations and revising others' considerations [2], but it has been reported that there are challenges in writing about evidence, which is one of the components of argumentation [3]. Therefore, in this study, we thought that by using a learning method that incorporates the instruction on formulation of consideration description under the peer evaluation activity, we could aim at fostering scientific expression while realizing learners' collaborative learning. In this study, we analyzed the changes in the consideration description that occurred as a result of this study, as well as the survey questions that were asked before and after the implementation of this study, and examined the effects of this study by focusing on scientific expressions. From the results of the analysis, it was suggested that learning to incorporate the instruction on formulation of consideration description under the peer evaluation activity had the effect of promoting the improvement of the consideration description including "results (data)," and "evidence (reason)" that constitute scientific expression.

Keywords: *peer evaluation activity, instruction on formulation of consideration description, scientific expression*

1. Background of this study

Japan's Ministry of Education, Culture, Sports, Science and Technology (MEXT) (2021) has proposed a direction that aims to realize optimal individualized learning and collaborative learning that will bring out the potential of all children [4]. However, many problems have been reported in the consideration of science education to date in the realization of collaborative learning. For example, in a report by the MEXT and National Institute for Educational Policy Research (NIER) (2018), in the National Survey on Academic Achievement and Learning conducted in FY 2018, when asked "Do you explain or present your ideas and thoughts to others in science class? The results show that 58.5% of the students answered "once a semester or more" and "rarely or not at all [5]. Furthermore, as for the consideration description in science education, it has also been pointed out that there is an issue with the lack of scientific expression. NIER (2019) shows that in Japan's results for scientific literacy questions in the OECD's PISA survey in 2018, the percentage of correct answers for "explaining phenomena scientifically" and "argumentation" is low [6].

Therefore, as one of the efforts to solve these problems, we focused on learning instruction that incorporates the instruction on formulation of consideration description under the peer evaluation activity. The instruction on formulation of consideration description means, as Matsubara (1997) indicated, "I thought (conclusion) from (results). The reason for this is that (evidence)" [7]. By using this learning, we thought that we could achieve collaborative learning in the consideration of science education, while also aiming to develop scientific expression.

1.2 Scientific expression

In science education in Japan, there have been recent reports on the practice of introducing Argument by claim, data, reason, background, limitation, and refutation, which are the components of Toulmin's argumentation structure, and Matsubara (1997) clarified the structure between Toulmin's model and formulation of consideration description. Results (data), claim (conclusion), and evidence (reason) are important elements in the consideration description, but background, limitation, and refutation are not always necessary. In this study, we supported this previous research and defined scientific expression as a text that includes results (data), claim (conclusion), and evidence (reason).

2. Purpose of this study

The purpose of this study was to implement a junior high school science class that incorporated the instruction on formulation of consideration description under the peer evaluation activity, and to clarify the effects on the development of learners' scientific expression.

3. Research Methods

First, students do an investigation question to investigate the first scientific expression. Next, students do a lesson with an experiment and write a consideration description on the learning task. After that, students rewrite their consideration description after learning to incorporate the instruction on formulation of consideration description under the peer evaluation activity, and then they do a second investigation question with the same content after the class. Then, we analyze the students' consideration description and the two investigation questions, and discuss the development of scientific expression.

3.1 Lesson with an experiment

In the lesson with an experiment, students conducted a combustion experiment of magnesium in carbon dioxide. After the experiment, we set a learning task called " Magnesium burned in carbon dioxide, producing a white substance and a black substance after combustion. The white material lost its metallic luster. Write a consideration of these facts to explain the changes that occur when magnesium burns in carbon dioxide " and asked the students to write their consideration description. An example of an appropriate consideration description was "After combustion, a white substance and a black substance were produced, and the white substance lost its metallic luster (results). This suggests that when magnesium was burned in carbon dioxide, it was transformed into magnesium oxide and carbon (claim). The reason for this is that magnesium took oxygen atoms of carbon dioxide and oxidized it, and carbon dioxide was deprived of oxygen atoms from magnesium and was reduced (evidence)."

3.2 Investigation question

Table 1 shows the investigation question, and Table 2 shows the evaluation criteria for the investigation question. For the investigation question, we set a discussion of the redox experiment of copper oxide and charcoal, which is a content related to the lesson with an experiment. The evaluation criteria consisted of six items. Items (1) and (2) are results (data), items (3) and (4) are claim (conclusion), and items (5) and (6) are evidence (reason). An example of an appropriate consideration description was "The gas produced after heating made the lime water white, and the red substance left in the test tube after heating glowed when rubbed (results). This suggests that when copper oxide and charcoal powder are well mixed and heated, they are converted to carbon dioxide and copper (claim). The reason for this is that carbon took oxygen atoms of copper oxide and oxidized it, and copper oxide was deprived of oxygen atoms from carbon and was reduced (evidence)."

Table 1. The investigation question

Copper oxide and charcoal powder were mixed well and the changes in the mixture were examined when it was heated. The gas generated after heating made the lime water white, and the red substance left in the test tube after heating glowed when rubbed. Based on this, write a consideration description to explain scientifically the changes that occur when copper oxide and charcoal powder are well mixed and heated.

Table 2. The evaluation criteria

(1) It is described that the gas generated after combustion made the lime water white. (2) It is described that the red substance left in the test tube after combustion glowed when it was rubbed. (3) It is described that one of the two substances after combustion was carbon dioxide. (4) It is stated that one of the two substances after combustion was copper. (5) It is described that carbon took oxygen atoms of copper oxide and oxidized it. (6) It is described that copper oxide was deprived of oxygen atoms from carbon and was reduced.

4. Analysis

4.1 Analysis of the changes in the consideration description

An example of the consideration description before (Table 3) and after (Table 4) the rewrite is shown. Before the rewrite, the consideration description related to one of the results (data) "it became brittle and lacked luster " and the claim (conclusion) " it was transformed into another substance " was found. The rewritten version added the results (data) of " a black substance and a white substance were produced" and the evidence (reason) for " oxidation-reduction". Thus, we can see that the learners' consideration description about the results (data) and the evidence (reason) has been improved by the instruction on formulation of consideration description under the peer evaluation activity.

Table 3. Before

When magnesium was burned, it became brittle and lacked luster, so it was transformed into another substance.

Table 4. After

When magnesium was burned in carbon dioxide, a black substance and a white substance were produced. The white material was brittle and lacked luster. This suggests that it has changed into another substance. The reason for this is that magnesium oxidized carbon dioxide by depriving it of oxygen atoms, and carbon dioxide was reduced, thus forming magnesium oxide and charcoal.

4.2 Analysis of the investigation question

A pre-post comparison of items was conducted on the first and second investigation question (McNemar test, two-tailed). As a result of the analysis, there was a significant increase in items (5) concerning evidence (reason). In addition, there was a significant increase in items (2) concerning

results (data) and items (6) concerning evidence (reason) by the 10% level of significance. However, no statistically significant differences were found for items (3) and (4) concerning claim (conclusion) (Table 5). From this, we can say that we have improved on results (data) and evidence (reason) in scientific expressions.

Table 5. A pre-post comparison

	pre		post		
	Number of correct answers	Number of non-correct answers	Number of correct answers	Number of non-correct answers	*p*
(1)	20	6	24	2	*ns*
(2)	19	7	25	1	†
(3)	25	1	24	2	*ns*
(4)	22	4	24	2	*ns*
(5)	9	17	18	8	*
(6)	10	16	18	8	†

n=26, *p<.05 †p<.10 *ns* p>.10

5. Conclusions

In this study, it was suggested that learning to incorporate the instruction on formulation of consideration description under the peer evaluation activity had the effect of promoting the improvement of the consideration description including "results (data)," and "evidence (reason)" that constitute scientific expression. In the future, it is our task to examine the advantages of learning to incorporate the instruction on formulation of consideration description under the peer evaluation activity by comparing the three groups: the group with only the peer evaluation activity, the group with only the instruction on formulation of consideration description, and the group with both.

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