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Full Length Research Paper

Development and evaluation of multimedia reciprocal representation instructional materials

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In Taiwan, e-learning systems have been widely used in universities and educational institutions, but many related studies pointed out that teaching activity and strategies have not been integrated into most of the curriculum. These systems made students not to have enough motivation to learn with the e-learning and as such, it affected the learning performance. Therefore, this study focused on incorporating the multimedia technologies and reciprocal representation strategy to develop the "multimedia reciprocal representation instructional materials" through ADDIE instructional design model. This study also evaluated the learning performance, learning retention and learning satisfaction by the learning tests and questionnaire survey. The results indicated that students' learning performance can be significantly affected through multimedia reciprocal representation instructional materials. Furthermore, the materials can help the learners to quickly understand the learning content and enhance the learning retention. Students also gave positive affirmations to the materials.

Key words: Electronic learning, reciprocal representation strategy, instructional materials, multimedia technology, ADDIE model.

INTRODUCTION

Having transformed traditional learning styles and raised the interest of business communities and schools, e-learning is now regarded as an effective way to save labor and money, while enhancing learning performance (Rosenberg, 2001). However, based on computer-based instruction (CBI) studies, Kulik (1983) found that, information technology cannot completely improve learning performance; rather, instructional design and strategies have been arranged timely. Teachers must change their roles and become learning facilitators, who apply different learning strategies to design the instructional materials in different learning environments (Chen and Tsai, 2009).

In Taiwan, universities and educational institutions have widely used the e-learning system, but many related studies pointed out that most of the curriculum adopted either the traditional instruction methods or materials such as static slides or audio presentation. However, teaching activities and strategies have not been integrated, in that people also focus too much on the technology of educational issues, and as such, they are unlikely to deliver solutions of a high learning quality (Molenda, 2003). Those made students not to have enough motivation to learn through the e-learning and it affected the learning performance (Krajnc, 2009).

These are the current difficulties and bottlenecks encountered by higher education in promoting e-learning. The purpose of this study is to develop dynamic instructional materials, using appropriate combinations of multimedia technologies such as text, animated graphics, sounds and videos. This technique can attract students' attention through liveliness, thereby increasing their learning intention.

LITERATURE REVIEW

Instructional design (ID)

Teaching is the most important and most practical link in the education process. Teaching involves many

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complicated interactions between the educator and the learner. Teachers can use the instructional design to transfer learning and teaching principles to teaching activities, teaching material planning and results assessment (Smith and Ragan, 1999). To arrange for appropriate learning activities and provide learning opportunities for students, designers take into account elements of design, such as teaching goals, content, learner characteristics and learning environments. It is important that technologies are integrated pedagogically and harmoniously by using the instructional design, in order to achieve active and meaningful integration of technology in the teaching and learning process (Zimnas et al., 2009). Instructional design is an organized and systematic approach that allows the developer to save time, energy and cost (Soulier, 1988). The main objective of an ID model or process is to build a learning environment for learners with conditions that support the desired learning processes (Zimnas et al., 2009). ID models are visualized representations of an instructional design process, which can show the main elements or phases, and their relationships (Taylor, 2004).

The development of the educational content is an important domain in educational technology, especially in instructional systems design. AECT, which is a professional organization in the educational technology field in the United States, has proclaimed the five stages of instructional design that can be used to develop any learning situations and learning content, that is, the ADDIE instructional design model to include analysis, design, development, implementation and evaluation (Seels and Richey, 1994). The ADDIE model has been popularly used as a step-by-step procedural blueprint in the process of multimedia production (Molenda et al., 1996). Many researchers (Zimnas et al., 2009; Aris et al., 2006; Jaafar and Chan, 2009; Strickland et al., 2010; Wen et al., 2010) used such an approach to design, produce and evaluate the diverse projects and it proved extremely useful.

Technology integrated pedagogic

Due to the rapid development of the multimedia technology, there is an important tendency of instructional strategies towards integrating the videos, virtual classrooms, voices, e-mail and animation. “Reciprocal representation instructional strategy” is one of the applied examples. “Representation” is the use of a concept to represent a real object, or the use of some understandable and acceptable phenomena to represent some real objects or events. One of the characteristics of instructional representations is the integration of subject content knowledge and teaching methods (Shulman, 1986). When teachers select and use instructional representation, they should consider how to use it to express concepts in an appropriate manner. Thus, the theoretical basis of “reciprocal representation instructional strategy” involves Bruner’s cognitive representation theory (Bruner, 1996).

Bruner posits that knowledge acquisition involves the conversion of external objects into internal psychological events through perceptions (Bruner, 1996). That is, using experiences that students are familiar with as the basis for development, teachers can employ representations that are concrete and applicable to life, such as graphics, explanations, demonstrations, conversations, examples and other concrete instructional representations. Virtual realities, conceptual animations, symbolic representations, viewing of images, explanatory figures and other abstract representations can also be used to present materials in an appropriate way (Chen et al., 2010). This enables students to fully understand and internalize the materials, and thus, have meaningful learning experiences (Shyu, 2008). This helps learners make organized and meaningful encoding, so that the received messages can be passed to long-term memory, enhancing learning outcomes and retention. Chiu et al. (2006) once used the extended reciprocal representation instructional strategy and multimedia technologies to present the concept of convection, whereas Chen et al. (2010) used the extended reciprocal representation instructional strategy to improve course materials and to perform experimental teaching (Chen and Chen, 2006).

They found that their materials effectively improved learning motivation and reduced fear of information-related courses. Based on this viewpoint, this study focuses on how to integrate the multimedia technologies and reciprocal representation instructional strategy into instructional materials, combined with the features and advantages of e-learning, to enhance learning outcomes. Hence, this study conducts field observation and experiments to provide an in-depth understanding of how different instructional materials affect student learning performance.

RESEARCH METHODS

The ADDIE model is a basic model for designing and developing learning courses, as well as the educational content. This model is a systematic instructional design model including five stages: (1) Analysis, (2) design, (3) development, (4) implementation, and (5) evaluation. It is a general-purpose model, suitable for the participation of small sample population, and often used to study issues related to education (Taylor, 2004). Hence, this study is based on the ADDIE model, described in the following steps.

Analysis

In this stage, different variables such as learning problem, instructional objectives, learners’ needs, existing knowledge, learning environment, delivery options, and the timeline for the course are analyzed and identified (Learning Theories Knowledgebase, 2008). In this study, we used an experimental teaching to develop and evaluate the multimedia reciprocal representation instructional materials. Since this experiment required class coordination, time constraints and other appropriate

Table 1. Samples' analysis.

	Samples	Chosen	Assigned group	Following process
Trial sample	University students	Randomly (30)	Exp. group	-Trial teaching -Modify instructional materials and evaluated tools
Formal sample	Freshmen	Two classes (80)	Exp. group (41) Ctrl. group (39)	-Experimental teaching -Learning performance test -Learning retention test -Learning satisfaction

Table 2. Two groups pre-test scores.

Groups	Exp.		Ctrl.		t-value	Sig.
	Mean	Std. deviation	Mean	Std. deviation		
Pre-test	57.90	10.80	58.60	8.91	-1.921	0.062

*, **, *** Significant at $p<0.05$, $p<0.01$ and $p<0.001$, respectively.

conditions, this study selected students from the school where the researchers taught the subjects of this study. The experimental course "Computer and Information Technology Applications" was a required general education course for first-year university students. The class time for the course was two hours per week and thirty-six hours in total per semester. The class content is primarily about the basic operation and applications of the functions of Excel (an electronic spreadsheet program). The learning purpose is to help students understand statistics and data management, and then through actual practice, apply concepts in various fields, such as personnel management, financial accounting and personal finance.

Furthermore, for convenience of development and implementation, we chose the moodle platform as the learning device. Moodle is a free learning and course management system, which was created by Martin Dougiamas. It is an acronym derived from "modular object-oriented dynamic learning environment". Moodle can freely use and modify program codes, and it adopts the web-based application system designed and developed by PHP. Through a browser, Moodle can easily manage users and construct curriculum and a variety of teaching activities (Moodle.org, 2010). In addition to providing simple setup functions for e-learning courses, Moodle also has a module for teacher-student interactions; for example, uploading or sharing teaching resources, contact channels and course calendars. Students' views and opinions are collected and their learning histories are recorded in detail, all of which are helpful for teachers to understand students' learning situations to increase their teaching quality.

Design

Learning objectives are specified and other issues such as instructional strategies and design, graphic design, user-interface and content are determined in this phase (Learning Theories Knowledgebase, 2008). This study's samples are divided into two types: trial and formal samples as shown in Table 1. For the formal test, this study arbitrarily assigns one of the two classes as the experimental group and the other as the control group. The experimental group (41 people) was taught with multimedia reciprocal representation instructional materials, whereas the control group (39 people) was taught with general textbooks for experimental teaching and the groups were given in the learning outcome tests (for example, post-tests and learning retention tests).

To minimize errors of the teaching experiments and enhance the internal validity of this study, the control variables for the two groups were the same during the research period. The control variables included the same instructor, course scope, assignments, evaluation tools and students' cognitive abilities in using the Excel software.

Development

In this stage, the actual content and teaching-learning materials are produced or developed (Learning Theories Knowledgebase, 2008). The teaching material of the experimental group was designed using the reciprocal representation teaching strategies. Also, the characteristics of information technology and diversified performances of multimedia, combined with familiar life experiences, were used to design the materials. Teachers also used teaching materials with concrete information (for example, viewing animations, picture cards and live-action videos), illustration of examples, explanations for displays, student operations, teacher demonstrations and other concrete teaching representations. Depending on students' needs, teachers can use abstract and concrete teaching representations alternately and supportively and supplement them with diverse information technology materials to enhance the learning outcomes.

In recent years, Taiwan's IT education has gradually taken root in primary and secondary schools. Nevertheless, to exclude the factor of digital divide, the two groups of students were required to take pre-tests in the first week of the school to understand their cognitive ability for the experimental course. The pre-test questions were collected from the Taiwan Ministry of Education's "College Students' Office Automation Software Application Level". Of special interest, are the parts that relate to Excel. Table 2 shows the statistical processing results. This study used Levene's test to conduct the homogeneity of variance. The Levene's tests showed that before the teaching experiment, regarding the learning pre-test, the average score of the experimental group was 57.90 and the average score of the control group was 58.60. These differences were not significant ($F=1.96$, $p=0.169>0.05$), indicating that the

discrete distributions of the samples of both groups did not have obvious differences. The t value and the significance level (t=-1.92, p=0.062>0.05) showed that the testing results did not reach a significant level, indicating that before the experiments, the two groups' initial cognitive abilities in Excel software were the same.

Implementation

In this phase, the plan or scenario, which is designed and developed in prior phases is implemented (Learning Theories Knowledgebase, 2008). The training materials are distributed to the learners through module platform. At the same time, we have the experimental teaching process.

Trial test of experimental teaching activities

This study integrated multimedia technologies and reciprocal representation strategy to design instructional materials and carry out a trial test of experimental teaching. After the trial test, the researchers interviewed the students and investigated their testimonies and opinions. The design of the teaching material content and teaching activities was then revised to attain perfection of the formal experimental teaching.

The experimental teaching phase

The formal experimental teaching time in this study was 8 weeks for a total of 16 classes. The content of the experimental course was about the introduction and application of Excel functions, in that the nature of the course involved software operation. Therefore, for the experimental teaching activity design of the control group, the teacher demonstrated the operating steps by static slides, asked the students' hand in assignments and take tests on the class within an appropriate timeframe. For the experimental group, through the module platform and the multimedia reciprocal representation materials, the teacher, first explains the topics in conjunction with a dynamic PowerPoint presentation that made connections with students' life experiences and kept students' attention, and then, students could repeatedly watch the software operation process through the pre-recorded video file. In this video file, in addition to the operation process images and voice explanations, low learning outcomes are caused by long-term viewing of texts. Finally, students could hand in assignments and take learning outcome tests through the online testing system. This group of students could learn in and outside the class, and repeatedly do exercises through the teaching platform.

EVALUATION

In this phase, the effectiveness of the training materials is evaluated. There are two tests and one questionnaire survey for evaluating students' learning performance, learning retention and satisfaction.

The learning performance test

After the experimental teaching, both groups of students adopted the learning performance test. The testing time was 50 min. This implementation was used to reveal the students' differences in learning performance. The researcher compiled the "Learning Performance Test of Computer and Information Technology Applications-Excel Function Unit" based on students' learning progress and how well students absorb the materials. Three university instructors with practical teaching experience in the related field were invited to provide proper guidance for the design of the test structure and the test content to establish expert validity for the learning outcome test. There were 20 questions in total. For the scale's reliability, Cronbach's α coefficient was used to test all the major construct variables to evaluate the internal consistency and reliability of the questionnaire items. The reliability of the entire scale is 0.81. Thus, the reliability of the questionnaire surveys is quite good. Before the two groups of students received the experimental teaching, the learning pre-test examined with the independent sample t test did not reach a significant level of difference, which indicated that the two groups of students' learning performance had the same initial cognitive abilities in Excel software. Cushner (2003) suggested that if the two groups' pre-tests have no difference, then the analysis of covariance can be used to increase its testing power.

Therefore, the one-way analysis of variance (abbreviated one-way ANOVA) was used. One-way ANOVA is a technique used to compare the mean of two or more samples by using the F distribution (Howell, 2001). Before conducting the one way ANOVA, the two groups' homogeneity within the regression in the "learning performance test of the Excel function unit" must be examined. The results of the regression homogeneity for the learning test (Table 3) do not reach a level of significance (F=1.05, p=0.312>0.05), which indicate that the slopes of the regression lines between the two groups are the same, agreeing to the hypothesis of homogeneity within the regression in the analysis of covariance. Therefore, the analysis of covariance can be conducted continually. In the one way ANOVA, the teaching method was the independent variable, the learning pre-test score was the covariance and the learning performance test score was the dependent variable. In Table 4, after the two groups of students received different teaching methods, the experimental group had a higher adjusted mean in the learning test than the control group (82.53 > 69.79).

Based on Table 5, excluding the effect of covariance (learning pre-test) on dependent variables (learning performance test), the experimental processing effect of the independent variable (teaching materials) on the dependent variable reached significance (F=56.87, p=0.000<0.05), which indicated that because of the different teaching materials, the two groups of students' learning performances differed and thus, obvious differences existed between them.

The learning retention test

Three weeks later, without informing the students to have

Table 3. Homogeneity within regression in the learning performance test.

Source	SS	Df	Mean square	F	Sig.
Materials	126.84	1	126.84	4.75	0.036
Covariance (pre-test)	2780.29	1	2780.29	104.71	0.000
Between groups	28.03	1	28.03	1.05	0.312
Error	960.83	36	26.69		
Corrected total	7647.10	39			

R Squared=0.87(Adjusted R squared=0.86); *, **, *** Significant at p<0.05, p<0.01 and p<0.001, respectively.

Table 4. Descriptive statistics of learning performance test.

Group	Mean	Std. deviation	Adjusted mean	Std. error
Exp. (41)	85.30	11.03	82.53	1.72
Ctrl. (39)	66.40	9.63	69.79	1.54

Table 5. ANOVA of learning performance test.

Source	SS	Df	Mean square	F	Sig.
Within groups	3086.14	1	3086.14	115.47	0.000***
Between groups	1519.97	1	1519.97	56.87	0.000***
Error	988.86	37	26.73		
Corrected total	7647.10	39			

*, **, *** Significant at p<0.05, p<0.01 and p<0.001, respectively.

Table 6. Homogeneity within regression in the learning retention test.

Source	SS	df	Mean square	F	Sig.
Materials	54.36	1	54.36	0.691	0.412
Covariance (Learning performance test)	1871.97	1	1871.97	23.78	0.000
Between groups	175.57	1	175.57	2.23	0.144
Error	660.62	36	18.35		
Corrected total	6165.50	39			

R Squared=0.54(Adjusted R Squared=0.50); *, **, *** Significant at p<0.05, p<0.01 and p<0.001, respectively.

reviews in advance, the two groups of students had the test to compare the students' performance in the learning retention tests. This test was adapted based on the aforementioned "learning performance test". Both tests used the same questions, but the numbering and ordering were different to prevent the answers from being influenced due to repeated exercises. First, we examined the two groups' homogeneity within the regression in the learning retention test and the results of the regression's homogeneity did not reach a level of significance (F=2.230, p=0.144>0.05) as shown in Table 6.

Therefore, the analysis of covariance can be conducted continually. Table 7 showed that the experimental group had a higher adjusted mean in the learning retention test than the control group (80.65 > 58.24). In Table 8, excluding the impact of covariance (learning performance test) on the dependent variable (learning retention), the experimental processing effect of the independent variable (teaching materials) on the dependent variable reached a level of significance (F=18.526, p=.000<.05), which indicated that due to different teaching materials, the two groups of students have obvious differences in

Table 7. Descriptive statistics of learning retention test.

Group	Mean	Std. deviation	Adjusted mean	Std. error
Exp.(41)	77.70	14.37	80.65	2.24
Ctrl. (39)	59.80	8.99	58.24	1.18

Table 8. ANOVA of learning performance test.

Source	SS	df	MS	F	Sig.
Within groups	2531.75	1	2531.75	31.13	0.000***
Between groups	1506.92	1	1506.92	18.26	0.000***
Error	3009.65	37	81.34		
Corrected total	6165.50	39			

R Squared=0.54 (Adjusted R Squared=0.50); *, **, *** Significant at $p<0.05$, $p<0.01$, and $p<0.001$, respectively.

their performances of learning retention.

Analysis of the e-learning satisfaction survey

This study modified and adopted the "e-learning quality satisfaction regulation standards" proposed to effectively measure the satisfaction levels of students who used the multimedia reciprocal representation materials. The proposal was based on the National Science and Technology Program for e-Learning promoted by the Ministry of Economic Affairs of the Industrial Development Bureau. The "e-learning quality satisfaction regulation standards", used in this study, consist of four constructs: "material contents", "learning guidance," "material design," and "media quality". Specifically, "material contents" measure the sufficient accuracy of materials, appropriately organized and clearly expressed to allow students learn the expected knowledge and skills. "Learning guidance" measures the guidance of carrying out e-learning activities in a smooth manner, that is, it includes the learning progress control mechanism, the guidance of learning progress, and learning tracking. "Material design" measures the clear learning goals of materials, appropriate instructional presentations, appropriate use of learning strategies to promote understanding in learning, excellent learning interactions, and proper evaluation and feedback. "Media quality" measures the appropriate learning interface design of materials, effective applications of instructional media, and high quality instructional media productions. There are 36 questions in total. Each of the questionnaire survey items adopted the five-point Likert scale, with a score range from +5 (Strongly agree) to +1 (Strongly disagree). For the scale's reliability, the nine questions for "material contents", "learning guidance", "material design" and "media quality" had a reliability of 0.84, 0.72, 0.79 and 0.86, respectively. However, the reliability of the entire scale is 0.89. Thus, the reliability of the questionnaire surveys is quite good. To confirm the validity, the authors of this study invited several scholars, whose fields' study were related to learning, to provide suggestions and give appropriate modifications and corrections, and integrate relevant questions and content to establish the validity of the questionnaire survey scale.

Table 9 shows the four constructs of the e-Learning satisfaction survey. The values of the mean are between 3.44 and 3.92, and the standard deviations are between 1.12 and 1.04, indicating that students generally have a positive attitude towards the learning situations of the experimental teaching. Based on the results in Table 9, most students generally consider that the use of instructional materials were suitable for their own circumstances. Overall, a high proportion of users showed the positive influences of the material design.

CONCLUSIONS AND DISCUSSION

Learning performance analysis of the two groups

Students in the experimental group received the multimedia reciprocal representation materials training, whereby their performance in learning performance tests was better than the performance of students in the control group. While integrating information technology into the teaching model, this study used a complementary set of teaching strategies, which was indicated to be helpful for students' learning about lessons related to "Excel function unit". As Hong et al. (2000) found out in their study that when teachers use computer information technology to assist their teaching, teachers must realize that information technology is only a teaching assistant tool. Appropriate teaching materials which are integrated

Table 9. Testing results of the e-Learning satisfaction survey's content.

Evaluation of the question items	Mean	Std. deviation
Material contents	3.44	1.12
Learning guidance	3.77	1.11
Materials design	3.56	1.09
Media quality	3.92	1.04

Table 10. The combined effects of media presentation on learners' performance.

Researchers	Object and subject	Media presentation	Findings
Kalyuga (2000)	Object: Machine micro-drilling process Subject: Technicians	1. Picture and text 2. Picture and sound 3. Picture, text and sound 4. Picture	For unexperienced learners, group 2 performed better than other groups but group 4 is suited for experienced learners.
Kuo and Chou(2003)	Object: Astronomy Subject: College students	1. Text and sound 2. Text, picture and sound 3. Text, video and sound	Group 3 performed better than other groups.
Chou (2007)	Object: Journalism Subject: College students	1. Text 2. Text and picture 3. Text, sound and video 4. Video and sound	Group 3 performed better than other groups
Chen and Wu (2009)	Object: Meteorology Subject: College students	1. Video and text 2. Video, text and sound 3. Video and sound	Group 3 performed better than other groups

with instructional strategy must be selected to enhance the learning outcomes and increase students' understanding.

Analysis of the effect of learning retention

Based on the results of the study, the students in the experimental group had better learning retention performance than the control group students. That is, the implementation of multimedia reciprocal representation materials was much more helpful for enhancing the understanding and memory of the learning content. Nonetheless, the learning retention was much more desirable as well.

As multimedia becomes a general instructional tool, researchers found that more than one modality (that is, visual and auditory) are better than one modality (visual) in any instructional message (Table 10), but according to Kalyuga (2000) who pointed out that human cognitive capacity is limited, concise and impressive source of information might be beneficial for learning. This study used the PowerPoint files to connect with students' life experiences and kept students' attention, with a pre-recorded video to tutor the software operation process. We also added well-timed voice explanations, annotations of texts and animations to let students understand and transfer the materials, thereby avoiding the low learning outcomes caused by long-term viewing of texts.

Analysis of e-learning satisfaction

Based on the results of the study, students had positive attitude towards the learning situations of the experimental teaching. In particular, the satisfaction level of "media quality" and "learning guidance" was higher. For satisfaction analysis of this experimental teaching, four constructs are used for evaluations. The overall mean and standard deviations of the four constructs, ordered from high to low, are "media quality", "learning guidance," "material design" and "material contents", respectively. In other words, students give positive

affirmations to experimental teaching materials, where multimedia assistant tools, such as animation films and audio files, are timely introduced to effectively increase students' interests and willingness for learning. Appropriate learning guidance is provided so that students can easily be involved in learning through the materials.

This study considers that today's information technology can develop different types of materials, which teachers should take a good advantage of, and by considering the teaching circumstances and students' prior knowledge, teachers should select and present representation forms that are suitable for students to learn, absorb and achieve individualized instructions. Moreover, with appropriate teaching materials, teachers can enrich the course content and are more close to life to increase the teaching effects and help students learn in a meaningful way.

IMPLICATIONS

The implementation of multimedia reciprocal representation materials can effectively enhance learning performance and retention. Introducing multimedia assistant tools in an appropriate time can enhance learning interests and willingness. Also, the presentation of reciprocal representations can enable students have an in-depth understanding of a course and extend the effect of learning retention. Besides integrating technology into teaching, an appropriate teaching strategy design is required. The results of this study echo the viewpoint of Wang and Reeves (2007), who pointed out that through diversified instructional methods and instructional design, the perspective, that information technology is a cognitive tool for learning corresponds more with the practice of modern education technology theories.

Without the appropriate integration of instructional design, e-learning that merely demonstrates the capacity of technology or the novelty of technology can only sustain learning for a short time. Information technology should be appropriately adjusted and transformed for teaching materials, methods and strategies (Rovai et al., 2007). Therefore, in consideration of learning performance, one must start with instructional design and combine it with information technology to help learners achieve their learning goals in a fast and effective way.

SUGGESTIONS

Promoting information technology integration with complementary teaching strategies

This study shows that integrating information technology into teaching and complementing it with appropriate teaching materials results in great learning outcomes. Information technology is a good learning assistant tool. In teaching, these tools must be integrated in each subject teaching activities. Also, through multimedia reciprocal representation materials, teachers' guidance and students' self-study can make learning more diversified, adaptive and individualized.

This, in turn, enhances student's learning outcomes and promotes their interest in learning. Therefore, the study suggests that interested teachers should try to integrate information technology in various fields of teaching, and promote and develop various IT integration teaching materials. This will help increase students' learning outcomes and motivations.

Using concrete teaching representations of computer aided instruction (CAI)

The multimedia reciprocal representation materials introduce multimedia static and dynamic reciprocal representations such as texts, pictures, sounds, images, animations, after-class exercises, interactive buttons, and other diverse and interactive teaching representations. This creates a diverse learning situation and lively teaching atmosphere (Mayer and Moreno, 2003). Hence, the researcher suggests that when integrating information technology in teaching, instructional designers should bring in diverse teaching representations to enhance the learning performance and interests of their students.

FUTURE RESEARCHES

Expand sample representative and course attributes for future related researches

Considering the administrative cooperation and implementation time, only two classes (in the same course) of freshmen in a technology university in southern Taiwan were chosen for the teaching experiment. Therefore, the inferences of this research are limited. In the future, the subjects of the research can be extended to more schools or wider fields, and can analyze and compare students in different age groups to enrich the results.

Providing quality interview data for analyzing the results of the study

This study used quality analysis to analyze the research results, but could not completely grasp and understand the learning situation of the subjects. Also, some variables, such as students' learning cognitive abilities and attitudes, can easily be influenced by the learning environment and time. Since it is impossible to control all

possible factors that influence these variables, this study can be complemented by a qualitative research, including student observations, interviews and recordings, to obtain more detailed and accurate explanations of the results.

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