A Computer-Media Communication Assisted Chemistry Approach with Constructivist Instructions

King-Dow Su

Professor, General Education Center, De Lin Institute of Technology

Abstract

This study aims at evaluating students' learning effects and attitudes of chemistry with integrated computer-media communication (CMC). The classroom samples in this study included 89 engineering students who took chemistry courses during the academic year. The results indicated that: (a) students acquired a better understanding of targeted chemistry concepts during integrated multimedia representations, (b) students' average performance on the pretests and posttests through our chemistry course indicated a 10-point grade growth, and (c) all variants under constructivist instructions, such as F-ratio, p-values, and Cohen's effect sizes of attitudes toward chemistry and learning chemistry were detected in terms of students' gender, major, use of computer-based multimedia, and disposition toward computerization. A factual and systematic assessment was made in this study to incorporate computer-based multimedia teachings utilizing constructivist design principles to facilitate students' chemistry understanding and learning attitude.

Keywords: computer-media communication, constructivist, Cohen's effect sizes, learning attitude

建構互動式電腦媒體輔助化學教學之研究

蘇金豆

德霖學院通識教育中心 教授

摘要

本研究目的旨在評量學生對融入式電腦媒體互動之化學學習成就及學習態度之影響。研究對象為本學年選讀化學課程之工程科系學生共 89 位。

研究結果顯示:

(1) 學生在學習融入式多媒體互動教學後，對重要化學觀念的了解獲益更多。
(2) 學生的化學學習前後測成績顯示，成長10分。
(3) 應用建構式教學的F值、P值、和Cohen實驗效果等變異數來評量學生性別、主修科系、電腦使用頻率、對電腦喜歡程度等項之對化學及學習化學之態度。

本研究以實際系統評量建構互動式電腦媒體輔助化學教學，提升學生對化學的了解及學習態度。

關鍵字: 電腦媒體互動、建構、Cohen 實驗效果、學習態度

INTRODUCTION

Our computer-media communication (CMC) chemical learning environment provides university students a swift access to new information. Its reasonable application can make our teaching effective, flexible, and multiple (Dawson, Faster, & Reid, 2006). To meet our multipurpose approach, it can manifest demonstrations, uplift students' thinking levels, facilitate problem-solving, and offer learning tools to construct knowledge and promote related scientific abilities. All CMC learning environment will guide university students to have a better understanding of science concepts from visualizing abstraction into concrete images, and arriving at a generalization to promote their relations between representations (Ainsworth, 1999).

For science educators, enhancing students' understanding of science concepts and process skills rather than teaching merely the lower textual-level scientific knowledge will be a major goal for their teaching (Galili, 1996); they have explored successfully some implementations of promising in science teaching, such as integrating computer-based learning environments (Bodemer et al. , 2005; Lowe, 2003) to promote students' learning and attain this goal. All potential benefits of these innovations include improvements of scientific concepts and the process of students' attitudes toward science.

Despite a widespread belief that CMC is a powerful instructional device, it is still an open and unsolved question-- under what conditions our multimedia technology can promote students' conceptual understanding (Van der Meij & De Jong, 2006; Ardac & Akaygun, 2004)?

This study is an attempt to explore students' conceptual understanding and attitude toward science in our multimedia learning environment. Our entire constructivist environment included multimedia texts, animations, and hands-on inquiry experiences to learn more major science concepts and procedures. The following two research questions were investigated in this paper, as the priority of our whole study:

1. How can our CMC -based multimedia be incorporated and put into practice in students' constructivist communication and learning of science?

2. What process of the multimedia technology should be making to the students' understanding of science learning?

THEORETICAL BACKGROUND

Constructivist Approaches of CMC

Constructivism is a learning theory that emphasizes explanations and demonstrations as to how and why knowledge now can be acquired in their relationships between preknowledge and implanted concepts. Our function of constructivism lies in the fact that knowledge is actively constructed in the mind of learners. Constructivist theories have been widely used in CMC instructions and provided us with inspiration for advanced studies (Steffe & Gale, 1995). Driscoll (1994) presents a clear framework in her articulation of five principles of constructivist' learning, such as (1) to integrate authentic activity within a complex learning environment, (2) to emphasize the social negotiation as integral to learning, (3) to juxtapose diverse contents and include multiple modes of representation, (4) to keep instructions relevant to students' needs, and (5) to perform students' competence and practices.

The integration of CMC into science teaching validates us more knowledges about students' developments of complex ideas and positive attitudes (Windschitl & Andre, 1998; Joiner et al., 2006). All fundamental improvements were related to awareness of suitable resources, pedagogy and critique of CMC in our learning activities that students participated in (Dawson et al., 2006).

Enrichment of Learning Environments for CMC

Ainsworth (1999) pointed out that multiple representations of learning environments were ubiquitous and existed outside technological fields of our learning environments. She said that a common justification for using more than one representation was that it would capture learners' interest and, in so doing, played an important role in promoting conditions for our effective learning. Yore and Treagust (2006) suggested the real value of CMC might be in its different transformations among representations.

The number of inexpensive CMCs devices (iPods, hand-held devices, personal response systems, etc.) with rare potential instructional applications have increased drastically over the last 5-10 years. CMC applications can be classified into four major aspects: instruction, communication, resource and tool, and guide for technology improvement and multiple learning (Zhao, 1996). The use of reasonable CMC makes our scientific teaching methods more effective, flexible, and multiple. The application of CMC in the classroom enables teachers to stimulate students' learning and challenge their higher mode thinking skills.

METHODOLOGY

This study involved three pretests-posttests with case studies of follow-up questionnaire for technical college students of required, non-major, chemistry course. It was assumed that our integration of multimedia technology was crucial to college students' understanding of chemistry learning in Taiwan.

Samples

All participants of this study were undergraduate students from researcher's chemistry classes as a survey. Students (N = 89) were recruited from different departments, such as civil engineering and mechanical engineering departments with a stratified procedure to eliminate voids in our sampling frame. All characteristics of variations-- such as students' gender (male, 82%; female, 18%), majors (civil engineering, 40%; mechanical engineering, 60%), use of computer-based multimedia (negative, 20%; neutral, 56%; positive, 24%), and disposition toward computers (positive, 10%; neutral, 67%; negative, 23%) were used to define our sampling frames and potential blocking variables for our data analyses.

Tools

Our research designs consisted of four stages; namely, pretest, computer-based technology instruction, posttest, and follow-up questionnaire. Various pretests and posttests aligned with the target topic of a chemical course were developed to assess students' achievements while the questionnaire evaluated their attitudes of the course. Our tests were designed to involve computer-based analysis with category focuses: knowledge (30%), understanding (30%), and applications (40%) (Bloom et al., 1956). The pretests and posttests for the courses were considered by the staffs at the Joint Colleges Entrance Examination Center in Taiwan and three well-known professors to assess our validity and designs. The reliability of the achievement tests was analyzed by the Cronbach's alpha technique. Reliability was explored in terms of Cronbach's α coefficients to determine the internal consistency of the total questionnaire and subscales. The alpha coefficients were 0.79 and 0.80 for pretest and posttest separately.

The learning attitude questionnaire was headed and developed by the author K.D. Su (2007). The learning attitude questionnaire with Likert-type items provided five response categories, from Category 1 (strongly disagree) to Category 5 (strongly agree); each item gave plus scores. The questionnaire indicated good content validity and constructed validity and high reliability, which include the following six subscales: learning attitude toward computer-orientated courses (MA1), learning attitude toward sciences instructor (MA2), multimedia learning environment (MA3), learning attitude toward other students (MA4), learning attitude toward self-evaluations (MA5), and learning attitude toward results (MA6).

The analyses of six subscales separately yielded coefficients ranging from 0.87 to 0.93 (MA1 = 0.90, MA2 = 0.88, M A3 = 0.91, M A4 = 0.87, M A5 = 0.90, and M A6 = 0.93).

Treatments

As a selected chemistry course, our computer-based animations were made by Flash MX (Macromedia, Inc.)and demonstrations were presented in PowerPoint bulletin and e-plus software in the lecture classroom. The conceptual ideas and dynamic processes treated by Adobe Photoshop 7.01 were shown as animations.

Data Analyses

All quantitative data were listed on SPSS of Windows 10.0 software for statistical analyses. Descriptive statistics (sample sizes, means, and standard deviations) were calculated for groups of comparison, and one-way analyses of covariance (ANOVA) with significant levels set at 0.05 to test the main effects. In cases of three categories where p-values were less than or equal to 0.05, Scheffe's post hoc comparisons were conducted on some significant main effects.

RESULTS

The central purposes of this study were to establish and apply multimedia principles from the chemistry education to the redesign of chemical courses at technical colleges and to explore the differentiated effects of these multimedia courses throughout specific implementation conditions and students' learning characters (blocking variables for the data analyses). The design principles and three courses developments have been described earlier. To examine the learning effects and also differences before and after instruction in the multimedia chemistry course, students' performance was documented and analyzed-- pretest means (37.47), posttest means (47.47) and standard deviations (9.69, 9.66), and improvements in the chemistry course. The inspection of students' average performance on the pretest and posttest throughout the course indicated a 10-point grade growth. The gains corresponded to percentage improvements of 27% in the chemical solution course.

The survey of students' attitude for the six subscales indicated positive attitudes toward chemistry courses with the means response being >4 in all attitudes. The descriptive statistics means (standard deviations) for students' attitudes on the six subscales and total survey were: 4.22 (0.17), 4.15 (0.20), 4.03 (0.07), 4.08 (0.17), 4.03 (0.16), 4.14 (0.24), and 4.11 (0.33). The differential effects of the multimedia-designed chemistry courses were explored for a variety of students' learning toward chemistry. The main effects of the multimedia courses on the six attitude subscales for the six blocking variables were tested using a series of ANOVAs for the combined samples since all students had to complete the same attitude survey. Table Ⅰ provided a brief summary for the F-ratios, p-values, and effect sizes (f) of 24 ANOVAs for gender, major, using of computers, and disposition toward multimedia computers.

The ANOVAs revealed significant main effects of gender favoring males over females for attitude toward incorporated courses (MA1), attitude toward teachers (MA2), and attitude toward learning results (MA6). The effect sizes between 0.11 and 0.25 showed small and medium effects (Cohen, 1988, 1994).

The significant main effects were found for major area (mechanical or civil engineering) for attitude toward learning environment (S3). The effect size 0.21 showed medium effects.

The main effect of significant ANOVAs favoring students who used CMC-based computers was found for attitude toward incorporated courses (MA1), attitude toward teachers (MA2), and attitude toward learning results (MA6). The effect sizes between 0.11 and 0.33 showed small and medium effects. Scheffe's post hoc comparisons revealed that attitudes MA1 and MA2 students reporting 'positive' expressed more positive attitudes than those reporting 'neutral.'

Significant main effects for positive disposition toward computers were found for all attitude subscales: attitude toward incorporated courses (MA1), learning attitude toward teachers (MA2), attitude toward students (MA4), attitude toward self-evaluation (MA5), and attitude toward learning results (MA6). The effect sizes between 0.44 and 0.64 indicated high effects. Scheffe's post hoc comparisons revealed that attitudes MA1, MA2, MA4, MA5, and MA6 students reporting 'positive' expressed more positive attitudes than those reporting 'neutral' and 'negative' and that attitudes MA1and MA4, students reporting 'neutral' were more positive than those reporting 'negative.'

All of the above results implied that multimedia technology can have a facilitating function in the process of learning which helps students acquire a better understanding of targeted chemistry concepts and promotes a positive attitude toward chemistry learning. A factual and systematic assessment was made in this study. Multimedia technology provided powerful means for fostering chemical understanding because they can represent multilevel thoughts of chemistry for engineering students.

Table 1 SUMMARY OF *F*-RATIOS, *P*-VALUES, AND EFFECT SIZES (*F*) FOR EACH OF THE ANOVAS

Blocking Variable	**Analysis of Variance**	**Attitude Measure**					
		MA_1	MA_2	MA_3	MA_4	MA_5	MA_6
Gender (male, female)	*F*-ratio	6.521	4.742	0.002	2.824	2.550	6.317
	p-value	.012	.032	.967	.096	.114	.014
	f	.25	.21	.11	.14	.13	.225
Major (civil, mechanical)	*F*-ratio	.148	.047	4.905	.735	1.017	0.041
	p-value	.702	.830	.029	.394	.316	.840
	f	.10	.11	.21	.05	.11	.11
Use of computers (negative, neutral, positive)	*F*-ratio	4.588	4.174	.471	0.792	2.287	3.114
	p-value	.001	.001	.626	.456	.108	.049
	f	.33	.31	.11	.14	.23	.27
	Scheffe's post hoc	3>2	3>2				
Disposition toward multimedia (negative, neutral, positive)	*F*-ratio	17.373	10.299	2.432	8.192	9.376	13.142
	p-value	.001	.001	.094	.001	.001	.001
	f	.64	.49	.24	.44	.47	.55
	Scheffe's post hoc	1>2,1>3, 2>3 1>3	1>2,1>3		1>2, 1>3	1>2,1>3 2>3	1>2,

CONCLUSION AND IMPLICATION

Multimedia technology offers unique benefits for chemistry courses when students are learning complex and new ideas; as Ainsworth (2006, p. 183) stated perfectly, the DeFT (Design, Functions, Tasks) framework with multiple representations integrates the cognitive science of representation and constructivist theories of education into the science research on students' learning. It proposes that the effectiveness of multiple representations can best be understood by considering three fundamental aspects of learning: the design parameters that are unique to learning with multiple representations; the functions that multiple representations serve in supporting learning and the cognitive tasks that must be undertaken by learners' interacting with multiple representations.

Our CMC research can supplement other information provided by traditional means in these chemistry courses. Results of this study support a dual-coding theory, which emphasizes that information presenting the functional importance of verbal and visual inputs can enhance students' learning (Butler & Mautz, 1996). Multimedia technology plays a vital mediating role in helping students overcome many difficult and abstract concepts; and it appears to have potential benefits for integrating the classroom teaching, group study, and individual meaning making. The results of this study may support the above benefits generally attributed to constructivist teaching that posits connections between verbal stimuli and visual representations to enhance students' chemistry learning and attitude.

It is believed that our multimedia approach would stimulate more student-student and professor-student interactions in different levels of students' competence and performances.

REFERENCES

1. Ainsworth, S.E. (1999). The functions of multiple representations. *Computers and Education, 33*, 131-152.

2. Ainsworth, S.E. (2006). DeFT: A conceptual framework for considering learning with multiple representations. *Learning and Instruction, 16(*3), 183-198.

3. Ardac, D., & Akaygun, S. (2004). Effectiveness of multimedia-based instruction that emphasizes molecular representations on students' understanding of chemical change. *Journal of Research in Science Teaching, 41*, 317-337.

4. Bodemer, D., Ploetzner, R., Bruchmuller, K. & Hacker, S. (2005). Supporting learning with interactive multimedia through active integration of representations. *Instructional Science, 33,* 73-95.

5. Butler, J.B., & Mautz, R.D., Jr. (1996). Multimedia presentations and learning: A laboratory experiment. *Issues in Accounting Education, 11*(2), 259-280.

6. Cohen, J. (1988). *Statistical power analysis for the behavioral sciences* (2nd Ed). Hillsdale, NJ: Lawrence Erlbaum Associates Inc.

7. Cohen, J. (1994). The earth is round ($p < .05$). *American Psychologist, 49*(12), 997-1003.

8. Dawson, V., Forster, P., & Reid, D. (2006). Information communication technology (ICT) integration in a science education unit for preservice science teachers; students' perceptions of their ICT skills, knowledge and pedagogy. *International Journal of Science and Mathematics Education, 4*, 345-363.

9. Driscoll, M.P. (1994). *Psychology of learning for instruction.* Boston: Allyn and Bacon.

10. Galili, I. (1996). Students' conceptual change in geometrical optics. *International Journal of Science Education, 18(7)*, 847-869.

11. Joiner R., Littleton K., Chou C. & Morahan-Martin J. (2006) Gender and information communication technology. *Journal of Computer Assisted Learning, 22,* 317-319.

12. Lowe, R. K. (2003). Animation and learning: selective processing of information in dynamic graphs. *Learning and Instruction, 13,* 157-176.

13. Steffe, L.P., & Gale, J. (1995). *Constructivism in education.* Hillsdale, NJ: Lawrence Erlbaum.

14. Su, K.D. (2007). The effects of a chemistry course with integrated information communication technologies on university students' learning and attitudes. *International Journal of Science and Mathematics Education, January,*1-25. Online journal: http://dx.doi.org/10.1007/s10763-006-9062-7

15. Van der Meij, J. & De Jong,. T. (2006). Supporting students' learning with multiple representations in a dynamic simulation-based learning environment. *Learning and Instruction, 16,* 199-212.

16. Windschitl, M.A., & Andre, T. (1998). Using computer simulations to enhance conceptual change: The roles of constructivist instruction and student epistemological beliefs. *Journal of Research in Science Education*, *35*, 145-160.

17. Yore, L.D., & Treagust, D.F. (2006). Current realities and future possibilities: Language and science literacy—empowering research and informing instruction. *International Journal of Science Education, 28*, 291-314.

18. Zhao, Y. (1996). Language learning on the World Wide Web: Toward a framework of network based call. *Calico Journal, 14*(1), 37-57.