Screen-capturing System with Two-layer Display for PowerPoint Presentation to Enhance Classroom Education

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ABSTRACT

This paper proposes a new presentation system integrating a Microsoft PowerPoint presentation in a two-layer method, called the TL system, to promote learning in a physical classroom. With the TL system, teachers can readily control hints or annotations as a way of making them visible or invisible to students so as to reduce information load. In addition, the system can synchronize a teacher’s lecturing actions for a PowerPoint presentation with his/her voice and also create web-based multimedia materials. By reviewing these multimedia materials, students can recall the problem-solving skills the teacher taught them in class. In this study, an exploratory test was carried out with 12 teachers and 91 students in a college of technology. Research data were collected through the instructional technology use questionnaire (ITUQ) for teachers as well as through the course attitudes scale (CAS) and the mathematics achievement test (MAT) for students. The results revealed that the TL system helps teachers to have a smooth teaching process of presenting teaching materials. The students in the experimental group had a better course attitude and achieved higher MAT scores than did those in the conventional group.

Keywords

Classroom learning, Media in education, Multimedia, PowerPoint presentation

Introduction

In traditional classrooms, teachers write learning content on a blackboard at the front of the classroom. What the teacher writes on the blackboard has an exemplary effect on the learners (Havens, 1989; Zhang & Deng, 2005). It is a real-time and flexible process of transferring the knowledge of the learning content from the teacher to the students (Lightfoot, 2005). One advantage of this method is that students can pay more attention to enhance their classroom experiences (Zhang & Deng, 2005). In the traditional classrooms, teachers write the problem-solving procedure on a blackboard in a step-by-step fashion. This allows teachers to emphasize abstract concepts such as switches and branch points in a flexible manner during the instruction. It allows students to feel the subtle rhythms in the teacher’s teaching, and makes it easier for students to comprehend and understand the mathematics learning content (Havens, 1989).

In the teaching process, one drawback of using blackboard writing is the fact that presenting the materials is time-consuming. This is especially true when the teacher’s back obscures a portion of what is written on the blackboard, which increases the level of restiveness in the class. Also, using a backboard this way limits the way of presenting teaching materials. For example, writing on a blackboard provides an inflexible presentation with few colors and styles, as well as difficulties in displaying pictures or multimedia content. Another disadvantage of using a blackboard is that the materials cannot be stored, reused, reproduced, or interchanged. Consequently, students have to make notes or copy the material from the blackboard, all of which is inconvenient (Apperson, Laws, & Scepansky, 2008). This results in an increased external cognitive load and splits the student’s attention. Blackboard writing is limited by the fact that the writing differs from teacher to teacher. In addition, a large amount of chalk dust is produced when using a blackboard.

Recently, many teachers have started to use technological tools to create teaching materials in multimedia formats. It is helpful to effectively scaffold learners (Lai, Tsai, & Yu, 2009; Lightfoot, 2005). However, it is not easy to use technological skills for creating multimedia teaching material. A popular lecturing method is to directly project Microsoft PowerPoint slides from a computer onto a screen (Rankin & Hoaas, 2001). Many studies have indicated that college instructors accompany their lectures with PowerPoint presentations so that their lectures will have a positive effect on their students’ attitude and belief of self-efficacy (Rankin & Hoaas, 2001; Susskind, 2008). Students attending classes where the teacher used PowerPoint believed that the lectures were more organized, clear, and interesting. The PowerPoint presentation can overcome the limits and the disadvantages mentioned for using a blackboard. This is due to the following. First, lecturing using PowerPoint presentation can save writing time in class...
because the PowerPoint slides are prepared beforehand. As a result, teachers have more time to interact with their students and effectively proceed to instructional activities. Second, while using PowerPoint presentations, teachers face students and not the blackboard. Thus, the teacher’s back will not obscure the student’s sight. Third, PowerPoint slides can be quickly stored, reused, reproduced, and interchanged. The contents of PowerPoint slides can be produced in various formats such as texts, tables, pictures, graphs, sounds, visual data, video clips, and so on. Lecturing with PowerPoint presentation can be used to provide important outlines, key terms or phrases, different background formatting, and various formats of annotation (Apperson, Laws, & Scepansky, 2008). Unlike with blackboard writing, teachers can present integrated multimedia instructions, including media format selection, and have random access to multimedia instruction (Corbeil, 2007). At the same time, teachers can easily convert PowerPoint content to multimedia formats. Finally, lecturing using PowerPoint presentations can enhance the lecturer’s ability to order and pace his/her lecture and present a clear summary (Lowry, 1999). This is because lecturers can easily control the lecture content and display the sequences when using PowerPoint slides.

However, PowerPoint presentations still have some potential limits. Each slide in the PowerPoint format contains only a small amount of information. In addition, a PowerPoint presentation is similar to a bullet-style presentation and is only suitable for a low level of information transfer (Tufte, 2003). Lecturing using PowerPoint results in a weak analysis of the learning content (Gabriel, 2008; Zhang, Zhao, & Nunamaker, 2004). In addition, when students review the PowerPoint material before or after class, the review is not effective because the material contains only key terms and pictures, but is not accompanied by the teacher’s action and voice. One solution to overcome the above problems is to adopt screen-capturing software that can create a video file of the teacher’s voice and the entire PowerPoint presentation. The most widely used software applications include Camtasia Studio, PowerCam, Articulate Presenter, etc. Any teacher can easily produce the video learning materials for a cyber classroom (Chen & Wang, 2008), and it provides students with more learning opportunities.

At present, teachers use screen-capturing software for delivering multimedia teaching contents via the Internet. However, these software applications lack one important function. In the TL system, a teacher, when lecturing, can see some of the teaching materials while those same materials are invisible to the students. From the student’s point of view, this function is helpful to reduce the extraneous cognitive load because all learning content will not appear at once, and those materials that do not need to appear do not. From a teacher’s point of view, this function is helpful to reduce tension for the student because the teacher can see the hints and annotations while teaching even though they remain invisible to students. In addition, this function can make the lecturing smoother, because the teacher can use the auxiliary descriptions or notes as reminders. At present, teachers can make speaking notes and reminders in the Note Page View for the PowerPoint slides. Unfortunately, these notes are only written in a text box using a simple text format. The limitations of using Note Page View are that the text box is locked at a fixed position in the PowerPoint slide and speaking notes cannot be made during a presentation.

This paper proposes a screen-capturing system with a two-layer display for PowerPoint presentations, called the TL system. The summarization of this study is threefold: (a) develop the TL system to record the slide content and any lecturing notes of the teacher in his/her handwriting and voice, and then upload the recorded files to the LMS; (b) examine whether the TL system is helpful to teachers during instruction in class; and (c) investigate whether there are any differences in the learning effects of the students between using PowerPoint and the TL system.

The rest of this paper is organized as follows. First, we present a literature review and the learning environment involving the TL system. Next, we compare the features of the TL system with those of other developed recording tools and discuss the experimental results. Finally, we present our concluding remarks.

### Literature review

#### Instructional design with cognitive theory

Multimedia instruction presents multiple materials that are intended to foster learning, including speech, printed text, static graphic, animation, and video (Moreno & Mayer, 2007). The cognitive theory of multimedia learning provides empirical guidelines to promote instructional design so as to achieve meaningful learning (Mayer, 2001). The theory is based on the assumptions of dual channel, limited capacity, and active processing (Moreno & Mayer, 2000). Cognitive load is related to human information-processing capacity (Guttmersen, Schär, & Zimmermann, 2007). When students control the information flow, they can chunk the information in a meaningful way, according to their
own processing pace (Guttormsen, Schär, & Zimmermann, 2007; Leahy & Sweller, 2008). According to the
cognitive theory of multimedia learning, Moreno and Mayer (2000) presented seven principles (multimedia
principle, spatial contiguity principle, temporal contiguity principle, coherence principle, modality principle,
redundancy principle, and individual differences principle) for instructional design.

**PowerPoint presentation in instruction**

Humans can simultaneously process information coming from auditory stimulus and visual stimulus (Moreno &
Mayer, 2000). Recently, face-to-face lectures have been delivered using presentation software such as Microsoft
PowerPoint. Using PowerPoint to present multimedia materials in class benefits students (Apperson, Laws, &
Scepansky, 2008). PowerPoint slides contain various multimedia formats such as text, chart, graph, sound, and
video. The way of lecturing with PowerPoint can provide students with a brief description for teaching sequence and
organization of the learning contents. This teaching manner contributes to students’ further constructing learning
that there are five principles of instructional design to help reduce extraneous cognitive load in PowerPoint: writing a
clear headline that explains the main idea of every slide, breaking up the story into digestible bites in the slide sorter
view, reducing visual load such as moving text off-screen and narrating the content, using words with visuals instead
of words alone, and rigorously removing every element that does not support the main idea.

**Instructional environment and implementation**

**Instructional environment**

Teachers can use the TL system to construct a new instructional environment with dual-channel display for
classroom learning. Figure 1 depicts the pictorial structure of the new instructional environment, which, in general,
consists of a PC (notebook or tablet PC), two (or one) projectors, a projection screen, and the TL system. The
environment can help teachers to have more flexible and useful presentations, especially when using PowerPoint.

![Figure 1. The structure of the instructional environment](image)

**System design and structure**

The TL system records the multimedia version of teaching materials during instruction process. The materials
include slide content accompanied by the teacher’s voice and all tracks left on the slides (note that the tracks
probably consist of teacher’s handwriting, the cursor’s movement, and the display and manipulation of learning
objects). Therefore, students can review the lectures by studying the multimedia teaching materials after class.
The main feature of the TL system, which differs from other existing systems, as shown in Table 1, is that some auxiliary materials or hints are visible to teachers but invisible to students. The feature is devised by using a two-layer display technique (Aboelsaadat & Balakrishnan, 2004), as shown in Figure 2. The two-layer display consists of the presentation layer and the script layer. The presentation layer includes the display items, which are teaching objects visible to teachers and students, and possibly contains texts, images, sounds, and movies. The script layer includes the hint items, which are auxiliary semi-transparent objects for teachers that are invisible to students, and possibly contains guidelines and scripts. When the teacher needs to display these invisible objects in the script layer, the teacher moves them to the presentation layer. A case of displaying method is that teacher can draw the invisible scripts of the script layer on the presentation layer. The aim of using the two-layer display is to help the teacher to have teaching guidelines while lecturing. Moreover, the teacher uses the feature in lecturing to make the teaching process go more smoothly and to reduce the teacher’s anxiety. It also reduces students’ extraneous cognitive load because not all of the content in a slide will appear (Mayer & Moreno, 2003).

![Figure 2. The two-layer displaying technique](image)

**Table 1. Comparison of screen-capturing software**

<table>
<thead>
<tr>
<th>Items</th>
<th>Tools</th>
<th>Screen-capturing software</th>
</tr>
</thead>
<tbody>
<tr>
<td>Recording method</td>
<td>Articulate Presenter</td>
<td>PowerPoint recording</td>
</tr>
<tr>
<td>Supports post-production</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Records voice, monitors, and cursor tracks synchronously</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Materials index with slide</td>
<td>No</td>
<td>Medium (Post-production)</td>
</tr>
<tr>
<td>Summarizes theme of slides in table for indexing</td>
<td>Manual</td>
<td>Medium (semiautomatic)</td>
</tr>
<tr>
<td>Selects monitor dpi freely</td>
<td>Multi-selection</td>
<td>Multi-selection</td>
</tr>
<tr>
<td>Support two-layer display mechanism</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Supports multi-monitor recording and displaying</td>
<td>No</td>
<td>No</td>
</tr>
</tbody>
</table>

Figure 3 shows the five principle components of the TL system: project, layer, multi-display, recording, and management. The project component creates, opens, saves, or closes a project and imports PowerPoint files. The layer component implements the script layer and the presentation layer. The multi-display component supports a multi-monitor display environment. The teacher can easily extend the learning material or annotations to the other monitors. The recording component records audio, handwriting, cursor movement, slide content, and more. The management component builds tree structures to manage project material. It offers the teacher a friendly interface to test the system, draw grids on the screen, set up the recording frame per second, and export the streaming video file. In the TL system, teaching materials are organized as a tree structure, as shown in Figure 4. The teacher can easily maintain the materials. Students can linearly or randomly access the multimedia materials with webpages via the
Internet, as shown in Figure 5, which can effectively help students to review those teaching materials. The reason is that students can listen to the verbal presentation of teaching materials as they view the visual presentation, instead of merely viewing static PowerPoint files or documents or listening to a recording of the teacher’s voice after class.

Figure 3. The structure of the TL system

Figure 4. Teacher’s authoring mode

Figure 5. Display mode for students on the Internet
Scenario of instructional implementation

This teaching scenario demonstrates that the teacher applies the TL system to an instructional procedure. The scenario is to teach a unit of calculus, in which students find the volume of the solid obtained by rotating a certain curve line about the $x$-axis. Figure 6 displays several screenshots of the teacher’s notebook computer. The teacher can see all objects in the slide, but some learning objects in the slide are invisible to students (as shown in Figure 7a).

Figure 6. The teacher’s screen in class

Figure 7. Six snapshots in the teaching process
The teaching procedure of the scenario is described as follows:

1. **Review the background for the teaching units.** The teacher presents the PowerPoint slide showing only the \( x \)-axis, \( y \)-axis, and a curve \( f(x) \) from \( a \) to \( b \) (Figure 7a). In the first five to ten minutes of class, the teacher helps students review the background for the teaching units, such as how to compute the area of the curve line to the \( x \)-axis. The teacher lectures the concepts of the key points, “slice” and “sum.”

2. **Present the new teaching materials.** Figures 7b to 7e show four snapshots of the teaching process. Figure 7b illustrates the initial content of the slide while the teacher is teaching. Students see only the initial content of the slide, but the teacher can see the complete content, as in Figure 6. Figure 7c shows that the teacher uses a digital pen to sketch the cylinder. The teacher draws the sketch and slices the solid, \( S \), into pieces by following the annotated hints. Figure 7d shows that the teacher has written the keywords and explanation. While teaching, the teacher can refer to the guidelines in the script layer to present topics such as slicing the cylinders like a loaf of bread. The purpose of showing auxiliary hints is to remind the teacher to emphasize the skill of solving a problem, such as getting the change of quantity, from \( a \) to \( b \), instead of making the error from \( b \) to \( a \). Figure 7e shows the teacher’s handwritten equations. The first equation illustrates the area of each piece of a cylinder. The remaining equations represent the summation of the cylinders to get the volume.

3. **Review the key points of the teaching materials.** The teacher concludes and reviews the problem-solving skills, including how to sketch the solid, how to find the formula \( f(x) \), how to find the limits of integration, and how to integrate the area (as shown in Figure 7f).

**Method**

**Participants**

A quasi-experiment was conducted to investigate the effects of applying the TL system in the physical classroom. Twelve teachers in a technology college of a university in middle Taiwan participated in the trial of the system. The teachers have experiences in using or producing PowerPoint slides as teaching materials. Moreover, 91 sophomore and junior students in the same technology college (55 men and 36 women, with a mean age of 19.8 years), who selected the linear algebra course enrolled in the experiment. The students were randomly assigned to two classes after they registered for the course. Then, the two classes were randomly assigned as the experimental group and the control group. The experimental group (42 students) was lectured by a teacher using the TL system, and the control group (49 students) was lectured by a teacher using a PowerPoint presentation.

The internal controls, which included teaching hours, instruments, course content, and instructor, were the same for the two groups. The experiment ran for four months, from September 2008 to December 2008. Each class met three times per week, for 50 minutes each session. The external controls included random assignment and analysis of covariance. First, at the beginning of the semester, the students were randomly assigned to each class. Second, the mathematics achievement pretest score was taken as a covariance variable so as to understand the students’ background regarding the learning content. The time factor, the course period of the experiment, is a history event that occurred outside of the experimental situation but may have affected the internal validity. It may also have affected the participants’ responses to experimental procedures. For example, some of the students may have gained knowledge related to the teaching materials outside of the classrooms through extra classes rather than solely using the TL system. Although the quasi-experimental design may be weaker than the experimental design, it is still used for much research in social sciences (Ainsworth, 2007; Kwon & Cifuentes, 2007; Lee, Shen, & Tsai, 2008; Wei, Chen, Kinshuk, & Hsu, 2009).

**Instruments**

**Instructional technology use questionnaire (ITUQ) for teachers**

In this paper, the ITUQ for teachers was investigated by using the questionnaire, which includes perceived use and trial experience of the TL system. Perceived use is the degree to which teachers believe that using a particular system would be easy and enhance their performance. Here, the ITUQ was modified and edited by the questionnaire of Davis’s study (1993) and the teachers’ trial experience (Hwang, Tsai, Tsai, & Tseng, 2008). There were 8 items in
the ITUQ, as shown in Table 2. Each item was assessed on a five-point Likert scale that ranged from 1 (strongly disagree) to 5 (strongly agree). The Cronbach’s alpha reliability coefficient for the questionnaire was 0.82.

Course attitudes scale (CAS) for students

We collected data from a 21-item CAS that students completed at the end of the semester. The scale included 6 items used by Apperson, Laws, and Scepansky (2008) to evaluate students’ attitudes toward the course, as well as 15 items from Susskind (2008) for material presented in the classroom via PowerPoint. Each item was measured on a seven-point Likert scale where 1 and 7 indicated strongly disagree and strongly agree, respectively. Reliability for the scale was measured with Cronbach’s alpha, which yielded a score of 0.85.

Mathematics achievement test (MAT)

A 33-item test for linear algebra was designed for pretest and posttest. The test included three components. The first component, which included seven items (28 points), referred to the problem-solving of procedural tasks that assess students’ ability to solve standard tasks that demand basic skills. Therefore, the purpose of the component was to evaluate students’ basic problem-solving skills. The second six-item component (30 points) referred to the problem-solving of transfer tasks. These items were more complex than those in the first component. The aim of the second component was to assess whether students had higher level skills. The third six-item (42-point) component referred to providing mathematical explanations. The mathematical-explanation items were identical in the pretest and posttest, whereas, the transfer tasks and the standard tasks were different.

Procedure

Twelve teachers and 91 sophomore and junior students in two classes contributed to the trial of the system. The classes agreed to teach with the instructional technology to support teaching of their lectures in the autumn 2008 semester. The control group, without using the TL system, received a lecture accompanied by a PowerPoint presentation. The experimental group used the TL system. A main difference between the two is that some content is invisible to students but visible to teachers in the TL system. The teaching materials were uploaded to the LMS for students. Students in the control group were able to download the PowerPoint presentation after class, and students in the experimental group were able to download the audio-video materials produced by the TL system after class. Absent students were also able to study the teaching materials by using the LMS. The procedure of the TL group, as shown in Figure 8, is described as follows.

1. Pretest: At the beginning of the semester, the students were asked to take the mathematics achievement test (MAT) to understand their background about the learning content. A change between the pretest and posttest is that teachers integrate the TL system into their instructional methods.
2. Before lecturing: Teachers create a new project of the TL system and import PowerPoint files into the project. Then, teachers use the TL system to edit the hint items and annotations and then arrange the presentation sequence of slide objects.
3. During lecturing: Teachers present the learning content and use the TL system to record their lecturing actions and voice simultaneously.
4. After class: Teachers post-edit the streaming video to optimize the materials and then upload the recorded materials in audio-video format to the LMS for students.
5. Posttest: At the end of the semester, teachers fill out the ITUQ. Students were asked to fill out the CAS and to do the MAT.

Data analysis

Research data were collected through the ITUQ for teachers and through the CAS and the MAT for students. Statistical analyses (t-test and ANCOVA) were conducted to investigate the differences between the experimental group and the control group related to questions, and learning achievement and effect sizes (Cohen’s d) were calculated. Here, the significant level was set at $p = 0.05$.

Results

Teachers’ data for ITUQ

The investigation of teachers’ data for instructional technology use aimed at introducing the effectiveness of the TL system to the teachers who were the users of the system. Table 2 shows the statistical results of the questionnaire, and some qualitative comments that the teachers made about the TL system.

It was found that over 67% of the teachers agreed that the TL system can make better recorded learning materials than the DV camera ($M = 3.67, SD = 1.15$). About 25% of the teachers disagreed with this statement possibly because they had to prepare more materials using the TL system rather than the DV camera to teach. Nearly 67% of the teachers agreed that the interface of the TL system was user-friendly ($M = 3.75, SD = 0.87$). Some of them suggested adding illustration to engage users. Only one teacher was not good at using the interface of the system.

Nearly 84% of the teachers agreed that the TL system was helpful to them ($M = 4.08, SD = 0.90$). Over 92% of the teachers agreed that viewing the process with the recorded materials helps them to revise their instructions ($M = 4.17, SD = 0.58$). About 67% of the teachers agreed that the function that some objects were visible to teachers but invisible to students can make the teaching process go more smoothly ($M = 3.83, SD = 0.72$). Nearly 58% of the teachers agreed that having some objects visible to teachers but invisible to students can reduce anxiety while teaching ($M = 3.42, SD = 1.44$). About 25% of the teachers disagreed with this item possibly because they had more than five years of teaching experience.

Moreover, 75% of the teachers would like to employ the TL system in the future ($M = 3.92, SD = 0.90$), and 75% would recommend it to other teachers ($M = 3.92, SD = 0.90$). Again, one of the 12 teachers hesitated to use the TL system because s/he preferred to use the blackboard rather than computer while teaching. We can conclude that the TL system is acceptable for most of teachers.

<table>
<thead>
<tr>
<th>Question</th>
<th>SA (%)</th>
<th>AG (%)</th>
<th>N (%)</th>
<th>DA (%)</th>
<th>SD (%)</th>
<th>M (SD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>I will use the TL system to make the recorded learning materials rather than using a DV camera.</td>
<td>25</td>
<td>42</td>
<td>8</td>
<td>25</td>
<td>0</td>
<td>3.67 (1.15)</td>
</tr>
<tr>
<td>The interface of the TL system is user-friendly.</td>
<td>17</td>
<td>50</td>
<td>25</td>
<td>8</td>
<td>0</td>
<td>3.75 (0.87)</td>
</tr>
<tr>
<td>The TL system was helpful to me.</td>
<td>34</td>
<td>50</td>
<td>8</td>
<td>8</td>
<td>0</td>
<td>4.08 (0.90)</td>
</tr>
<tr>
<td>Viewing the recorded materials helps me to revise my teaching.</td>
<td>25</td>
<td>67</td>
<td>8</td>
<td>0</td>
<td>0</td>
<td>4.17 (0.58)</td>
</tr>
<tr>
<td>While teaching, having some objects visible to</td>
<td>17</td>
<td>50</td>
<td>33</td>
<td>0</td>
<td>0</td>
<td>3.83</td>
</tr>
</tbody>
</table>
teachers but invisible to students can make my teaching process smoother. 
While teaching, the function that some objects are visible to teachers but invisible to students can reduce my anxiety.
I am willing to use the TL system in my class.
I will recommend the TL system to other teachers.

Strongly agree: SG; Agree: AG; Neural: N; Disagree: DA; Strongly Disagree: SD

Students’ data for CAS

The analyses of independent *t*-test and the effect size (Cohen’s *d*) was conducted to assess the effects of the experimental group with the TL system and the control group with PowerPoint on the 21 survey items related to the CAS. Table 3 shows the significant results of the experimental analysis, which indicate that the students in the experimental group felt the instructor’s use of the instructional technology helped them pay attention in class, *t*(89) = 3.170, *p* < 0.01, *d* = 0.68. It may be that the teacher effectively presented teaching materials. When the students studied the materials through the LMS platform, they felt that they could recall classroom experiences, *t*(89) = 4.215, *p* < 0.001, *d* = 0.90. The materials on the LMS platform could help students understand the learning content, *t*(89) = 3.698, *p* < 0.001, *d* = 0.78. Students felt they were more confident for the exams, *t*(89) = 2.024, *p* < 0.05, *d* = 0.43. Compared to the experimental group, students in the conventional group felt that they required more reading, *t*(89) = 3.757, *p* < 0.001, *d* = −0.78. They found it difficult to understand the course, *t*(89) = −2.151, *p* < 0.05, *d* = −0.45. They had to work hard, *t*(89) = −2.151, *p* < 0.05, *d* = −0.45. They spent more time studying for exams, *t*(89) = −2.276, *p* < 0.05, *d* = −0.48. Accordingly, these results reflected that the TL system was helpful for students in the experimental group.

<table>
<thead>
<tr>
<th>Question (7, strongly agree; 1, strongly disagree)</th>
<th>Experimental group <em>(n = 42)</em></th>
<th>Conventional group <em>(n = 49)</em></th>
<th><em>t</em> value</th>
<th>Effect size Cohen’s <em>d</em></th>
</tr>
</thead>
<tbody>
<tr>
<td>Compared to other courses, this course required more reading.</td>
<td>5.76(1.05)</td>
<td>6.51(0.84)</td>
<td>–3.757*</td>
<td>−0.78</td>
</tr>
<tr>
<td>Compared to other courses, this course required more writing.</td>
<td>5.47(1.17)</td>
<td>5.91(1.20)</td>
<td>−1.766</td>
<td></td>
</tr>
<tr>
<td>Compared to other courses, this course required doing additional work.</td>
<td>3.86(1.60)</td>
<td>3.84(1.52)</td>
<td>–0.062</td>
<td></td>
</tr>
<tr>
<td>Compared to other courses, this course was difficult to understand.</td>
<td>4.97(1.26)</td>
<td>5.59(1.44)</td>
<td>–2.151*</td>
<td>−0.45</td>
</tr>
<tr>
<td>Compared to other courses, this course required me to work harder.</td>
<td>5.40(1.15)</td>
<td>6.08(1.00)</td>
<td>–3.010*</td>
<td>−0.63</td>
</tr>
<tr>
<td>I can easily discuss the lecture with classmates afterwards.</td>
<td>4.52(1.09)</td>
<td>4.86(1.24)</td>
<td>–1.351</td>
<td></td>
</tr>
<tr>
<td>The use of instructional technology helps me pay attention in class.</td>
<td>4.81(0.89)</td>
<td>4.04(1.33)</td>
<td>3.170*</td>
<td>0.68</td>
</tr>
<tr>
<td>I thought the teacher’s use of instructional technology while teaching was effective.</td>
<td>4.90(0.96)</td>
<td>4.38(1.37)</td>
<td>2.065*</td>
<td>0.43</td>
</tr>
<tr>
<td>When I studied the material through the LMS platform, I could clearly recall the classroom experience.</td>
<td>5.05(0.83)</td>
<td>4.16(1.12)</td>
<td>4.215*</td>
<td>0.90</td>
</tr>
<tr>
<td>The materials on the LMS platform help me understand the learning content.</td>
<td>4.95(0.96)</td>
<td>4.08(1.24)</td>
<td>3.698*</td>
<td>0.78</td>
</tr>
<tr>
<td>During the lecture, I took more notes.</td>
<td>4.38(1.17)</td>
<td>5.06(1.43)</td>
<td>–2.454*</td>
<td>−0.52</td>
</tr>
<tr>
<td>My notes were more useful for exams.</td>
<td>4.17(0.96)</td>
<td>4.28(1.24)</td>
<td>−0.505</td>
<td></td>
</tr>
<tr>
<td>I spent more time studying for exams.</td>
<td>5.17(1.18)</td>
<td>5.73(1.18)</td>
<td>–2.276*</td>
<td>−0.48</td>
</tr>
<tr>
<td>I was more confident about the exams.</td>
<td>3.45(1.21)</td>
<td>2.92(1.28)</td>
<td>2.024*</td>
<td>0.43</td>
</tr>
</tbody>
</table>

* *p* < .05, *b* *p* < .01, *c* *p* < .001
Student score

Table 4 shows the mean ($M$), adjusted means, and standard deviations ($SD$) of students' MAT scores. A pretest was conducted, which showed that the students in both the experimental group and the control group have equivalent prior knowledge for learning the linear algebra course, $t(89) = -1.085, p > 0.05$. A one-way analysis of covariance (ANCOVA) was conducted on the scores of the learning goal with the pretest scores used as a covariant. ANCOVA was performed after confirming requirement of homogeneity of within-cell regressions ($F(1, 87) = 0.714; p > 0.05$). Results of the ANCOVA revealed a statistically significant difference for learning achievement, $F(1, 88) = 4.22, p < 0.05$. Effect size indicated that at the end of the study the experimental group outperformed the conventional group in problem-solving tasks ($d = 0.41$). This indicates that students in the experimental group gained higher scores than those in the control group.

<table>
<thead>
<tr>
<th></th>
<th>Experimental group ($n = 42$)</th>
<th>Control group ($n = 49$)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$M$</td>
<td>$SD$</td>
</tr>
<tr>
<td>Pretest</td>
<td>34.48</td>
<td>17.10</td>
</tr>
<tr>
<td>Posttest</td>
<td>69.76</td>
<td>16.01</td>
</tr>
<tr>
<td>Adjusted means</td>
<td>70.65</td>
<td></td>
</tr>
</tbody>
</table>

Discussion

It should be useful for teachers and learners to apply the TL system in instruction. In learning activities, teachers and students can benefit by following the four findings found in the experimental results. First, teachers indicated that the TL system is helpful for them (as presented in Table 2). An outstandingly useful feature of the system is that, while lecturing, teachers can display some objects of the PowerPoint slides in their own monitor yet prevent the students from viewing them (as shown in Figure 7). Teachers can see the hint items (or annotations) that they made prior to the lecture, which enables them to confidently present materials. These hints help reduce teachers’ anxiety and make the teaching process go more smoothly.

Second, this feature can be integrated with handwriting and pop-up objects to become a new presentation method. The displayed content is semi-transparent for teachers but invisible to students (as illustrated in Figure 2). Teachers can handwrite the content by drawing the strokes on the semi-transparent content on PowerPoint, which is invisible to students. Alternatively, a simple way to show the semi-transparent content is by using the pop-up functions provided by PowerPoint. Several studies indicated that instructors should no longer rely on the traditional blackboard when teaching (Bruun, 2009; Corbeil, 2007; Havens, 1989). It is impossible for the TL system to completely replace the blackboard because teachers may prefer to handwrite information on the blackboard instead of on a computer screen. However, students are interested in studying through teaching materials such as texts, pictures, graphs, tables, charts, and animation (Liu, Liao, & Pratt, 2009). Furthermore, teachers can review the recorded materials and then improve their teaching (as shown in Figure 8).

Third, students felt that the TL system helped them pay attention in class (as presented in Table 3). With the TL system, while teachers are writing, students have the advantage of having a face-to-face interaction with their teacher. The possible reason is that the handwriting process forced students to think critically and enrich their learning experience at a deeper level (Zhang & Deng, 2005). Thus, the teacher’s writing allowed students to pay more attention, especially when learning mathematics, in which there are many problem-solving steps. Students in the conventional group felt that the learning content was difficult. Moreover, they felt it necessary to read more and study harder. The finding is similar to Susskind’s (2008) finding that PowerPoint lectures did not enhance the students’ performance on exams. However, there is no significant difference between two groups in time spent preparing and studying for this class each week. The possible reason is that, although PowerPoint presentations were well-constructed, the typical organizational benefits of lectures might have been minimized through the use of PowerPoint because the slides present only outlines and key points, as opposed to detailed content. Moreover, teachers often overemphasize the items in slides and directly present slides one by one. As a result, students are not encouraged to think deeply about the presented material. The result does not promote student interactivity, engagement with the content, or learning, which is similar to that of the traditional PowerPoint working methods (Zhang, Zhao, & Nunamaker, 2004). On the contrary, PowerPoint presentations gradually reduce the students’
interest, which can lead to confusion and frustration. The teaching manner with the TL system keeps students attentive while teachers handwrite lessons rather than mechanically displaying content from the PowerPoint slides.

Finally, students agreed the materials on the LMS platform can help them understand the learning content (as presented in Table 3). It may be that students can repeatedly study the recorded materials to review teachers’ problem-solving skills and thinking methods (as shown in Figure 5). Accordingly, they easily followed the teachers’ logic because the multimedia teaching materials included imitating teachers’ problem-solving skills, listening to what the teachers said, and reading what the teachers wrote. According to schema acquisition and the borrowing and reorganizing principles of cognitive load theory (Guttormsen, Schär, & Zimmermann, 2007), the method of studying the recorded materials can benefit students because they can primarily build the bulk of information in long-term memory (Leahy & Sweller, 2008). When students in the experimental group studied the teaching materials, they had a feeling that they were in class. In other words, they can almost recall learning activities in the class situation. This is helpful to transform the knowledge of the teacher’s problem-solving skills to the students. Moreover, teachers can use the TL system to produce multimedia teaching content with webpages through the Internet (as shown in Figure 4). Then, the content can be conveniently uploaded in the LMS system or web-based platform for learning by Web 2.0 to provide students with interactive functions in the cyber classroom (Chen & Wang, 2008). This provides learners with more opportunities to enhance the learning process.

Conclusion

This paper has proposed the TL system. The survey and empirical measures appear to measure that the TL system is helpful to teachers and the students in traditional classrooms. While the teacher lectures, some items in the PowerPoint slides displayed in the teacher’s monitor (or notebook) are visible to teachers but invisible to students. This function is helpful for teachers because it allows them to control the presentation sequence of the PowerPoint slides. Teachers can conveniently refer to the hint items or annotations to smooth their presentation. The TL system is also helpful for improving students’ learning effects while requiring teachers’ handwriting for solving problems (Bruun, 2009). Additionally, teachers’ lecturing voices and whole teaching actions on PowerPoint slides are simultaneously recorded into multimedia teaching content in a web-based format. Students, therefore, can recall teaching activities such as teachers’ problem-solving skills and logic. Finally, the results show that students in the experimental group had a more positive attitude toward learning and gained higher mathematics scores than students in the control group. The TL system benefits students while they review teaching content asynchronously in the cyber classroom (Chen & Wang, 2008).

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References


