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The implementation of a digital learning management system - a case study of flipped teaching in design courses

So-Jeng Hung, Cheng-Hung Wang & Chia-Huang Hsu

National University of Kaohsiung
Kaohsiung, Taiwan

ABSTRACT: Traditional classrooms have changed from being teacher-oriented to learner-oriented flipped classrooms. Students watch videos on a designated Web site before class, before completing assessments and assignments on-line. After having acquired general knowledge from the video lectures, students can apply that knowledge via class interaction. The method of learning is similar to design students applying the general skills they have learnt. This research attempted to implement a digital learning management system that is suitable for teaching design courses. The system uses content from a digital design course, and uses video lectures made by teachers in accordance with the cognitive theory of multimedia learning. The research attempts to investigate the students' level of satisfaction with the system, as well as whether their learning performance has improved significantly. Results show that participants were satisfied with the interaction with the digital learning management system and it showed an improvement in learning performance.

INTRODUCTION

The education of knowledge has always been teacher-centred, placing emphasis on the transmission of knowledge to learners through lectures [1]. The focus was on absorbing knowledge and understanding concepts, as well as giving repeated practice and assessments in order to increase the students' understanding [2]. However, that method lacks classroom interaction, does not engage learners in active thinking [3] and discourages the development of cognitive abilities [4]. With the evolution of technology and media, learning materials have changed from static to dynamic, evolving from texts to videos. The most famous example of massive open on-line courses (MOOCs) would be the Khan Academy's integration of flipped teaching into its platform [5]. Based on the concept of MOOCs, Fox developed the concept of small private on-line courses (SPOCs), which is a combination of MOOCs and flipped classrooms [6].

The teaching of experience is just as important as the fundamental concepts when teaching design technology. Traditional teaching methods consist of the teacher giving a lecture in a physical classroom, making it difficult for the teacher to be aware of the students' grasp of concepts and knowledge; thus, reducing the capacity of the teacher to provide students with feedback or help in time. Furthermore, most teaching systems are designed for academic subjects; less attention is paid to art or design courses. For that reason, this research designed a SPOCs-style learning management system suitable for design courses.

Participants can use the system before class to have a better understanding of basic concepts, as well as the system's interactive functions, such as assessments, discussion forums and assignment uploading. Teachers can know students' progress before class and help them with problems through interactive discussion. For these purposes, this research will attempt to investigate the possibility of implementing digital learning management systems in digital design courses, as well its usability and satisfaction to students.

LITERATURE REVIEW

Colorado high school teachers J. Bergmann and A. Sams came up with the concept of flipped classrooms in 2007 as a remedy for absent students to catch up. The teachers made video lectures of class content and uploaded them onto YouTube for students to watch later. The focus here was not the videos, but thinking about how to use classroom interaction effectively to encourage higher level thinking in students [4]. In recent years, many scholars' studies on the effects of flipped classrooms on learning efficiency have shown that flipped classrooms transform passive learning to active learning in learners. The learner now has an active role in learning, whereas the teacher now plays the role of analysing and integrating knowledge. Classroom learning performance is improved through methods of problem-solving to help learners better absorb the contents; thus, flipped classrooms are suitable for mission-oriented or project-oriented courses [7].

SPOCs is a term coined by Fox in 2013. SPOCs are a derivative of MOOCs. Unlike MOOCs, SPOCs is not unrestricted in terms of accessibility and student numbers. In short, SPOCs is a teaching solution by giving MOOCs resources to a small and specific group of people. It is a hybrid form of learning, combining MOOCs resources and flipped classrooms. The US Department of Education studied the effects of on-line learning and classroom learning on learning performance in 2010. Results showed that there is little difference in students' performance from on-line learning and classroom learning. The blending of both on-line and classroom learning showed learning outcomes *significantly superior* to just on-line learning or classroom learning alone. Most SPOCs classes are a hybrid of classroom learning and self-learning on-line. The teacher assigns MOOCs videos as homework to the students, answers students' questions in class, and deals with assignments or other learning tasks in class.

Cognitive theory of multimedia learning was developed by Richard Mayer in 1997 and it defines multimedia learning as *learning through words and pictures*. Words can be in the printed or spoken forms; pictures include graphics, photographs, animations or videos. According to the theory, different forms of messages will have different processes of cognition. The process of *picture cognition* is that the eyes pick up the stimulations, and selected stimulations will be delivered to the visual sensory memory and, then, transferred into the pictorial model after organisation. The process of voice cognition is that the ears pick up the stimulations, and selected stimulations will be delivered to the audio sensory memory and, then, transferred into verbal model after organisation. The process of words cognitions is that the eyes pick up the stimulations, and selected stimulations will be delivered to the visual sensory memory, and are converted into auditory messages and, then, transferred into the verbal model after organisation. In the end, both of them will be integrated with prior knowledge (Figure 1).

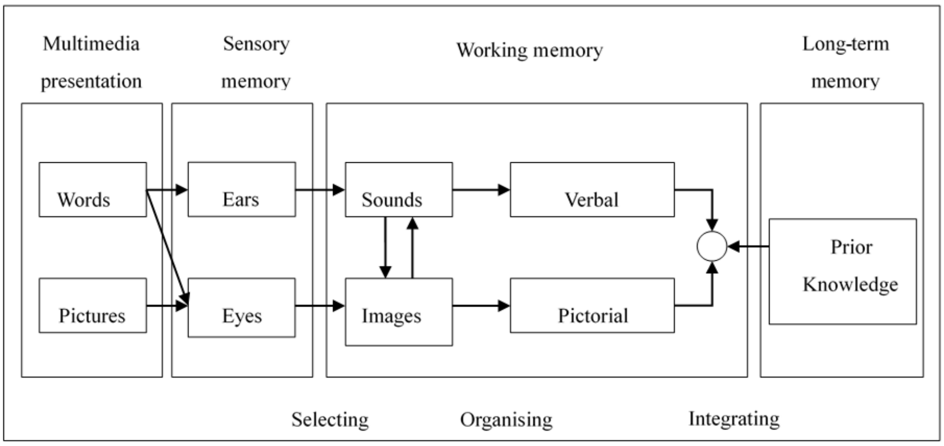

Figure 1: Cognitive model of multimedia learning.

Most scholars pointed out in related research that learners show significant discrepancy in their learning performance with different combinations of teaching media. The combination, which produced the best learning performance was *video + voiceover* [8]. This is because learners prefer to learn from videos [9]. When images were added into the combination (image+words+voiceover), learning performance was reduced because words and voiceover overlapped in the message, which matches the hypothesis of the redundancy principle [10]. However, if the words are shown as keywords and are not the same as from the voiceover, it can promote learning [11]. If the design of the teaching material allows students to play the video themselves, then, they have them sufficient time to organise and absorb the material, making them less prone to distractions [12].

METHODOLOGY

The research developed a digital cultural and creative learning management system (DCC) suitable for teaching design courses. The system allows learners to learn, discuss and take examinations on the system, and allows teachers to be aware of the learners' progress, enabling them to give timely help. The system usability scale (SUS) was used as the method of evaluation in order to know the participants' evaluation of the system after use. As for the final evaluation, the questionnaire for user interaction satisfaction (QUIS) was used. The questionnaire evaluates the participants' subjective satisfaction of the human-machine interface and has high degree of reliability and validity.

Before the experiment, the research conducted a preliminary investigation on user understanding in the form of questionnaire of prior knowledge, to know the participants' computer usage habits, as well as experience with learning systems. To understand better whether the system will affect learner performance, the test questions were designed by three experienced teachers with a digital design background to ensure the appropriateness and content relatedness of the questionnaire. The sample consisted of eighty subjects selected from an elective design course at the undergraduate level. Due to time constraints, the research could not carry out a year-long study; instead important unit lessons that could be taught in two weeks were chosen. The content of the course was chosen from the 3Ds Max. The questions used to evaluate the students' learning performance were chosen from the 3Ds Max test bank. The questionnaire contained ten multiple-choice and ten true/false questions for a total of twenty questions. The students had 30 minutes to complete the questionnaire. The questionnaire had two versions, consisting of the same questions, but in different order, to use for the pre-test and the post-test. From the perspective of cognitive psychology, learners use different kinds of memory to remember when they learn. Short-term memory capacity is limited; if the information is not saved into long term memory, it can only be retained for twenty seconds before it disappears permanently. Thus, the research left a two-week gap between the questionnaires to allow the learners to absorb and understand fully what they had learned.

System Design

The interface of the system is divided into three major components: functions, teaching functions and courses. Figure 2 illustrates the setup of the system:

A. Course information: all course-related functions are here. Learners can choose courses, learn and be assessed. Teachers can edit course materials and assessments.
B. Course interaction: a platform for learners to communicate with peers and the teacher.
C. User tools: provides all users a personalised digital learning management tool.

Figure 2: System interface setup.

Experimental Design

In this research, the experimental course was divided into on-line learning and classroom learning. The digital learning management system has to be able to distinguish learners and teachers, as well as allow the setup of a student number limit and course prerequisites in order meet the conditions of a SPOCs course. The learning materials were *video+voiceover* of five to ten minutes, designed according to the cognitive theory of multimedia learning. The video lectures contain one to three concepts only. The number of concepts was kept low to avoid students losing interest due to excessive amounts of material. The video was uploaded onto the system to allow learners to preview and absorb the material at their own pace. The research attempts to use digital learning management systems as a tool for flipped teaching. Through experimental research, the research will discuss whether the use of digital learning management systems in digital design courses can improve students' motivation and performance.

The participants had to complete a prior knowledge questionnaire and learning performance evaluation (pre-test). Upon completion, students participated in two weeks of lectures, using the DCC system for class preview and assessment. Once finished, students were required to complete a SUS before they could begin classroom learning. After the last class, students were required to complete the system usability questionnaire (post-test). Upon completion of the post-test, students were then asked to complete a QUIS. Upon completion of these steps the experiment was finished.

EXPERIMENT RESULTS AND ANALYSIS

A computer with an Internet connection is critical to learning on the DCC system, thus, this was the first question. If the subject does not have a computer with Internet access, solutions could be found before the experiment started.

The results show that 80 persons (100%) said they had both a computer and Internet access where they live. 36 persons (45%) spent between 3 and 6 hours on the Internet every day. 23 persons (29%) spent between 1 to 3 hours, 13 persons

(16%) spent more than 6 hours, and 8 persons (10%) spent less than 1 hour on the Internet every day. It showed that most participants were frequent computer users and had a basic grasp of computer usage. 53 persons (66%) had prior experience in using learning systems, whereas 27 persons (34%) had no experience with learning systems. 78 persons (98%) were willing to learn by means of a learning system, whereas two persons (2%) of the participants were not. 64 persons (80%) previewed before class with the aid of the learning system; 16 persons (20%) did not. 78 persons (98%) believed that the aid of a learning system helped their learning; whereas two persons (2%) found it unhelpful. 39 persons (49%) were willing to use the system for between 1 to 3 hours; 16 persons (20%) were willing to use it for less than 1 hour; 14 persons (18%) were willing to use it for between 3 to 6 hours; 11 persons (13%) were willing to use it for more than 6 hours.

In terms of learning system experience, the participants showed a positive attitude towards the learning systems. Most of the participants (98%) were willing to use the system to learn and believed it to be helpful to their learning. Thus, the research direction is feasible. Twenty percent of participants used the system for less than 1 hour a week, thus, there needs to be a reward mechanism to encourage the completion of learning missions in order to increase research feasibility.

The Cronbach's alpha value obtained from the SUS was 0.783. For a general-purposed research, a value above 0.7 indicates that the questionnaire is reliable. Responses on the 5-point Likert scale to each question were analysed. All negatively worded questions were reworded as positively worded in the SUS. The scores for the two highest points (4 and 5) were summed and analysed. According to the point system of the scale, the result value represents the participants' overall assessment of the system's usability. This can be used to understand how participants feel about the system, as illustrated in Table 1.

Table 1: Usability of the system - descriptive statistics.

Question	Mean	Standard deviation	5-point Likert scale（%）				
			1	2	3	4	5
Q1	3.78	0.650	0	0	33.8	53.8	12.5
Q2	3.81	0.781	0	5.0	26.3	51.3	17.5
Q3	4.18	0.689	0	0	16.3	50.0	33.8
Q4	3.39	0.921	1.3	17.5	27.5	46.3	7.5
Q5	3.89	0.595	0	0	23.8	63.8	12.5
Q6	4.15	0.887	0	6.3	13.3	38.8	41.3
Q7	4.18	0.675	0	0	17.5	47.5	35.0
Q8	4.28	0.675	0	0	12.5	47.5	40.0
Q9	4.25	0.540	0	0	5.0	65.0	30.0
Q10	3.93	0.854	0	6.3	21.3	46.3	26.3
Overall	3.98	0.727	0.13	2.88	19.73	51.03	25.64

Q1 results show that 66.3% of participants were willing to use the system frequently. Q2 results show that 68.8% of participants thought the system was not overly complicated. In Q3, results show 83.8% of participants believed the system was easy to use. In Q4, 53.8% of participants thought that they did not need technical support when using the system. In Q5, 76.3% of participants thought the system's functions were well integrated. In Q6, 80.1% of participants thought that the system was not inconsistent. In Q7, 82.5% of participants thought that most people can learn how to use the system fairly quickly. In Q8, 87.5% of participants thought that the system was not very difficult to use. In Q9, 95% of participants were confident that they could use the system. In Q10, 72.6% of participants thought they did not need a lot of prior knowledge before using the system. The scores of participants' responses were calculated and, then, analysed to find out how participants felt about the system's usability.

Results for each item and the distribution of their values are shown in Table 2. Participants' evaluation of the system's usability is shown below. The mean, median, mode, standard deviation, minimum and maximum are 74.72, 75.00, 77.50, 10.78, 47.50 and 95.00, respectively.

Table 2: System usability - score statistics.

Sample number	Mean	Median	Mode	Standard deviation	Minimum	Maximum
80	74.72	75.00	77.50	10.78	47.50	95.00

Generally speaking, if a system's usability has a score of above 70, this means that most participants are satisfied with the system. The system has a mean score of 74.72, meaning that the average participant was satisfied with the system. Thus, it could be said that the usability of the DCC system is good. The system's usability is 74.72, a score that is between *good* and *excellent* on the SUS score diagram.

Eighty participants completed an evaluation in the final evaluation stage of the research. The user interaction satisfaction questionnaire had five criteria: overall system operation, Web page display, system wording and information, learning functions and system functions. Each criterion had four to six questions, for a total of 27 questions on the questionnaire. A reliability test was run on the questionnaire. The Cronbach's alpha value for the QUIS was 0.954, well above the general standard of 0.7 or even 0.9; thus, the follow-up evaluation of the system was very reliable. The mean was obtained by the sum of scores divided by the number of questions. The descriptive statistics of the scores are shown in Table 3.

Table 3: User interaction satisfaction - descriptive statistics.

	High prior knowledge group		Low prior knowledge group		Total	
	Mean	SD	Mean	SD	Mean	SD
Overall system operation	4.91	0.720	4.71	0.724	4.81	0.866
Web page display	5.34	0.867	4.96	0.831	5.15	0.866
System wording and information	5.11	0.799	4.86	0.892	4.99	0.761
Learning functions	4.80	0.894	4.71	0.823	4.75	0.761
System functions	5.06	0.662	4.95	0.993	5.01	0.939
Average	5.02	0.662	4.82	0.793	4.93	0.731

For the criterion of overall system operation, the overall mean was 4.81, meaning that participants were high/intermediate-level users in operating the system. The mean of the higher prior knowledge group (M = 4.91) was higher than the lower prior knowledge group (M = 4.71).

For the criterion of Web page display, the overall mean was 5.15, meaning that participants showed high satisfaction in the graphic display of the system. The mean of the higher prior knowledge group (M = 5.34) was higher than the lower prior knowledge group (M = 4.96). For the criterion of system wording and information, the overall mean was 4.99, meaning that most users could understand the information provided by the system. The mean of the higher prior knowledge group (M = 5.11) was higher than the lower prior knowledge group (M = 4.86). For the criterion of learning functions, the overall mean was 4.75, meaning that that participants were satisfied with the learning experience of the system. The mean of the higher prior knowledge group (M = 4.80) was higher than the lower prior knowledge group (M = 4.71). For the criterion of system functions, the overall mean was 5.01, meaning that that participants were satisfied with the performance the system. The mean of the higher prior knowledge group (M = 5.06) is higher than the lower prior knowledge group (M = 4.95).

From the results above, the system had a slightly lower score in the criteria of overall system operation and learning functions. It could be that the system was unclear or lacking in instructions or explanations, which consequently affected students' learning conditions, leading to the lower score. However, the criteria of Web page display and system functions had means of 5.15 and 5.01, respectively. This shows that the system had good user satisfaction in terms of interaction. The high overall score of 4.93 indicates that most participants thought the system was easy to use and understand.

To understand the difference in student level before the class starts, a *t*-test was run on the pre-test and post-test scores. This was to analyse whether the system is helpful in learning. As a whole, as illustrated in Table 4, the mean score of the post-test (M = 62.25) was 15.81 points higher than the mean of the pre-test mean (M = 46.44). The *p*-value is $p = 0.000$ ($p < 0.001$) and the effect size was d = 1.66 (d > 0.8). The statistic is very significant; indicating that the use of a digital learning management system can significantly and positive increase learning performance.

Table 4: Overall and group learning performance.

Overall	Individual	Mean	Standard deviation	Improvement	*t* value	*p*-value	Effect
Pre-test (overall)	80	46.44	11.31	15.81	-14.54	0.000***	1.66
Post-test (overall)	80	62.25	7.71				
Pre-test (high group)	41	55.85	5.11	9.03	-7.60	0.000***	1.35
Post-test (high	41	64.88	8.25				
Pre-test (low group)	39	36.54	6.51	22.95	-24.83	0.000***	3.65
Post-test (low group)	39	59.49	6.05				

*** $p < 0.001$

Participants were further divided into high prior knowledge and low prior knowledge groups to understand whether the difference in system usage affects the improvement of learning performance. The post-test scores (M = 64.88) for the high prior knowledge group increased 9.03 points from the pre-test mean (M = 55.85). This data has a *p*-value of

$p = 0.000$ ($p < 0.001$) and an effect size of $d = 1.35$ ($d > 0.8$), which is very significant. The mean of the post-test score ($M = 59.49$) of the lower prior knowledge group improved 22.95 points from the pre-test ($M = 36.54$). This data has a p-value of $p = 0.000$ ($p < 0.001$) and an effect size of $d = 3.65$ ($d > 0.8$), which is very significant. From the results above, digital learning systems bring a very positive and significant increase in learning performance to both high and low prior knowledge groups. The difference in the level of prior knowledge in using a digital creative learning system does not affect learning performance.

CONCLUSIONS

The research used various system evaluation processes to evaluate the system. The prototype used the SUS, but the final evaluation used the QUIS to understand how participants felt about a digital creative learning management system, as well as their level of satisfaction with it. A pre-test and a post-test were given to evaluate students' learning performance before arriving at a conclusion.

In the learning process, the students used the system to preview class materials and engage in on-line discussions. In terms of system usability, they were generally satisfied with the system's method of learning and usability. In terms of system satisfaction, they showed a significant improvement in scores between the pre-test and the post-test, regardless of their level of prior knowledge. Thus, the combination of a learning management system with a flipped digital design class can improve the learning performance of design courses.

For future research, if time allows, the researchers suggest adding a variety of units to strike curiosity in users, as well as observing how student learning behaviour changes with time. In the future, more in-depth learning activities may be tried, to allow learners to not only learn knowledge, but to give knowledge as well.

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