How the Redox Equation Happens: An Integration of Multimedia Technology

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ABSTRACT

The purpose of this study is to investigate the learning outcomes of using computer animations, power point bulletins, and e-Plus software as the multimedia technology teaching texts in the redox equation course. This study takes undergraduate students as samples from researcher's group present classes as incorporated objects learning attitudes. It gets the amount of 89 samples students, eliminating void samples. Various achievement pretests and posttests of conceptual problems and learning attitude questionnaire are included in this study. The results show that there are at least four academic advantages worthy to mention: (1) It was found that multimedia helps students a lot to acquire a better understanding of targeted redox chemistry concepts. (2) The learning attitude of one-way ANCOVA for the students indicated the significant differences in their variances of mastery, fondness, and genders. Scheffe's post comparison, we found that have significant difference in variants of mastery and fondness. (3) It is helpful for students to combine redox compused-animations literature, images and sounds into teaching, and to have concrete understandings from abstract chemistry course. (4) Incorporated multimedia teaching validates to be an effective redox chemical learning.

Key Words: redox equation, learning attitudes, multimedia technology, Scheffe's post comparison

多媒體科技融入氧化還原方程式探究

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摘要

本研究旨在應用電腦動畫、power point、e-Plus 軟體等多媒體技術在氧化還原方程式課程之教學。本研究選擇兩班 89 位大學生做為研究對象，研究工具包含前後測觀念問題成就測驗以及學習態度問卷量表。

研究結果有四點值得一提: (1)多媒體技術協助學生獲得許多關鍵性氧化還原化學觀念之了解；(2)單因子變異數分析顯示，學生在學習多媒體教材、喜歡多媒體教材和性別等學習態度變項中有顯著差異，進一步做 Scheffe 事後比較，發現學習多媒體教材和喜歡多媒體教材二變項有顯著差異；(3)結合氧化還原方程式平衡之動畫、影像和音效融入教學有助於學生對抽象化學的具體了解；(4)融入式的多媒體教學成為一種有效氧化還原化學學習方式。

關鍵字: 學習態度, 多媒體技術, 單因子變異數分析,Scheffe 事後比較,氧化還原方程式

INTRODUCTION

For many students, balancing redox equations is a difficult subject to master. Students learn much about chemistry, but they still do not really know what chemistry is. Various studies have confirmed students' difficulties in grasping key concepts of chemistry (Anderson, 1986; Frank, Baker and Herron, 1985). To memorize algorithms in order to pass exam is a great nightmare for undergraduates. The misunderstanding of chemical alternative conceptions and schemata is developed to hinder students' further learning (Nurrenbern & Pickering, 1987). For chemistry educators, enhancing students' understanding of chemistry process skills rather than teaching merely the chemical knowledge will be a major goal for their teaching.

Instructional materials are widely open for many learners to get in touch today. Researchers pointed out the potential benefits of integrating teaching into chemistry, such as benefits of multimedia (Yang & Andre, 2003; Ardac & Akaygun, 2004; Su, Lin & Chang, in press) and those of science history (Lin, 1998; Lin, Hang & Hang, 2002; Rodriguez & Niaz, 2002). These benefits include the effectiveness in facilitating mastery of the chemical concepts, process of chemistry, and students' learning attitude. If any positive opportunities can be found to promote students' conceptual learning, chemical teachers will adopt some special methods of integrating multimedia technology into chemistry.

Hodson (1996) supposed four important steps of the constructivist research: (1) identify students' ideas and views, (2) create opportunities for students to explore their ideas, (3) provide stimuli for students to develop, (4) support their attempts to re-think and reconstruct their ideas and views. The essence of this theory lies in "knowledge is constructed in the mind of the learners." As for constructive learning, the integration of computer-based technology into teaching helps a lot to cultivate students' learning developments (Windschitl & Andre, 1998; Thomas & Hooper, 1991).

A recent methodology proposes computer-based learning as the major contribution for students to have the basic abilities of technology and information; also at the same time, to explore the spirit of research, to do independent thinking and to fulfil career programme and life-long learning (Chang, Sung & Chen, 2001). Theoretical and empirical evidence indicates the importance of multiple symbol systems in enhancing multimedia learning. Words and pictures are two primary teaching aids available for multimedia instruction (Mayer & Anderson, 1992). Contiguity principle is a principle, which states that the effectiveness of computer-based instruction increases when words and pictures are presented contiguously in time or space. It is derived from a dual coding theory (Mayer & Sims, 1994; Mayer & Anderson, 1991; Clark & Pavio, 1991). Computer-based multimedia texts, a combination and presentation of characters, graphs, animations and sound effects, attract students' eye-sight, stimulate their learning motivations, and make an effective and better learning (Yang & Andre 2003; Sperling, Seyedmonir, Aleksic & Meadows, 2003; Mayer, 1999; Moore & Miller, 1996; Rieber, 1996; Barron & Atkins, 1994).

Critical questions about why the multimedia can promote students' conceptual understanding have been addressed by many researchers (Ardac & Akaygun, 2004; Kiboss, 2002; Schoenfeld-Tacher, Jones & Persichitte, 2001). Burke, Greenbowe & Windschitl (1998) think that when instructors take the time to emphasize the particulate nature of matter and conceptual issues through the use of computer-based animations, students' understanding and performance on conceptual exam questions increase. Yang & Andre (2003) imply that instructor-guided animations may help students acquire a better understanding of targeted chemistry concepts. While these works indicate that computer-based learning can serve as a dominant factor for students' science learning, Sperling et al., (2003) argue that regardless of inconsistent multimedia findings, authentic instructional science materials are needed to facilitate appropriate design decisions. Lin & Dwyer (2004) discuss that animations are not an effective or ineffective strategy for improving students' achievements of knowledge acquisition for objectives employed in their web-based instruction.

Recently, the advancements in computer-based technology have allowed the educators to incorporate texts, visual, and sounds resources into a profound computer-mediated programmer (Lai, 2000). Computer-based technology provides powerful means for fostering chemical understanding, because it is involved in multilevel chemistry thoughts.

For many chemical instructors (Sanger & Greenbowe, 1997; Nakhleh & Mitchell, 1993; Gabel, Sherwood & Enochs, 1984), including the present author, to teach students to apply chemistry concepts and knowledge into their lives becomes one of the most important goals in chemistry teaching. Although the goal is emphasized on teaching-education programs, it is common for students to learn fundamental chemistry courses.

Researchers have shown that chemistry teaching using computer-based technology can improve students' understanding of chemistry (Sanger, Phelps & Fienhold, 2000; Sanger, 2000; Gabel, 1993; Pickering, 1990), and help them make closed integrations between the macroscopic, microscopic, and symbolic representations used by chemists (Johnstone, 1993). Computer-based multimedia learning environments can promote constructive learning which, in turn, enables students' problem-solving abilities to be easily handled (Mayer, 1999).

With the above proposals in content, the purpose of this study is designed to investigate the effectiveness of integrating computer-based technology into redox equations chemistry teaching and to focus on students' conceptual understanding and chemical applications.

METHODOLOGY

Samples

This study takes undergraduate students as samples from researcher's group present classes as incorporated objects learning attitudes. It gets the amount of 89 samples students, eliminating void samples. Because the research object is limited to undergraduates at this school, it should be careful to make further inferences on other undergraduates.

Tools

Various achievement pretests and posttests of conceptual problems and learning attitude questionnaire are included in this study. To avoid convergence of tests and to have computer-based analysis, we focus our teaching strategies on three categories: (a) knowledge (b) understanding (c) applications. The achievement pretests and posttests are referred to the College Entrance Examination Center in Taiwan. Pretests and Posttests are composed of twenty concept questions. The contents of each test include seven knowledges, six rationalizations, and seven application questions. The reliability of achievement test is assumed from the observation in consistency exam scores of different semesters; it is a judgment of learning results for the students. This study serves as a short, simple test to identify these students between the pre-teaching and post-teaching of the environmental science courses investigating differential performances on the tests.

The learning attitude questionnaire was headed and developed by Dr. Su (in press). This questionnaire took the score of Likert-type (1932) five grades; each item gave plus scores. The questionnaire indicated good content validity and constructed validity and high reliability, which include following six aspects: (a) learning attitude toward incorporated courses (S_1) (b) learning attitude toward teachers (S_2) (c) learning environment toward multimedia (S_3) (d) attitude toward students (S_4) (e) attitude toward self-evaluations (S_5) (f) learning results (S_6). The questionnaire in our study adopted Cronbach's α coefficient (internal consistency) to testify reliability. The reliability analysis of the study showed the results in Table 1; all α coefficient of six aspects are from 0.87 up to 0.93. Compared to average pedagogical reports, this questionnaire had higher reliability than others (Katerina & Tzougraki, 2004).

Table 1. Reliability of the questionnaire

Aspect	S_1	S_2	S_3	S_4	S_5	S_6	Total
Cronbach's α	0.90	0.88	0.91	0.87	0.90	0.93	0.97

Treatments

The supplementary materials for multimedia learning environment were developed by author of this study. Computer animations figures were made by Flash MX (Macromedia, Inc.) and demonstrations or presented in power point bulletin and e-plus software in classroom. An attempt was made to emphasize the development of chemical concept for instruction. The conceptual animations were treated by Adobe Photoshop 7.01 and showed in figure 1.

Figure 1 shows the animation of balancing redox equation. It will be divided into two parts. The first part is Half-Reaction Method, such as chart (b) to (d). In this approach, the overall reaction is divided into two half-reactions, one for oxidation and one for reduction. The two half-reactions are balanced separately and then added together to give the overall balancing equation. The second part is the Oxidation-Number-Charge Method, such as chart (e) to (h). The method focuses on the atoms of the elements undergoing a change in oxidation state.

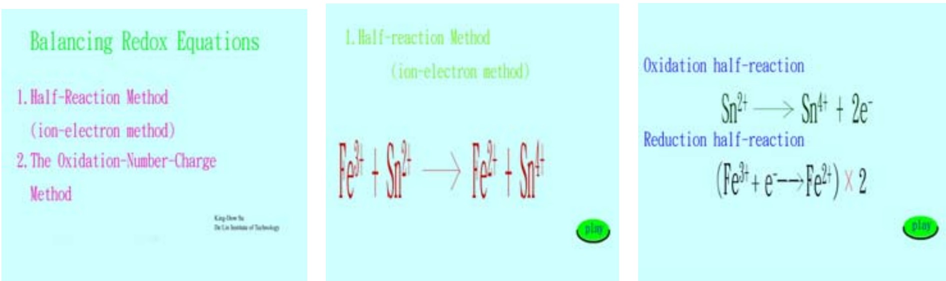
Data Managements and Analyses

All information is listed on SPSS for Windows 10.0 software statistic analysis; significant levels of each test will be 0.05 by various statistic methods, such as mean value, standard deviation, one-way ANCOVA, and Scheff's post comparison.

RESULTS AND DISCUSSION

To examine our focus -- differences before and after attending the chemistry courses, we need to check the performance of multimedia learning on the pretest and posttest achievements that the mean scores and standard deviations of this course will be antecedent 10 score -- an obvious different grade between the pretests and posttests. The students after attending science classes got average score 47.47 while the students not

(a)　(b)　(c)



(d)　(e)　(f)

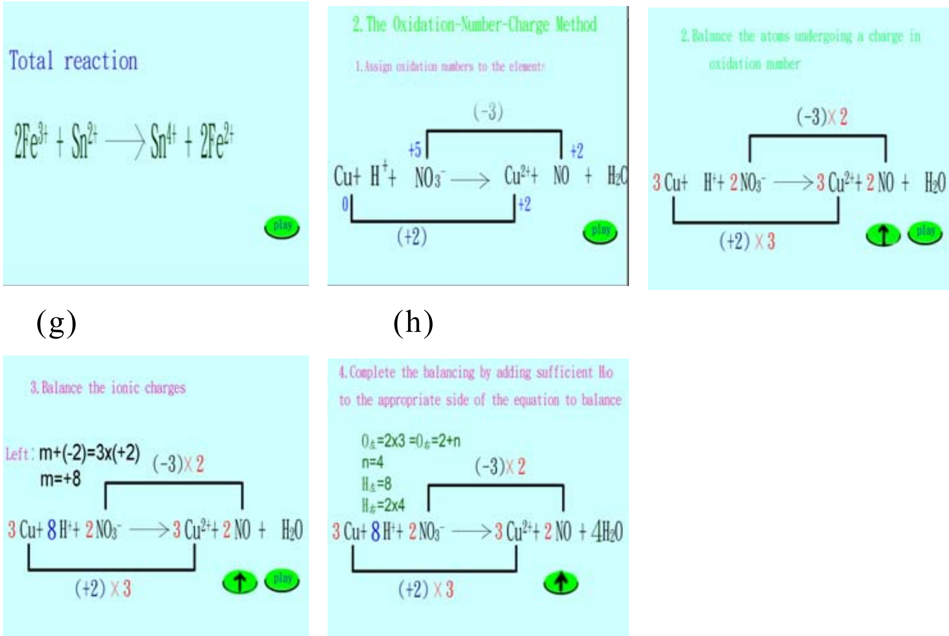


Figure1. Shows the animation of balancing redox equation from (a) to (h).

attending science classes got 37.47; the results standard deviation will be 9.66 and 9.69, respectively.

To investigate the multimedia students' attitude toward multimedia learning, a statistic one-way ANCOVA was adopted for our analysis.

Table 2 represents different students' "fondness" of learning attitude; the mean value of each aspect indicates a positive learning attitude toward multimedia technology. From Table 2 we got five aspects: students' learning attitude (S_1) ($F=17.373$, $p<0.05$), teacher's attitude (S_2) ($F=10.299$, $p<0.05$), attitude toward students (S_4) ($F=8.192$, $p<0.05$), attitude toward self-evaluation (S_5) ($F=9.376$, $p<0.05$) , and attitude toward learning results(S_6) ($F=13.142$, $p<0.05$); all have significant differences. Scheffe's post comparison has the same result of aspect S_1, $S_4$and S_6 as 1(shows very like)>2(shows like), 1>3(shows insensitive), and 2>3. Scheffe's post comparison has the same result of aspect S_2, and S_3 as 1>2, and 1>3. We can be sure that "very like" is a significant different from "like", and "insensitive" in the variants of students' fondness learning attitudes in aspects S_1, S_2, S_4, S_5 and S_6. Our conclusion will be sure that "like" is a significant different from "insensitive" in the variants of difference students' fondness learning attitudes in aspects S_1, $S_4$and S_6.

TABLE 2. ONE-WAY ANCOVA OF THE DIFFERENT LEVEL FONDNESS STUDENTS' LEARNING ATTITUDES

Aspect	Variant[a]	N	M	SD	Analysis of Variance					
					Source	df	SS	Ms	F[b]	Schef fe
S_1	1.00	9	30.56	5.08	Between	2	358.995	179.498	17.373	1>2;
	2.00	60	25.83	3.24	Groups	868	888.556	10.3327	*	1>3;
	3.00	20	23.00	1.84	within	8	1247.551			2>3
	Total	89	25.67	3.77	Groups Total					
S_2	1.00	9	20.89	4.54	Between	2	155.279	77.640		1>2;
	2.00	60	17.65	2.66	Groups	868	648.339	7.539	10.299	1>3
	3.00	20	15.90	1.86	within	8	803.618		**	
	Total	89	17.58	3.02	Groups Total					
S_3	1.00	9	11.33	3.61	Between	2	33.906	16.953	2.432	
	2.00	60	9.80	2.73	Groups	868	599.600	6.972		
	3.00	20	9.00	1.72	within	8	633.506			
	Total	89	9.78	2.68	Groups Total					
S_4	1.00	9	20.11	4.78	Between	2	131.199	65.599	8.192**	1>2;
	2.00	60	17.50	2.45	Groups	868	688.689	8.008		1>3;
	3.00	20	15.60	2.82	within	8	819.888			2>3
	Total	89	17.34	3.05	Groups Total					
S_5	1.00	9	20.67	4.61	Between	2	172.507	86.254	9.376**	1>2;
	2.00	60	17.17	2.79	Groups	868	791.133	9.199		1>3
	3.00	20	15.40	2.91	within	8	963.640			
	Total	89	17.12	3.31	Groups Total					
S_6	1.00	9	31.67	4.92	Between	2	426.576	213.288	13.142	1>2;
	2.00	60	26.32	3.60	Groups	868	1395.783	16.230	**	1>3;
	3.00	20	23.40	4.81	within	8	1822.360			2>3
	Total	89	26.20	4.55	Groups Total					

[a] 1.00 shows "very like", 2.00 shows "like", and 3.00 shows "insensitive."
[b] * shows $p<0.05$, and ** shows $p<0.01$.

Table 3 represents students' "mastery" of computer; the mean value of each aspect indicates a positive learning attitude toward multimedia technology. From Table 3 we got three aspects: students' learning attitude (S_1) ($F=4.588$, $p<0.05$), teacher's attitude (S_2) ($F=4.174$, $p<0.05$), and attitude toward learning results (S_6) ($F=3.114$, $p<0.05$) all have significant differences. Scheffe's post comparison of has the same result of aspect S_1 and S_2 as 3(shows usually)>2(shows occasionally). We can be sure that the "usually" is a significant different from "occasionally" in the variants of students' mastery learning attitudes in aspects S_1 and S_2.

TABLE 3. ONE-WAY ANCOVA OF MASTERY COMPUTER-MULTIMEDIA DIFFERENT LEVEL STUDENTS' LEARNING ATTITUDE

Aspect	Variant[a]	N	M	SD	Analysis of Variance					
					Source	df	SS	MS	F[b]	Scheffe
S_1	1.00 2.00 3.00 Total	18 50 21 89	24.89 25.08 27.76 25.67	2.49 3.46 4.67 3.76	Between Groups within Groups Total	2 86 88	120.283 1127.267 1247.551	60.142 13.108	4.588*	3>2
S_2	1.00 2.00 3.00 Total	18 50 21 89	17.00 17.12 19.19 17.58	2.09 2.72 3.84 3.02	Between Groups within Groups Total	2 86 88	71.100 732.518 803.618	35.550 8.518	4.174*	3>2
S_3	1.00 2.00 3.00 Total	18 50 21 89	10.22 9.78 9.38 9.78	2.07 2.63 3.28 2.68	Between Groups within Groups Total	2 86 88	6.862 626.643 633.506	3..431 7.287	0.471	
S_4	1.00 2.00 3.00 Total	18 50 21 89	16.72 17.30 17.95 17.34	2.35 2.95 3.77 3.05	Between Groups within Groups Total	2 86 88	14.824 805.063 819.888	7.412 9.361	0.792	
S_5	1.00 2.00 3.00 Total	18 50 21 89	16.44 16.82 18.43 17.12	2.77 3.14 3.88 3.31	Between Groups within Groups Total	2 86 88	48.647 914.967 963.640	24.337 10.639	2.287	
S_6	1.00 2.00 3.00 Total	18 50 21 89	25.17 25.70 28.29 26.20	4.05 4.28 5.12 4.55	Between Groups within Groups Total	2 86 88	123.074 1699.286 1822.360	61.537 19.759	3.114*	

[a] 1.00 shows "never", 2.00 shows "occasionally", 3.00 shows "usually."

[b] * shows $p<0.05$.

Table 4 represents different students' "genders" of learning attitude; the mean value of each aspect indicates a positive learning attitude toward multimedia technology. From Table 4 we got three aspects: students' learning attitude (S_1) ($F=6.521$, $p<0.05$), teacher's attitude (S_2) ($F=4.742$, $p<0.05$), and attitude toward learning results (S_6) ($F=6.317$, $p<0.05$) all have significant differences.

TABLE 4 One-way ANCOVA for different genders of students’ learning attitude

Aspect	Variant[a]	N	M	SD	Analysis of Variance					
					Source	df	SS	Ms	F	p
S1	1.00	73	26.14	3.87	Between	1	86.983	86.983	6.521	0.012
	2.00	16	23.56	2.33	Groups					
	Total	89	25.67	3.76	Within	87	1160.568	13.340		
					Groups					
					Total	88	1247.551			
S2	1.00	73	17.90	3.10	Between	1	41.539	41.539	4.742	0.032
	2.00	16	16.12	2.19	Groups	87	762.079	8.760		
	Total	89	17.58	3.02	within	88	803.618			
					Groups					
					Total					
S3	1.00	73	9.78	2.85	Between	1	0.01247	0.0127.	.002	0.967
	2.00	16	9.75	1.77	Groups	87	633.493	282		
	Total	89	9.78	2.68	within	88	633.506			
					Groups					
					Total					
S4	1.00	73	17.50	3.13	Between	1	25.779	25.779.	2.824	0.096
	2.00	16	16.19	2.43	Groups	87	794.109	128		
	Total	89	17.34	3.05	within	88	819.888			
					Groups					
					Total					
S5	1.00	73	17.38	3.44	Between	1	27.443	27.443	2.550	0.114
	2.00	16	15.94	2.35	Groups	87	936.198	10.761		
	Total	89	17.12	3.31	within	88	963.640			
					Groups					
					Total					
S6	1.00	73	26.75	4.65	Between	1	123.360	123.360	6.317	0.014
	2.00	16	23.69	3.07	Groups	87	1698.999	19.529		
	Total	89	26.20	4.55	within	88	1822.360			
					Groups					
					Total					

[a] 1.00 shows “boy”, and 2.00 shows “girl.”

The variants of different degrees “attendance or not” and “major” do not appear any significant impact in all aspects.

These results imply that multimedia helps students a lot to acquire a better understanding of targeted chemistry concepts, and that the aspects of learning attitude, such as students’ learning attitude, , teacher’s attitude , toward learning environment, attitude toward students, attitude toward self-evaluation, and attitude toward learning results should be a catalyst further. Variants of mastery, fondness, and genders have a significant difference in statistic analyze ($p<0.05$). We further checked the impact by Scheffe’s post comparison, which variants of mastery and fondness have a significant difference, but variants of gender not.

The fruitful result of integrating multimedia into scientific teaching in this study is encouraging and helpful. We found from previous research that the abundance multimedia materials and significant effort help students to have a better conceptual understanding of chemistry (Ardac and Akaygun, 2004; Yang and Andre, 2003; Su, in press), mathematics (Lavy and Leron, 2004), physics (Kiboss, 2002; Tao, 2004), basic computer concept (Lai, 1998 and 2000), and biochemistry (Good, 2004). This study explored the efficiency of integrating multimedia technology into scientific teaching. It was found out that this study created a significant positive contribution toward students' chemical learning attitude.

As stated above, multimedia technology plays a vital mediating role in helping students overcome many difficult conceptions, regarding the potential benefits of integrating it in scientific teaching. Despite the statistical significance of the results, readers are reminded that the samples in this case study is limited and the researchers can not implement our scope abundantly. Continuing efforts are also needed to confirm the further approach to fulfill the benefit of this teaching in the future.

CONCLUSION

From the above study, we get the following conclusions: (1) It was found that multimedia helps students a lot to acquire a better understanding of targeted chemistry concepts. (2) The learning attitude of one-way ANCOVA for the students indicated the significant differences in their variances of mastery, fondness, and genders. Scheffe's post comparison, we found that have significant difference in variants of mastery and fondness. (3) It is helpful for students to combine animations literature, images and sounds into teaching, and to have concrete understandings from abstract chemistry course. (4) Incorporated multimedia teaching validates to be an effective chemical learning.

Generally speaking, we found from this study that only by putting multimedia technology incorporation into science courses can we enhance students' learning abilities and upgrade their performance of multimedia technology.

ACKNOWLEDGEMENT

A short but sincere thank must be given to the patronage of Ministry of Education, research project No. B-91-FDE9-3, without their help our study can not be completed.

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