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ABSTRACT

This article presents the development and evaluation of a Web-based lesson with multiple representations that is developed to cultivate situated learning. The quasi-experimental method along with semi-structured interviews was used to investigate the effects of a Web-based lesson on science learning at the senior high school level. Three classes of second-year students from two senior high schools in Taipei were selected as the participants for this study. The total number of participants was 110 including 49 males and 61 females. The statistical results indicated that: student conceptual progress almost reached the significant level ($t=1.98$, $p<0.051$) before and after the experiment; there were significant differences between the conceptual progress of male and female students on their conceptual progress before and after the experiment ($F=11.48$, $p<0.001$); computer logs also showed that less male students participated in the online discussion than female students did; and most students had positive opinions about this Web-based lesson. The qualitative data analysis indicated that some students thought that the Web-based lesson, named Lesson Rainbow, provided a daily-life situation could promote their motivation on learning and help them integrate knowledge. (Contains 14 references and 4 tables.) (Author)

The Use of Multiple Representations in a Web-Based and Situated Learning Environment

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Abstract

This article presents the development and evaluation of a web-based lesson with multiple representations that is developed to cultivate situated learning. The quasi-experimental method along with semi-structured interviews was used to investigate the effects of a web-based lesson on science learning at the senior high school level. Three classes of second-year students from two senior high schools in Taipei were selected as the participants for this study. The total number of participants was 110 including 49 males and 61 females. The statistical results indicated that (a) student conceptual progress almost reached the significant level ($t=1.98$, $p<0.051$) before and after the experiment, (b) there were significant differences between the conceptual progress of male and female students on their conceptual progress before and after the experiment ($F=11.48$, $p<0.001$), (c) computer logs also showed that less male students participated in the online discussion than female students did, and that (d) most students had positive opinions about this web-based lesson. The qualitative data analysis indicated that some students thought that the web-based lesson, named Lesson Rainbow, provided a daily-life situation could promote their motivation on learning and help them integrate knowledge.

Keywords: Web-Based Learning, Situated Learning, Hypermedia, Science Learning

Introduction

Many researchers have suggested that computer hypermedia and networking technology are effective tools to simulate realistic situations when a realistic situation can not be provided in a traditional classroom (Winn, 1993; Hay,1996; McLellan, 1994; The Cognition and Technology Group at Vanderbilt, 1997; Harley, 1993). If learning activities can make a connection between the real situation and its underlying theory, it is realistic to learners (Moor et al., 1994). If computer multimedia can simulate realistic situation in a meaningful way, it can make learners to immerse in and to feel it realistic. This study attempts to develop a web-based lesson according to the theory of situated learning and to examine how the Internet supports student situated learning.

Internet technology can not only integrate the advantages of traditional CAI into instruction but also provide a variety of learning environments from self-directed learning to individual learning, one-to-one interactive learning, group learning, and situational learning (Mason, 1995). With the Internet, students are able to work with current data that are much more up-to-date, and authentic than the material in textbooks. Online resources can help students make connections between their schoolwork and the concerns of people in the real world. In these ways new technologies can make learning and curriculum more generative (Wiske, 2000). Many researches have shown that web-based instructions produced positive effects on student learning motivation, scientific attitude and learning efficiency (Hsu & Thomas, in press; Krajcik, 2000; Edelson, 2001; Hoadley & Linn, 2000). Most of these researches concluded that the positive effects came from careful designs on web pages, learning materials and web managements. The benefits of web-based instructions are not reaped automatically but only come as a result of careful planning.

In this study, we chose the theory of situated learning as the theoretical base for the development of a web-based lesson, named "Lesson Rainbow". It is because most teaching contents and processes in school activities do not start from real-life situations. This produces students who can not apply their learning to solve problems in real life or work related situations. Educational reform in many countries focused primarily on lifelong learning and transfer of what students learn to real-life situations (Ministry of Education in Taiwan, 1999; National Science Education Standards, 1996). Situated learning emphases that learning occurs in real situations and the construction of knowledge is in the continuous interaction between humans and situations (Brown et al., 1989; Lave & Wenger, 1991; McLellan, 1996). This leads students to gain synthetic knowledge instead of inert knowledge. Three realistic situations can be used in class: (1) taking students to the real workplace; (2) immersing students in an authentic or similar situation; (3) providing students an anchoring context (McLellan, 1996). This study used flash animations to immerse students in an authentic situation, a trip to the northeast in Taiwan.

Goldenberg (1995) claimed that we can not expect to understand how students learn if we look only at the student's facility with one representation or student's handling of each representation in isolation. It is limited to understanding students' understanding when research is preformed only in a single-representation environment because it is hard to tell whether a particular observation is or is not merely an artifact of that representation. In a multiple representation environment, the researcher can easily discriminate between surface confusions about any one representation and true misconstructions of the concept. Multi-representational simulations embedded in a situated learning environment provide scaffoldings and context for students to explore the simulations. Some multi-representational simulations are designed in Lesson Rainbow. Through the Internet, we record student actions in detail so that we can describe a web-based environment that instantiates this approach, and we analyze formative

evaluation data to test the hypothesized mechanisms of learning. This study attempts to investigate how multiple representations support students with different learning preference on the construction of their scientific concepts, whether students with different learning character tics prefer difference functions design in the situated learning environment, and how students benefit from multi-representation simulations in a situated learning environment.

Method

This research project employed the quasi-experimental method along with semi-structured interviews to investigate the effects of a web-based lesson on science learning at the senior high school level.

Participants

The participants for this study were selected from two senior high schools (called as School A and School B) in Taipei. They were second-year students and their majors were social sciences. There were four classes who enrolled in Earth Science class at School A and two of them were randomly chosen as our participants including forty-four males and forty-two females. One of two classes who enrolled in Earth Science class at school B was selected randomly as the sample including 16 males and 30 females. Totally, the participants were 132. After excluding invalid data, the number of the valid participants was 110 (49 males and 61 females).

Instrumentation

In addition to the web-based lesson (called as Lesson Rainbow), there were three other instruments, a test, a questionnaire and a follow-up interview, that were developed to collect data on student conceptual progress and their opinions about the web-based lesson. Experts validated all instructions used in this study. The characteristics of each instrument are shown as follows:

Lesson Rainbow: McLellan (1996) suggested there are eight key components included in situated learning: stories, reflection, cognitive apprenticeship, collaboration, coaching, multiple practices, articulation of learning skills and technology. Five of these were designed in Lesson Rainbow except for cognitive apprenticeship, coaching, and articulation of leaming skills. How did we apply situated learning theory to Lesson Rainbow? The learning activities are designed with story-based animations to display situations, discipline-integrated themes to integrate the concepts of mathematics, physics, biology and earth sciences, problem-based assessments, social interaction to empower knowledge construction, and implicit hints to scaffold student learning. Associated with the design of animated tutorials(Berger et al., 1994) , we provide some analytic or problem-based questions which can guide students apply, analyze and synthesize data or information shown in the Lesson Rainbow. Animated tutorials aim to increase new concepts into students' schema so the computer program provide only guiding feedback but not correct answers. The learning tools provided in Lesson Rainbow include an electronic notebook, an equation editor, a discussion board, and an electronic map. The mapping between these components and Lesson Rainbow is shown as below (see Table 1):

Table 1: Mapping between the Components of Situated Learning and the Designs of Lesson Rainbow

Component	The mapping design of Lesson Rainbow
Stories (Story-based animations)	The animation design displays realistic situations about a story about a trip to the northeast coast in Taiwan.
Collaboration (Discussion board)	The function of asynchronous online discussion provides students with an opportunity to form a virtual learning community for collaborative learning.
Multiple practices (Animated tutorials)	The formative tests following after each unit in the story provide students multiple practices.
Reflection (An electronic notebook)	The electronic notebook that was designed as a learning tool helps students reflect and take notes on what they are learning.
Technology (Internet technology and multi-representational simulations)	Hypermedia and network technology display learning materials to students.

Test: A test was conducted to detect student understanding of the concepts related to rainbows, humidity, and condensation. There were 23 items on the test, which were validated and was examined for reliability (The Cronbachα= 0.76) before the formal experiment.

Questionnaire: A questionnaire with 34 Likert-type items was used to conduct student opinions about the design of this web-based lesson. Four dimensions in the questionnaire solicited opinions on interface design, situation design, the design of learning tools and the overall design of Lesson Rainbow. The Cronbach$\alpha$of the questionnaire was reported as 0.87.

The follow-up interviews: Semi-structured interviews were conducted to investigate student understanding of the relative concepts and to collected their opinions about the lesson. Twenty students (8 males and 12 female s) were selected for interviews based on specific purposes. Each student was interviewed for 20-30 minutes.

Procedure

This study included three stages: (1) The preparation stage (01/2000~11/2000): In this stage, the major work was to develop Lesson Rainbow and the instruments. After a pilot study, the instruments were validated and revised for the experimental stage. (2) The experimental stage (12/2000~1/2001): A pretest on the concepts was conducted in the week before the experiment. In the experiment, students received a training session for one hour and completed Lesson Rainbow in two hours. The week after the experiment, a posttest on the concepts and the questionnaire were administrated. The selected students received follow-up interviews a few weeks later because we needed time to analyze the data and determine typical cases for the interviews. (3) The data analysis stage (1/2001~5/2001): Data analysis and concluding remarks were the major jobs in this stage.

Data Analysis

The data were analyzed in several ways. In order to examine if there was a significant difference between before and after treatments, the paired t-test was used to compare the pretest and posttest scores on concepts. A mixed design of repeated ANOVA was used to test the hypotheses that stated male and female students had a significant difference before and after the experiment. We used descriptive statistics for the analysis of each item in the questionnaire and used Chi square to test if there was a significant difference among the four dimensions (the opinions on the interface designs, the design of situations, the design of learning tools and the overall design of Lesson Rainbow.) in the questionnaire. The collected data was analyzed using SPSS (Statistical Package for Social Science, version 7.0). The assumptions of normal distribution and homogeneity of variance for dependent variables were tested before applying statistic methods, t test and ANOVA. If the dependent variable did not display a normal distribution, the significant level was cut to 0.04 in order to reduce the Type I error (Stevens, 1996). Qualitative data were coded and summarized to show a deep understanding of student learning processes and perspectives using the web-based lesson, Lesson Rainbow.

Results and Discussion

It was hypothesized that there was a significant difference between student pre and post concept tests. For Lesson Rainbow, the mean for the pretest was 16.7 with a standard deviation of 2.32. In contrast, the posttest mean was 17.4 with a standard deviation of 2.45. The result of repeated t-test showed that there was nearly a significant difference (at a 0.04 significant level because of the abnormally-distributed scores of tests) between student pretest and posttests on concepts ($t = 1.98$, $p<0.051$; The data is shown in Table 2).

The pretest mean was 16.6 for male students and that for female students was 17.0. In contrast, the posttest mean for male students was 16.5 and that for female was 18.1 (The data is shown in Table 4). The result of mixed design of 2X2 ANOVA showed that there was a significant difference between male and female student performances on the pretest and posttest ($F=11.48$, $p<0.001$; The data is shown in Table 5). Few male students said that the animations in Lesson Rainbow were not as attractive as online games in interviews. Their low attention to the learning materials leaded to their low performances on the posttest. Computer logs also showed that less male students participated in the online discussion than female students did. This may reduce male students to construct their knowledge when they used Lesson Rainbow. These two reasons made male students could not learn better than female students.

Table 2: Summary Table for Paired-t test

N=110	Mean	S.D.	t Value	P
Pretest	16.7	2.32	1.98	0.051
Posttest	17.4	2.45		

$p< 0.04$

Table 3: Descriptive Statistics

	Male(N= 49)		Female(N= 61)	
	Mean	S.D.	Mean	S.D.
Pretest	16.6	2.22	17.0	2.39
Posttest	16.5	2.55	18.1	2.14

Table 4: Summary Table for Two Way ANOVA

Sources	df	SS	MS	F	Sig

Before &After(A)	1	17.01	17.01	3.22	0.075
Gender(C)	1	63.11	63.11	11.48	0.001
Interaction(A* C)	1	15.79	15.79	2.99	0.087
Residual(A* S)	108	570.20	5.28		
Residual(C* S)	108	593.60	5.50		

$p < 0.04$; $p < 0.01$

The data from interviewing the 20 students showed that most students thought the web-based lesson was more interesting than textbooks because of the animations and interactions. The online discussions made students feel more involved in the learning activities. Five of the twenty students suggested that the teacher should participate in the online discussion with them because sometimes they did not know how to solve problems without the teacher's scaffolding. A student said in his interview: " If the teacher could participate in the online discussion, it would increase the interactions and cleared confusions. I would learn better if the teacher involved in the online discussion." Different students have different needs in a web-based learning environment. Few of them need teachers' assistances because they are lack of skills on communication and reflective thinking. It is advised that the well-trained teachers involve in online communications with students in order to help weak students overcome their obstacles.

Conclusions

This study investigated the effect of a web-based lesson (Lesson Rainbow) developed to cultivate situated learning. A realistic situation served as a bridge to connect student daily-life experiences and constructing knowledge. Most students had positive opinions about Lesson Rainbow. From the interviews, some students said that the animations for the simulated authentic situations could promote their learning motivation and immerse them in an interesting context for meaningful learning.

Networked technologies supported collaborative work in which the students combined components or worked together to make successive drafts (Wiske, 2000). Social learning theory emphasized the value of dialogue and collaboration in helping students to develop and articulate their understanding. In order to reach effective cooperation, students needed to share ideas, adventure and argue with others so that they could come to reasonable interpretations of the subjects they were studying (Blumfnfeld, et al., 1997). Students can compare the varied views of a topic and enhance cohesive understanding of science from a well-designed online asynchronous discussion. In this study, Lesson Rainbow succeeded in helping students to integrate knowledge by evoking discussions to search for answers to the questions following realistic situations. When students communicate with others, they retrieve their pre-knowledge and reconstruct concepts. Meaningful learning occurs when students interact with others or environments (Savery & Duffy, 1995). Therefore, online asynchronous discussion designed for a situated learning environment can promote knowledge integration.

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