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Evaluation of Inquiry Science to Motivate Students to Learn

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Abstract

In "Inquiry-Based Study of Science and Mathematics (Inquiry Science) ", all students choose their own research themes and was engaged in inquiry activities. We hypothesized that, if given a clearly defined rubric for self and mutual evaluation, students would be able to assess their own progress and maintain self-motivation while taking part in inquiry activities.

Based on the specific evaluation items already presented to students, we created a long-term rubric for inquiry science with an eye on addressing three key elements of the new Course of Study in Japan. Using the rubric, students conducted self-evaluation every hour, and together with the teacher, they focused on one of the perspectives, " Basic and fundamental knowledge and skills " or " The ability to think, to make decisions, to express themselves and other abilities ". The teacher and the students then discussed and set specific goals for the research content. The teacher evaluated the third elemnt " An attitude of proactive learning " at the end of the term.

We conducted self-evaluation and mutual evaluation for the tasks of "summarizing the contents of the group's research in writing". Using the following criteria proposed Goto's the mutual evaluation chart [1],these are "Corresponds to the question", " The results are presented and the necessary evidence is provided.", and " Written correctly ".

From the results of the mutual evaluation practice, the self-evaluation scores, which were based on the evaluation from others and re-written, were significantly higher for all evaluation criteria when compared to the first self-evaluation scores. The evaluation criteria are known to be related to the "ability" of scientific literacy as defined in previous research [1], and it is thought that the students further acquired the "ability" of scientific literacy through this practice. It is suggested that the rubric for evaluation in "Inquiry Science " and the self and mutual evaluation by students will help students to recognize their own progress and increase their motivation to learn through inquiry activities.

Keywords: *rubric, self and mutual evaluation, motivation to learn, Inquiry Science*

1. Basic approach

1.1 Aiming for assessment that motivates students to learn

Our school opened in 2004 as the first public single course high school for science and mathematics in Japan. In 2011, the school was designated as a Super Science High School (hereinafter referred to as "SSH") for five years by the Ministry of Education, Culture, Sports, Science and Technology. The school was re-designated as an SSH for the third term in 2021. In 2014, Nara Prefectural Seisho Junior High School was integrated into the school, making it the first integrated middle and high education school in Nara Prefecture.

In the school-set subject of "Inquiry Science," emphasis is placed on observation and experimentation so that students can determine their own science topics study problems and the problems related to the topic and solve them. It is a subjects that fosters the abilities of problem-solving and inquiry and communication through the repeated process of inquiry activities (Plan, Do, Check, Action). All students from the first grade of junior high school to the third grade of senior high school are required to take this course. To ensure that students remain highly motivated to learn throughout the year, We postulated that working on improving the manner in which evaluation is performed would lead to the improvement of students' self-motivation to learn over the course of the school year.

A long-term rubric for Inquiry Scienc

	An attitude of proactive learning
A	Trying to make their learning in Inquiry Science lead to the future.
B	Trying to think about their own research from various perspectives and what they can do with it.
C	Trying to think about their own research.
	The ability to think, to make decisions, to express themselves and other abilities
A	Able to set new challenges for themselves.
B	Able to investigate on their own.
C	Able to work under the guidance of a teacher.
	Basic and fundamental knowledge and skills
A	Able to deepen and implement newly learned knowledge about their research.
B	Able to understand and carry out the instructions given by the teacher.
C	Able to analyze, and manipulate data in the same way as in previous research.

Today's Objective

Reflection on today's Inquiry Scienc

Fig.1. Rubrics and evaluation sheets

1.2 Purpose of the research

Work to develop a system of assessment for Inquiry Science that motivates students to learn. We hypothesized that, if given a clearly defined rubric for self and mutual evaluation through self and mutual evaluation, students would be able to assess their own progress and remain motivated while taking part in inquiry activities.

1.3 Method

(1) Research period

May to November 2017

(2) Research target

School: Nara Prefectural Seisho Junior and Senior High School

Target students: Second-grade students at Seisho High School, Nara Prefecture (24 students in the researcher's charge)

2 Approaches to evaluation to increase student's motivation to learn through inquiry activities

2.1 Content of practice

(1) Design and practice of rubrics

(a) Design of rubrics for Inquiry Science

We designated the rubric for Inquiry Science as a long-term rubric because our school's Inquiry Science needs to meet the requirement to capture student growth from the first grade of junior high school to the third grade of senior high school. In The new Courses of Study of Japan, which were published in March 2017, teachers are expected to be aware of what students will be able to accomplish academically, and the three qualities and abilities that were determined to be monitored in this regard are " An attitude for proactive learning"," Basic and fundamental knowledge and skills " and " The ability to think, to make decisions, to express themselves and other abilities ". Therefore, the rubric focuses on the perspectives of the new Courses of Study and has three perspectives.These keystone principles are therefore integrated into the rubric. Furthermore, we simplified the use of the rubric for students by defining the evaluation criteria in a manner already familiar to the students (Figure 1).

(b) Self-evaluation using the rubric

At the beginning of each one hour lesson, the students were asked to discuss and select one of the following evaluation criteria, " Basic and fundamental knowledge and skills " or " The ability to think, to make decisions, to express themselves and other abilities " (suitable for the purposes and approaches of the one-hour class). Students were then required to define the requirements to meet the selected criteria together with the teacher. In addition, the teacher and students discussed the specific purposes of the research content, and each group set its own goals and wrote them down (Figure 1). At the end of the lesson, the students were asked to evaluate themselves on a scale from A to C (Figure 1). The students were also asked to write their self-evaluation in the column "Reflection on today's Inquiry Science". As the "attitude to independent learning" should be evaluated over a long period of time, the teacher in charge of the class made an evaluation at the end of the term, considering the overall state of the students and their presentations.

(2) Preparation and practice of the mutual evaluation table

(a) Preparation of the mutual evaluation table

In order to conduct a self and mutual evaluation for the task of "summarizing the contents of the group's research in writing", a self and mutual evaluation table was prepared and is presented below in Figure 2. In preparing the sheet, we referred to the criteria and examples of descriptions proposed

1.Corresponds to the question (Understanding of learning objectives and content)	①Does the information correspond to the objectives of the research? ②Does it contain the necessary keywords? Does it contain any irrelevant information? ③Are your own opinions (thoughts and feelings) mixed up?
2. The results are presented and the necessary evidence is provided. (The content of the discussion statements and the structure of the debate)	①Are the specific facts and evidence necessary to explain the conclusion provided? ② Is the structure as follows?"On the basis of (result), I considered (conclusion). The reason for this is (consideration)." ③Is the content of the claim correct?
3. Written correctly	①Are there any errors in the correspondence between subject and predicate, spelling, particles, conjunctions, etc.? ②Is each sentence too long, does it pack too much information, or does the amount of text exceed the given boundaries? ③Isn't the text difficult to read?

Fig.2. The mutual evaluation table

in Goto's the mutual evaluation chart [1]

For scoring, a maximum score was set for each evaluation item, and the full score was set when all of the sub-items were satisfied by comparing the sub-items with the results of the study and the description of the discussion. Points were also deducted if any of the examples of point reduction applied the requirements to do so were met. The total points for each item were used as the total evaluation score, and a score of zero was allocated in cases where students did not perform an evaluation. In this study, each item was scored on a 4-point scale, with a maximum total of 12 points per evaluation. One point was then deducted for each reduction criteria satisfied. The evaluation criteria are known to be related to the "ability" of scientific literacy as defined in previous research [1].

(b) Practice using the self and mutual evaluation table

The learning activities using the self and mutual evaluation table were carried out in the second semester, from September to October, during three hours of class.

3 Results and tasks

3.1 Results of mutual evaluation practice

(1) Transformation of self-evaluation

Regarding self-evaluation, the first submission was performed at the start of the class and is compared to a resubmission at the end of the class.

The means of pupils' points at the time of submission and resubmission of the evaluation criteria were compared (t-test, Table 1). The results showed a significant increase in the mean value of points for evaluation criteria 1 and 2. This suggests that students' scientific literacy ' ability ' has improved.

Table 1. Comparison of results between submission and resubmission of mutual-evaluation points

	At submission Mean ±SD		At re-presentation Average value ± SD	Significance probability (two-sided) P-value		t-ratio	N
1.Corresponds to the question (Understanding of learning objectives and content) 4-point scale)	3.15±0.95	<	3.65±0.59	0.021	*	2.52	20
2. The results are presented and the necessary evidence is provided. The content of the discussion statements and the structure of the debate) 4-point scale)	7.75±0.97	<	3.55±0.61	0.000	**	4.66	20
3. Written correctly 4-point scale)	2.95±0.95		3.35±0.67	0.072	ns	1.91	20

t-test * P＜0.05 ** P＜0.01 ns P＞0.05)

3.2 Results of the questionnaire survey

The questionnaire survey was developed with reference to the items on the Assessment of Academic Ability of the National Survey, and the items set by Shigeo Sakurai [2] to measure pupils' motivation to learn on their own. Questionnaires were administered in May, before the start of practice, and in October, after the end of practice, to observe changes in students' attitudes towards learning. Responses were scored and statistically processed (Wilcoxon signed-rank test) using the four-point scale.

The results of the first questionnaire in May were compared with the results of the second questionnaire in October, and the items that showed statistically significant differences are shown in Table 2. The results show an increased sense of achievement in Inquiry Science and a deepening of enquiry thinking. In addition, there was a trend for students' interest and motivation to learn to increase. There was no significant decrease in the mean value of any of the other evaluation items investigated.

Table 2. Comparison of the results of the first and second questionnaire surveys

Question No.	Questionnaire	1st mean ± SD		2nd mean ± SD	Z	Significance probability (two-sided) P-value	N
5	I am happy when I understand something I didn't understand in the inquiry science class.	3.40 ± 0.67	<	3.64 ± 0.49	2.236 *	0.025	22
15	I know what inquiry science is all about.	3.00 ± 0.68	<	3.45 ± 0.51	2.678 **	0.008	22
19	It is important to think of hypotheses for issues.	3.32 ± 0.65	<	3.59 ± 0.59	2.121 *	0.039	22

(Wilcoxon signed-rank test ＊P＜0.05 ＊＊P＜0.01)

3.3 Outcomes

The findings of the current research project suggests that the rubric for evaluation in "Inquiry Science" and the self and mutual evaluation performed by students are effective in helping them to recognize their own progress and increase their motivation to learn through inquiry activities.

3.4 Future tasks

The items with an average score of less than 3 out of 4 on the second questionnaire were found to be the following items: "12. Enquiry Science is useful in everyday life." "29. I will think about how I can use what I have learnt in Enquiry Science in my everyday life." These are issues that have not yet been resolved. In the future, we will work to help students make connections between their enquiry and their everyday lives as they progress through their research projects.

References

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