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A Preliminary Study on Posing Questions during Operations for Safety Training in Chemistry Experiments

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Abstract. A classroom lecture-style of safety training is often conducted at the beginning of each semester in university chemistry experiments. However, we consider that a gap exists between such learning style and actual practice. In our previous study, we showed the effectiveness of ambiguous presentation to memorize the topic of learning. In this paper, we propose to utilize *on-site questioning about a caution in a particular operation* as a form of ambiguous presentation. A preliminary experiment showed the effectiveness of this learning style.

Key words: On-site safety training, Chemistry experiment, Learning contents, Questioning

1 Intoduction

Traditional safety training in university classes is basically conducted in a classroom lecture-style that utilizes materials such as a textbook and a video at the beginning of a semester. However, we consider that there is a gap between the lecture-style learning and actual practice. We have proposed a tangible chemistry experiment support system that helps *on-site safety training* for the beginner to avoid danger [3], in which the most important design issues is to make students independent of the system in the future. Here, the core idea is to facilitate *active thinking*, and we have shown the effect of multiple presentations or ambiguities of a message for learning [1].

By taking a hint from hazard-prediction training [2], we propose to leverage “questions” as a form of ambiguous message. People try to find answer when they are asked, which we expect to facilitate active thinking that contributes to memorize the topic related to the question. We carry out a preliminary experiment to validate the question-thinking style of learning as well as to evaluate the appropriate length of thinking time.

2 Designing Learning Contents

The proposed method facilitates “active thinking” of students during an experiment from two points of view: leveraging questioning and presenting a failed operation as an answer to the question.

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2.1 Question and Thinking Phase

In the context of our *on-site safety training*, a student participate to a training activity during an experiment to narrow the gap between the time of learning and the time of doing. A computer system poses questions to individual student through a computer display. The left part of Fig. 1 shows an example of the question presentation. The answer to a posed question and related information is then provided after a certain period of "thinking time" (Fig. 1-right).

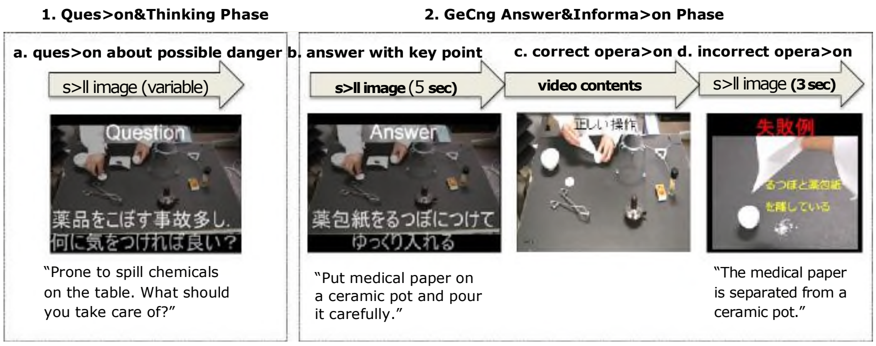

Fig. 1. The Flow of Learning Contents

2.2 Getting Answer and Caution Phase

The answer to the posed question is designed so that a student can learn the key point of a certain operation and actual correct operation. The actual correct operation may be provided as video contents (Fig. 1-c), while the key point can be simply presented a still picture with a short textual message (Fig. 1-b). Additionally, a failed operation is included to help a student to have a concrete image of "what should NOT do" (Fig. 1-d).

3 Preliminary Experiment

We conducted an experiment to evaluate the effect of *question-thinking style of learning*. In order to focus on the effectiveness of the learning style, the subjects learned safe ways of chemistry experiments by watching a video.

3.1 Methodology

The experiment consists of two phases. The first phase is intended to be a *learning period*, while the second is a *test period*. The learning period is further divided into three steps. Each subject conducts three types of simulated basic chemistry experiments in Step 1 (see Fig. 2). This step is intended to obtain safe experimental skill of each subject as a baseline. Step 2 comes every after Step 1, in which the subjects watches learning contents as shown in Fig. 1 and Fig. 2-b. During thinking time, the subjects are asked to tell the answer in words to ensure that they actually try to find the answer and the appropriateness of the duration of thinking time. As Step 3, the subjects fill out questionnaire survey to obtain subjective opinions on their experiences.

Step 4 in the second phase is carried out in one week, in which the subject conducts the same experiments as in Step 1. In both Step 1 and 4, the subjects' operational skills are assessed based on a checklist for safe experiment. The number of unsafe operations in Step 1 is subtracted by that of Step 4 to obtain the net effect of the learning contents (Step 5).

We tested with three different length of thinking time, i.e. 5, 10 and 30 seconds. The length of 10 seconds was determined based on our finding in [1] that it took about 10 seconds to comprehend message. Additionally, a control group is realized by skipping the first phase of the learning contents and by only providing the second phase contents.

a) conducting chemistry experiment b) watching the learning contents

Fig. 2. Experimental scenes: a) experimental operation (Step 1 and 4) and b) watching learning contents (Step 2)

3.2 Subjects

Thirty-two students who were majoring in science and engineering participated. They were divided into four groups, and conducted three types of chemistry experiments with different length of thinking time including the control group.

3.3 Results

The bar chart in Fig. 3 shows the relationship between the length of thinking time and the number of improved points (NIPs) in experimental operations. NIP indicates the net effect of the learning contents as proposed in Step 5. One-way ANOVA showed significant difference in NIPs against thinking time ($F(3, 73)=2.96614$, $p < 0.05$). The Dunnett multiple comparison between "N/A" and other three thinking time showed significant differences ($p < 0.05$) in 5 and 10 [sec]. The preferences on the thinking time collected in the questionnaire survey indicate that thinking time of 10 and 30 [sec] were preferred (see Fig. 3).

4 Discussion

Thinking time of 5 and 10 seconds performed effectively in acquiring the knowledge of safe experimental operations. We consider that the reason for the ineffectiveness of 30 seconds exists in the low eagerness for the answer from the system. That is, only one subject among 24 tried to find answers by the end

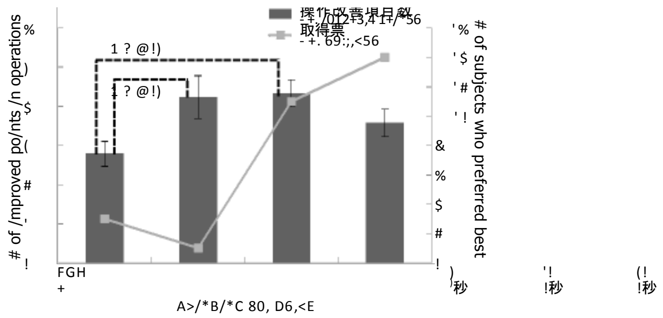

Fig. 3. The relationship between the length of thinking time and the number of improved points in operations (left axis) and the number of subjects who preferred the length best (right axis). “N/A” indicates that thinking time is not given.

of thinking time (30 [sec]), and others dropped by the wayside and looked boring. Our observation revealed that the subjects were looking forward the answer from the system, and became happy or sad when they were given the answer. We consider that providing answers from the system at the peak of their eagerness contributes to maximize the memorization of the information. Although there was significant improvement of experimental operation with 5 seconds of thinking time, the subjects did not prefer the length because they did not feel that they had reached to the conclusion of the question and thus felt frustrated.

5 Summary and Outlook

We adopted *questioning about a caution* to facilitate *active-thinking* for safety training in chemistry experiment. The findings are listed as follows:

– Learning with Q/A contributed better than learning with answer only.
– The effect of learning is not direct proportion to the length of thinking time. Too long might weaken a user’s capability of acquiring presented answers.
– Thinking time with 10 and 30 seconds were significantly effective in learning compared with answer-only style.

We will integrate the mechanism into our tangible chemistry experiment support system [3] to conduct an experiment under a real experimental condition.

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