

DESIGNING A SCIENCE CLASS USING A COMPUTERIZED MICROWORLD AND ITS EVALUATION

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ABSTRACT

We constructed a science class where Japanese university freshmen experienced scientific activities. The class topic was the psychology of discovery. Students analyzed and described experimental data (description of phenomena) using a computerized microworld and constructed an explanation why the phenomena appeared (construction of an explanation). We evaluated its usefulness by analyzing the process by which participants collaboratively constructed explanations and the performance whether or not the participants successfully constructed the collect explanations.

1. INTRODUCTION

The objectives of the scientific activities are “description of phenomena” and “construction of an explanation” [1]. Here, “description of phenomena” is discovering laws and regularities of phenomena through experiments or observation, and the “construction of an explanation” is explaining the mechanisms that cause the phenomena.

In science education, having students spontaneously experience such activities is crucial. In this study, we examine how we can support students’ scientific activities in a class. We constructed a sample university class in which the validity of our method for designing a class is evaluated.

2. CLASS DESIGN

2.1. Class topic

In this class, the topic of class was the psychology of discovery. In the psychology of discovery, experimental researches are conducted using simple reasoning tasks. Here, we used Wason’s 2-4-6 task where subjects are required to find a rule of relationship among three numerals [2].

Students were required to conduct experiments by manipulating parameters as an experimental psychologist would. “Description of phenomena” is to identify the relationship between controlled factors and the proportion of subjects’ successful discovery. “Construction of an explanation” is to explain why such relationship appears.

2.2. Learning Phases

Twelve Japanese university freshmen participated in this class. The students’ main activities were hands-on, however if necessary, teachers gave them lectures.

2.2.1 Phase: Description of phenomena

First, each student took part in a real psychological experiment as a subject and actually solved Wason’s task by him/herself. Then, each one received the experimental data of all students including his/her own and analyzed them.

Next, the students reproduce the results in real experiment by using the simulation system which is computerized microworld developed by one of the authors and called VPL (Virtual Psychology Laboratory) [3].

VPL installs a computer agent as a subject to solve Wason’s task. In VPL, the students can construct experiments by controlling six parameters of the agent’s behavior. The students can compare the proportion of successful discoveries by having the agent solve the task in various situations.

Students described phenomena through real experiment and simulation. Then they wrote a technical report. In the report, the students were required to write “experiment objectives”, “experimental design”, “experimental results”, and “discussion”.

2.2.2. Phase: Construction of an explanation

After describing the phenomena, the students were required to construct explanations about why phenomena described in above experiments appear.

The explanations are constructed from three sets of fundamental knowledge in level 1. Here we call Knowledge X, A, B. First, the students should construct the knowledge in level 2 by integrating the two sets of the lower knowledge from level 1 (Knowledge X and A); then they find the knowledge in level 3 by integrating the knowledge from level 2 and the other knowledge from level 1 (Knowledge B).

From the teacher’s lectures in “Phase: Description of phenomena”, the students acquired the Knowledge X in

level 1, however, they did not understand the other two sets of knowledge. Thus, we adopted a learning design where the students first learned two knowledge sets that they had not acquired (Knowledge A and B), and then collaboratively integrated knowledge sets in level 1. By adopting the Jigsaw method, effective distributed collaboration was brought about [4].

This method of learning consisted of two stages. In the first stage, all students were divided into three groups of four students, called Expert groups, and the students in each group learned a different set of knowledge. That is, in level 1 the students in each group learned one of three sets of knowledge, either Knowledge A, B, or C. Knowledge C means a contradicts phenomena that the students described. However this knowledge was not directly related to the “construction of explanations”.

Next, we constructed Jigsaw groups. Each group consisted of three students who had each learned a different knowledge set in one of the Expert groups. The students in each Jigsaw group tried to construct explanations by integrating multiple sets of knowledge from level 1. After the Jigsaw group activities, the three students in each group were required to collaboratively write their conclusions on an answer sheet. Each student was also required to independently rewrite the discussion in the technical report written in “Phase: Description of phenomena”.

3. EVALUATION

In their technical reports written in “Phase: Description of phenomena”, students described phenomena (relationship between controlled factors and the proportion of subjects’ discovery) and explained why those phenomena appeared. Although some students described cases that differ from phenomena in each report, all students successfully described the phenomena. We evaluated whether or not the students successfully constructed the explanations. We also examine the processes by which the students construct explanations in the Jigsaw group.

3.1. Successful Explanation

We analyzed the discussion which subjects wrote in their technical reports. Ten reports were analyzed because two students did not submit their reports. In “Phase: Description of phenomena”, they were required to explain in their discussion why phenomena appeared. After learning in the Jigsaw groups, students rewrote their discussions. We call the former pre-discussion and the latter post-discussion, and compared the number of students who successfully explained each set of knowledge in the pre- and post-discussions. The knowledge C was excluded from the analysis because this knowledge was not directly related to

the explanations here and its frequency was actually very small.

In pre-discussion, nine out of ten students mentioned the Knowledge X, however no students constructed the knowledge in level 3 because they did not understand other two knowledge sets in level 1 (Knowledge A and B). On the other hand, in post-discussion, nine out of ten students mentioned all knowledge sets in level 1 and successfully constructed the highest knowledge in level 3 by integrating these three lower knowledge sets. In particular, we should note that although only one of the three students in the Jigsaw group knew one of the three knowledge sets in level 1, almost all students constructed explanations by integrating their learned knowledge and the other two knowledge sets learned by the other two partners. This implies that explanation activities were successfully facilitated using the Jigsaw method.

3.2. Process Analysis

Although we constructed four Jigsaw groups we only focus on one group as an example. This group consisted of three students: Student a who learned the Knowledge A; Student b who learned the Knowledge B; and Student c who learned Knowledge C in each Expert group, respectively. We analyzed the subjects’ verbal data.

The students in this group engaged in a discussion for one hour. In the first stage, they discussed their acquired knowledge, which had been learned in each Expert group, with each other. Next, in the second stage, they attempted to integrate three knowledge sets; however their attempts were not successful. Therefore, in the third stage, a teacher indirectly joined the students’ discussion as a facilitator. In this stage, the students constructed explanations while repeating correct explanations based on a lower level of knowledge and incorrect explanations in a higher level.

4. REFERENCES

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