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Teaching Practice of Using the Mutual Evaluation Chart in the Observation of Somatic Cell Division.

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Abstract

We hypothesised and tested the hypothesis that conducting mutual evaluation and recognising students' own growth in the process of observation and discussion writing of somatic cell division would be effective in understanding the learning content. Observations of somatic cell division were carried out on the third graders in our junior high school. The experimental group carried out mutual evaluation on the task where students were asked to explain why the interphase is longer in the cell cycle based on the number of cells at each stage of cell division. Referring to the criteria proposed by Goto's mutual evaluation chart [1], we set the criteria as follows: 1) To correspond to the question, 2) The results are presented and the necessary evidence is provided, 3) Content is correct, and 4) Written correctly. No mutual evaluations were conducted in the control group. Subsequently, survey questions were administered to ascertain the degree of understanding of the experimental results and their discussion. Based on the results of the survey questions, the relationship between mutual evaluation and understanding of the learning content was discussed. The results of the survey questions showed that the experimental group scored significantly higher (chi-square test $P<0.05$) than the control group on 8 of the 13 items, which were questions that required students to relate their existing knowledge to understand what they had learned. Five questions did not differ significantly, four of which were about the understanding of individual knowledge. In the process of mutual evaluation, the experimental group is considered to have made progress in associating their existing knowledge with the results of the experiment and its discussion. These results suggest that mutual evaluation is effective in helping students to relate their existing knowledge and understand what they have learned. It was suggested that when reflecting on observations of somatic cell division, recognising their own development by carrying out mutual evaluation and recording their thought processes is effective in understanding the learning content. Note that recording the thinking process means comparing pre- and post-discussion and examining the content for improvement based on the evaluation criteria chart.

Keywords: *peer assessment (mutual evaluation), somatic cell division*

1. Objectives

From the practice in "Inquiry Science", it was suggested that peer assessment by students (from now on, peer assessment means the implementation of self-assessment and others' assessment) would enable students to recognize their own growth and increase their motivation to learn in inquiry activities [2]. Therefore, we conducted a peer assessment of the task of "summarizing in writing why the interphase is long in the observation of somatic cell division" in the Science, Basic Biology 'Observation of somatic cell division'. The aim of the study was to verify that the recognition of one's own growth through peer assessment is effective in understanding the content of the study in the situation where students write a discussion from observations of somatic cell division.

2. Method

A task was set for describing a discussion from the results of an experiment in a class involving experiments in the third grade of junior high school. This task was based on the content of Basic Biology in the first grade of high school. Afterwards, a peer assessment was carried out and an investigation question (quiz) was administered to check the degree of understanding of the

experimental results and the discussion. The results of the quiz were used to examine the relationship between the peer assessment and the understanding of the study content.

2.1 Subjects, timing and groups surveyed

The 36 students in the classes where peer assessment was conducted were the experimental group, and the 36 students in the classes where peer assessment was not conducted were the control group. The period of implementation was October 2020. Based on the results of the school's regularly-scheduled exam before and after the implementation of these two classes, an F-test was conducted to confirm equal variances (prior $F=0.57$, $p>.05$, posterior $F=1.78$, $p>.05$), followed by a t-test to confirm that there was no significant difference between the mean scores of the two classes (prior $t= 1.72$, two-sided test, $p>.05$, posterior $t= 1.41$, two-sided test, $p >.05$). The two groups were therefore judged to be homogenous.

2.2 Class outline for each group

The experimental group was scheduled for four hours, with the first hour spent observing somatic cell division and writing up the results and discussion of the experiment; the second hour was spent conducting the first self-assessment andothers' assessment , and rewriting the discussion based on the assessments of others; the third hour was spent conducting the second self-assessment; and the fourth hour was spent conducting a survey of the students' understanding of the study content. Three days later, a survey question (quiz) on the students' understanding of the study content was administered. The control group carried out a one-hour experiment on somatic cell division and wrote the results and discussion of the experiment. No peer assessment was carried out, but examples of the discussion were provided by the teacher. Three days later, a quiz was administered to assess students' understanding of the content. The survey questions were administered in the classroom for 20 minutes for both the experimental and the control groups. Note that a peer assessment of the observation of somatic cell division was given to the control group after the quiz.

2.3 Experiment

The root apical meristem of the sprouts of Kujo leek were observed and the number of cells in interphase and each mitotic phase was counted. From this, the reason why the interphase is long in the cell cycle was discussed.

2.4 Learning tasks

The students were given the task of explaining why the interphase is the longest part of the cell cycle, based on the number of cells in each phase of somatic cell division, and were given the knowledge that the characteristics of each phase and the proportion of the number of cells in each phase are the proportion of time required for each phase, and were asked to write a discussion.

2.5 Practice of peer assessment

Peer assessment was conducted using the assessment criteria table (Table 1) and the peer assessment table (Table 2) set by the teachers. The assessment criteria table (Table 1) was based on the elements and description examples of the peer assessment table by Goto [1], with the following evaluation criteria: 1) To correspond to the question, 2) The results are presented and the necessary evidence is provided, 3) Content is correct, and 4) Written correctly. Each criteria had several sub-criteria, and each sub-criteria received one point. A score of 1 was given if the sub-criteria were fulfilled, and 0 if not. The sum of the sub-criteria was used as the score for each criterion.

For the peer assessment of the second and third hours of the class, each individual student conducted a self-assessment using the assessment criteria table (Table 1), followed by a peer assessment by the other members of the group. After the peer assessment, the students rewrote their discussion statements based on the feedback. Self-evaluation was carried out again on that discussion statement. The results of the first and second discussion statements and peer assessment were reflected on so that the students could recognise their own personal growth.

Table 1 The assessment criteria table

1.Corresponds to the question	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	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. Content is correct	①Has the necessary evidence been raised to explain the discussion?
	②Is it based on concrete facts?
4.Written correctly	①Are there any errors in the correspondence between subject and predicate, spelling, particles, conjunctions, etc.? ②Isn't the text difficult to read?

Table 2 The peer assessment table

Criteria	Sub-criteria ①	Sub-criteria②	Sub-criteria③	Subtotal	Comment
1.Corresponds to the question					
2. The results are presented and the necessary evidence is provided					
3. Content is correct					
4.Written correctly					
					Total points / 12

2.6 Investigative questions (quiz)

Investigative questions were used to check the degree of understanding of the experimental results and their discussion. The quiz consisted of questions on knowledge alone and questions on the combination of previously known knowledge and newly gained knowledge . Apart from the written content, one point was awarded for a written description and zero for a blank description.

3. Results

3.1 Changes in self-assessment

Self-assessments are shown as a submission for the first assessment and re-submission for the second assessment (the same applies below). The means of the students' points at the time of submission and re-submission of the assessment criteria were compared (t-test, Table 3). The results showed a significant increase in the mean of points for assessment criteria 1, 2, and 3. This suggests that the students' scientific literacy 'competence' has increased.

Table 3 Changes in self-assessment

	Submission Mean ±SD		Re-submission Mean ± SD	Significance probability (two-sided)	t-ratio	N
Criteria 1 (Corresponds to the question) (3-point scale)	1.53 (0.84)	<	2.70 (0.62)	0.000 **	7.47	36
Criteria 2 (The results are presented and the necessary evidence is provided) (3-point scale)	0.78 (0.76)	<	1.73 (0.53)	0.000 **	6.41	36
Criteria 3 (Content is correct) (2-point scale)	1.19 (0.71)	<	1.88 (0.38)	0.000 **	6.02	36
Criteria 4 (Written correctly) (2-point scale)	1.67 (0.63)		1.89 (0.37)	0.065 ns	1.88	36

(t-test * P<0.05 ** P<0.01 ns P>0.05)

3.2 The results of the survey questions

The results of the survey questions are shown in Table 4. The questions for which the experimental group scored significantly higher than the control group were (3)⑤ (5), (7) ⑥ to ⑪, (8) rationale (what we already know), data, the total score for (8) and writing something in (8) (not blank). All questions except (3) ⑤ were questions that relate previously known knowledge and newly gained knowledge to understanding what was learned. All questions that did not have a significant difference were about the understanding of individual knowledge. The experimental group conducted the discussion writing twice, through trial and error, based on the evaluation criteria and the results of others' evaluations, whereas the control group only conducted it once. The control group did not write about the results of the experiment and its discussion through trial and error, because the teacher only presented the discussion description. This suggests that in the process of the peer assessment, the experimental group made progress in associating the existing knowledge related to the results of the experiment and its discussion.

From these results, it can be considered that the peer assessment efforts were not effective in understanding individual knowledge. However, peer assessment activities are considered to be effective for understanding the learning contents by relating the previously known knowledge and newly gained knowledge.

Table 4 The results of the survey questions

The survey question items			The experimental group [N]	The control group [N]	Significance probability (two-side test)		φ
(1)Rearrange experimental steps (a) to (f) in the correct order	(i) Individual knowledge	Correct ○	19	18	0.814	ns	0.028
		Wrong ×	17	18			
(2)Appropriate words for ② in sentence B	(i) Individual knowledge	Correct ○	24	18	0.151	ns	0.169
		Wrong ×	12	18			
(2)Appropriate words for ③ in sentence B	(i) Individual knowledge	Correct ○	23	19	0.339	ns	0.113
		Wrong ×	13	17			
(3)Appropriate words for ④ in sentence B	(i) Individual knowledge	Equatorial plane, lined' Description	12	4	0.047	*	Cramer's V
		Equatorial plane/aligned' No description	6	12			0.291
		Other than the above	18	20			
(3)Appropriate words for ⑤ in sentence B	(i) Individual knowledge	Correct ○	14	3	0.002	**	0.360
		Wrong ×	22	33			
	(i) Individual knowledge	Correct ○	24	21	0.465	ns	0.086
		Wrong ×	12	15			
(5) ⑦ in sentence B (identify the stages of development from the graph)	(ii) Relate knowledge	Correct ○	20	11	0.032	*	0.252
		Wrong ×	16	25			
(6) Appropriate words for ⑧ in sentence B	(i) Individual knowledge	Correct ○	33	34	0.643	ns	-0.055
		Wrong ×	3	2			
(7) ⑨ in sentence B (% of cell cycle from cell numbers)	(ii) Relate knowledge	Correct ○	20	11	0.032	*	0.025
		Wrong ×	16	25			
(7) ⑩ in sentence B (calculate time [h] from the ratio of the number of cells)	(ii) Relate knowledge	Correct ○	23	13	0.018	*	0.278
		Wrong ×	13	23			
(7) ⑪ in sentence B (Calculate time [m] from the ratio of the number of cells)	(ii) Relate knowledge	Correct ○	19	10	0.031	*	0.255
		Wrong ×	17	26			
(8) Underlined part Ⅰ of sentence B. Explanation of reasons	(ii) Relate knowledge	Correct ○	24	2	0.000	**	0.636
		Wrong ×	12	34			
(8) Underlined part Ⅰ of sentence B. Explanation of reasons (data)	(ii) Relate knowledge	Correct ○	14	5	0.016	*	0.284
		Wrong ×	22	31			
Number of blank responses in (8)		Description	32	21	0.003	**	0.347
		Blank answers	4	15			

(Chi-squared test SPSS27 * $p<0.05$ ** $p<0.01$ ns $p>0.05$)

References

[1] Goto Kenichi. "A Study on the Effectiveness of Self-Evaluation in High School Chemistry Experiments: Using a Mutual Evaluation Table," Journal of research in science education, Vol. 54, No. 1, pp. 13-24, 2013.

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