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Is Students' Learning Improved by Computer-Assisted Programmed Instruction? An Experiment in Blended Learning

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ABSTRACT

Due to the increased popularity of e-learning, the phrase "blended learning" has recaptured people's attention. The manner in which blended-learning classes can be designed to improve learning effectiveness has become an important issue. This study combines classroom learning (abbreviated as C) with computer-assisted programmed instruction (abbreviated as E) to implement C + E. Based on the principle of programmed instruction, teaching material for the computer-assisted instruction (CAI) for a statistics course was produced, and a teaching experiment was conducted in various statistics courses at a university of technology. The results indicated that, as opposed to the "traditional classroom learning," the blended learning of "computer-assisted programmed instruction" increased students' learning effectiveness.

1. INTRODUCTION

With regard to the application of instructional strategies, "blended learning" is neither a new phrase nor a new product. Blended learning has been widely employed by most curriculum designers; however, in recent years, the phrase, blended learning has recaptured people's attention due to the increasing popularity of e-learning. How to best use blended learning in order to increase learning effectiveness—in other words, how to combine classroom learning (abbreviated as C) with e-learning (abbreviated as E)—has become an issue worth investigating. In recent years, the status of e-learning has been gradually transformed from a "substituent" to an "auxiliary instrument." Although e-learning has many advantages, it has many disadvantages as well. In order to enable e-learning to assist in the instruction of classroom learning and improve learning effectiveness, it is important to draw on the strength of classroom learning in order to offset the weakness of e-learning when developing curriculum using blended learning (Chen & Yao, 2009).

The development of e-learning began as computer-assisted instruction (CAI) during the initial introduction and increase in the ownership of personal computers. However, with the rise of the Internet in the 1990s, various countries began promoting national information infrastructures and employing information technology to support instructional activities, which further enriched the diversity of learning. CAI refers to the use of computer technology to improve instructional quality and learning effectiveness. However, changes in many aspects of computer technology, such as digital voice, images, hyperlinks, and information processing speed have brought about revolutionary progress in the quality and quantity of CAI. For example, there have been significant improvements in the development and design of e-learning materials, management of instructional activities, implementation of online assessment, and synchronous (or non-synchronous) instruction. In Taiwan, CAI has been utilized to improve programmed instruction for over two decades. Currently, the progressive multimedia function of information technology enables computer-assisted programmed instruction to win recognition and accolades from education authorities regarding its production method, playback quality, interactive response, and learning effectiveness.

This study combined classroom learning (C) with computer-assisted programmed instruction (E) to implement C+E. The CAI teaching materials were produced in advance according to the principle of programmed instruction, and the teaching experiment was conducted in the statistics courses at a university of technology in order to verify the actual effectiveness of "computer-assisted programmed instruction" in combination with the "traditional classroom instruction" (i.e., the blended learning of C + E).

2. LITERATURE REVIEW

2.1. Computer-Assisted Programmed Instruction

Programmed instruction was proposed by Skinner in 1954. It is a type of progressive instructional method based on the principle of operant conditioning, which emphasizes the concepts of reinforcement and chaining. Furthermore, programmed instruction is not merely a self-directed instructional method. It emphasizes the preparation of teaching material in advance in order to facilitate instruction. The following are the core concepts of programmed instruction:

2.1.1. Systematic teaching materials

Teaching materials are divided into many detailed items (units) in advance, and these items are then arranged according to the logical sequence of learning activities or according to difficulty levels, from the simplest to the most difficult.

2.2.2. Progressive learning

Students are placed in progressive learning environments according to a pre-arranged order, from simple to complicated learning activities; they cannot advance to the second stage until they have passed (or learned) the first stage. After they have passed the second stage, they can continue on to the third stage on the basis of their experiences from the first and second stages. In other words, they have learned step by step and have eventually achieved the intended goal.

2.2.3. Formative assessments and feedback

During each learning stage, teachers constantly provide formative assessments of students' learning achievement. For students who have learned well, teachers provide prompt encouragement in order to increase their learning motivation. For students who have not learned well or encountered difficulties, teachers provide prompt remedial instruction in order to avoid the accumulation of learning failure.

2.2.4. Individualized learning

When students receive their assessment of programmed instruction, they adjust their learning speed in accordance with their capabilities, thus proving that programmed instruction is a method for individualized adaptive learning.

2.2.5. Learning validation and instructional improvement

Teachers can make adjustments to the individual detailed items of their teaching materials according to student performance. General instruction tends to lack the accuracy by which teachers can improve their curriculum. However, in programmed instruction, teachers can make adjustments to the detailed items of teaching materials according to student performance; such adjustments are made on the basis of learners' trials and actual responses instead of speculation and estimation.

Since modern computers are equipped with diversified functions such as the presentation of multimedia, responses of hyperlinks, and huge data storage, programmed instruction can be fully utilized. Over the past ten years, curriculum experts have developed quite a few hardcopies of programmed teaching materials, learning machines, and materials for computer-assisted programmed instruction. Materials for computer-assisted programmed instruction have been widely incorporated into teacher education and have been recognized and approved by both teachers and students.

The e-learning instruction model is based on the concept that training must enable learners to apply the concepts learned at their workplace and evaluate the results (Alonso, López, Manrique, & Viñes, 2005). In fact, computer-assisted programmed instruction cannot be unconditionally applied to the instruction of every subject. In general, programmed learning is only suitable for subjects that have a hierarchical relationship or serial correlation. The nature of statistics shows explicit hierarchy and order of continuity; thus, it is suitable for material for computer-assisted programmed instruction; therefore, in this study, a teaching experiment was conducted in a statistics course.

2.2. Blended learning

In a broad sense, blended learning refers to the combination of two or more instruction methods or media learning activities; thus, the traditional classroom instruction in combination with extracurricular practice is one type of blended learning. However, after the rapid growth of the computer and its use in education and training, blended learning tends to be defined, in a narrow sense, as the combination of face-to-face (traditional classroom learning) and technology-based learning (Stubbs, Martin, & Endlar, 2006).

Although e-learning has its own advantages when compared to traditional classroom instruction, it has its disadvantages as well. The first disadvantage is that there are fewer interactions among students. Second, its degree of freedom is too high to be manageable. Third, there is less communication between teachers and students (Kuo, 2009). As a result, a new learning model that combines the advantages of classroom instruction with those of e-learning, but without the shortcomings of either, has been developed. This blended learning, which effectively combines C with E, and relevant studies on it have also become an important field of research in contemporary education.

There are three general definitions of blended learning: (1) the blending of different instructional media; (2) the blending of different instructional strategies; and (3) the blending of different instructional environments (Rooney, 2003; He & Chen, 2008). Tsou (2003, 2007) indicated that blended learning comprises, at least, the blending or combination of the following four different methodologies:

1. The blending of different learning contents and the addition of technology-based-learning, such as e-learning or the virtual classroom.
2. The combination of different instructional methods (behaviorist, cognitivist, and constructivist).
3. The blending of different types of instructional technologies (face-to-face, Internet, and CD-ROM).
4. The integration of instructional technology with practical instructional activities.

The major reason for adopting a blended learning approach is to improve pedagogy. The attraction of blended learning is that it combines the advantage of face-to-face teaching (social interaction and inspiration) and on-line instruction (flexibility of access) (Williams, Bland, & Christie, 2008). When "blending" was first applied to distance education, it was referred to as "hybrid," which was developed by the combination of e-learning with traditional learning methods. In Taiwan, the earliest prototype of blended learning was the use of television or broadcasting, which was used to transmit courses, in combination with classroom instruction for assisting students in reviewing key aspects and solving problems. This type of blended learning was found primarily in open universities or open colleges of business. The advantages and characteristics of blended learning can be described in the following manner:

- **Improving the quality of manpower and enhancing performance**

The promotion of effective blended learning programs can improve the quality of organizational manpower and is helpful in improving organizational performance. Three major key factors affecting the costs of blended learning are: the number of learners, learning media that is adopted, and information infrastructure.

- **Innovation of effective learning**

E-learning in which only online instruction method is used, will affect learning effectiveness. The introduction of blended learning has changed the focus of learning onto learners and is regarded as an effective and innovative idea because learners can actively explore content and absorb knowledge.

- **No "general" blended strategy**

There is no "general" strategy for blended learning that applies to all learning problems and situations. The blending of various learning media depends on the nature of problems and characteristics of learners.

- **Effective improvement of learning quality**

Through the application of various learning media, the learning process can be more flexible and effective.

Table 1 summarizes all the blended learning media. Different learning media possess different learning values, learning scales, development costs, feasibility assessment, and traceability. In order to choose the most suitable combination of blended learning media, curriculum designers and instructors can perform a comprehensive assessment according to learning objectives, student characteristics, and resources and conditions possessed.

Table 1: Assessment of blended learning media

Characteristics / Media types	Learning value	Learning scale	Implementation duration	Development cost	Implementation cost	Feasibility assessment	Traceability
Classroom training	H	L	3–6 wks	M	H	M	L
CD-ROM	H	H	6–20 wks	H	M	H	L
Conference calls	L	M	0–2 wks	L	L	N/A	N/A
Online or computer simulations	Very H	M	8–20 wks	H	M	H	H
Lab-based simulations	Very H	L	3–6 wks	H	H	M	M
Job aids or handbooks	L	H	0–3 wks	L	L	N/A	N/A
Web pages	L	H	1–8 wks	L	L	N/A	N/A
Web sites	L	H	1–8 wks	L	L	N/A	N/A
Mentors	M	L	2–3 wks	H	H	L	L
Chat rooms or online forums	M	L	4–6 wks	M	M	N/A	L
Video (VCR/Online)	H	M	6–20 wks	H	H	N/A	L

Technological revolution has altered the blending of learning models. In response to technological trends and the tendency toward technological expansion, most future learning models will be based on blended learning (Rooney, 2003). Maximizing the success of blended learning requires a planned and well-supported approach, which includes a theory-based instructional model, high-quality faculty development, course development assistance, learner support, and ongoing formative and summative assessment (Dziuban, Hartman, & Moskal, 2004).

Because material for computer-assisted

programmed instruction is one part of electronic material, the C + E learning developed in this study mainly combines traditional classroom learning (C) with computer-assisted programmed instruction (E). Traditional classroom instruction (or instruction) is mainly teacher-oriented, while the learning through computer-assisted programmed instruction is an after-class learning activity, which is mainly student-oriented.

3. METHODOLOGY

3.1. Research Tools

The functions of multimedia and hyperlinks in current information technology have substantially realized the advantages of programmed instruction. Therefore, in order to fully put programmed instruction into practice, first, the CAI materials were developed in this study in the following manner:

1. The arrangement of instructional units is in order:

All the teaching materials are systemically organized according to the logical progression of learning units or difficulty levels.

2. The font is large and clear, and the focuses are highlighted:

A large font on a computer screen facilitates reading. The use of specific font types or highlighted texts emphasizes the focus of the learning units, which helps to attract the students' attention and strengthen their memory.

3. The use of voice reminders increases understanding:

The use of voices in more complicated or difficult learning units helps to remind students of a unit's focus and can provide a more simplified explanation in order to immediately strengthen the impression and assist students in understanding.

4. Rapid interactive responses save time:

Due to the rapid response of hyperlinks, this material for computer-assisted programmed instruction can provide instant feedback on students' formative assessment of performance in order to increase learning effectiveness.

5. Progressive learning provides a well-established learning foundation:

Students are not allowed to begin a subsequent unit unless they have given the right answers to the formative assessment of the preceding unit.

6. Progress can be adjusted according to personal needs:

For answers to the example questions or formula verification of the material for computer-assisted programmed instruction students can choose whether to read the "solution explanation" or skip it and directly begin the next new unit, according to their own needs and preferences. Thus, students can adjust their learning progress according to their own capabilities and needs.

3.2. Research Procedures

The subjects of this study were students of statistics courses in the department of business administration at a university of technology. The material for computer-assisted programmed instruction developed for this study was used for an after-class learning activity in order to conduct the experiment and compare the results. The results obtained from the experiment were intended for use in investigating the actual contribution of "C + E blended learning" model designed in this study for the teaching of statistics.

3.2.1. Samples and grouping

The subjects were students taking statistics courses in two classes in the department of business administration at a university of technology in 2010. In order to avoid the Hawthorne effect caused by the subjects' intentional efforts or performance improvement due to possible increased attention, students' original classes were used as the grouping units to randomize one class as the experimental group and the other as the control group.

3.2.2. **Model of experimental design**

Nonequivalent control group pretest-posttest design was employed in this study. The experiment and its processing are described in the following manner:

Experimental group	O_1	X_1	O_2
Control group	O_3		O_4

O_1, O_3: pretests

O_2, O_4: posttests

X: Instruction in the experiment

3.2.3. Experimental procedures

(1) The original classes were used as grouping units. The experimental group received the “C + E blended learning” designed in this study, while the control group received traditional classroom learning.

(2) The statistics final examination scores of the students in both groups in the first semester were regarded as the pretest scores.

(3) The same instructor taught both statistics courses for both groups; therefore, the students were familiar with and adapted well to the instructor’s methods and teaching style during the experiment.

(4) During the experiment, both groups were taught by the same teacher, and the course contents, progress, and assessment (e.g., assessment method and test questions) all remained the same; the only difference was the after-class individual study method. Material for computer-assisted programmed instruction was offered in the experimental group, while traditional textbook instruction was used in the control group. In addition, during the experiment, the teacher did not mention the ongoing experiment in order to avoid interruption due to irrelevant factors. Hence, the students in the two groups could not perceive any difference psychologically.

(5) The experiment lasted for a total of four weeks. “Common probability distribution” was chosen as the teaching unit for both groups in the experiment. After the completion of the experiment, the two groups received the same learning performance assessment test. Moreover, a questionnaire survey was conducted for students in the experimental group in order to investigate their response to the use of material for computer-assisted programmed instruction.

4. RESULTS AND DISCUSSIONS

4.1. T-test on the pretest scores of the two groups

The statistics final examination scores of both groups in the first semester were employed as pretest scores. In other words, the pretest scores were used as the entry behavioral indicator at the beginning of the experiment. As shown in Table 1, the t-test on the pretest scores of the two groups indicated that there was no significant difference in pretest scores between the two groups ($p > 0.05$), thereby suggesting that the learning level for statistics of the two groups were quite consistent.

Table 1 t-test on pretest scores

Groups	Mean	t-value	p-value
Experimental group	82.8605	1.131	0.291
Control group	84.8974		

* $p < 0.05$

4.2. ANCOVA on the posttest scores of the two groups

1. In the experimental design of grouping, one class of students was randomized as the experimental group, and the other was randomized as the control group. After the completion of the experiment, ANCOVA was performed in order to test the difference in posttest scores between the two groups. In other words, the students' learning level of statistics (pretest scores) before the experiment was used as covariance. Regression analysis was employed in order to eliminate the possible influence of pretest scores on the experimental result (posttest scores). Thereafter, ANCOVA was performed on the mean difference in scores in order to determine whether there was a statistically significant difference in the leaning performance of the two groups. Furthermore, the difference between the "C + E blended learning" designed in this study and the traditional instruction was also inferred.

2. As indicated in Tables 2 and 3, after the posttest scores of the groups were adjusted by ANCOVA, the mean score of the experimental group was 72.962 (Table 2) and that of the control group was 55.298. The F-value obtained from the F-test of ANCOVA was 25.819 (Table 3) and $\alpha = 0.001$, thereby suggesting that there was a significant difference between the two groups.

Therefore, the result of ANCOVA indicated that the learning effectiveness of "C + E blended learning" developed in this study was significantly better than that of traditional instruction. Specifically, in terms of statistics instruction at the department of business administration at the university of technology, the material for computer-assisted programmed instruction developed in this study increases learning effectiveness when compared to general textbook instruction.

Table 2 Posttest mean score

	Number of subjects	Mean	Adjusted mean	Standard deviation
Experimental group	43	71.9535	72.962	2.389
Control group	39	56.4103	55.298	2.509

Table 3 ANCOVA

	SS	Df	MS	F	Sig
Between-group	6291.179	1	6291.179	25.819	P<.001
Intragroup	19249.252	79	243.661		

4.3. Analysis on the experimental group's evaluation of the material for computer-assisted programmed instruction

1. Response to the production quality of the material for computer-assisted programmed instruction: As indicated in Table 4, when compared to general textbook instruction, 83.72% of the students were satisfied with the voice quality of the material for computer-assisted programmed instruction, and 62.79% were satisfied with character quality (font size and readability). With regard to the two questions mentioned above, over half the students suggested that the material for computer-assisted programmed instruction was better than general textbooks. However, in terms of the layout (colors, diagrams, typesetting, etc.) of the CAI material, less than half (48.84%) suggested that the teaching material was better than general textbook. Thus, it could be inferred that, in terms of the production quality of teaching materials, the overall quality of the material for computer-assisted programmed instruction was slightly better than general textbook instruction. However, in terms of artistic design and layout, there was still room for improvement because the materials were not designed by a well-trained layout designer.

Table 4 Analysis of the production quality of material for computer-assisted programmed instruction

Questions	Better	Same	Worse
Layout quality	21 (48.84%)	21 (48.84%)	1 (2.32%)
Font quality	27 (62.79%)	12 (27.91%)	4 (9.30%)
Voice quality	36 (83.72%)	7 (16.28%)	0 (0%)

N = 43

Table 5 Students' satisfaction after the use of material for computer-assisted programmed instruction

Questions	Good	Normal	Bad
Adaption level	25 (58.14%)	15 (34.88%)	3 (6.98%)
Beneficial to learning	25 (58.14%)	16 (37.21%)	2 (4.65%)
Willing to continue to use it personally	29 (67.44%)	13 (30.23%)	1 (2.33%)
Willing to recommend its use to other people	27 (62.79%)	15 (34.88%)	1 (2.33%)

N = 43

2. Students' evaluation after the use of the material for computer-assisted programmed instruction

(1) Opinions on the level of adaption to CAI material:

Table 5 indicates that 58.14% of the students suggested that they adapted to the material well, while 6.98% did not adapt well. Thus, most of the students in the experimental group adapted to the material for computer-assisted programmed instruction.

(2) Opinions on whether the material for computer-assisted programmed instruction was beneficial to learning:

As shown in Table 5, 58.14% of the students suggested that the material for computer-assisted programmed instructions was better than the general statistics textbook; 37.21% suggested that there was no significant difference between them, and 4.65% suggested that the CAI material was worse than the general textbook. However, a majority of students still suggested that the material for computer-assisted programmed instruction was beneficial to the learning of statistics.

(3) Opinions on the willingness to continue to use material for computer-assisted programmed instruction:

Approximately 67.44 % of the students were personally willing to continue to use material for computer-assisted programmed instruction, and only 2.33% were not. Moreover, 62.79% of the students were willing to recommend the material for computer-assisted programmed instruction to other people, and only 2.33% were not. It could be inferred that more than half of the students in the experimental group had a positive opinion of material for computer-assisted programmed instruction; they were willing to continue to use it and were willing to recommend it to others.

The results of the questionnaire survey mentioned above indicated that more than 80% of the students in the experimental group could adapt to the material for computer-assisted programmed instruction, and almost half evaluated it positively. They affirmed that the CAI material was beneficial to the learning of statistics; thus, they were willing to continue to use it and recommend it to others.

This study investigated whether the "C + E blended learning" model could make a substantial contribution to statistics instruction at a university of technology. First, material for computer-assisted programmed instruction was developed; thereafter, the teaching experiment on "C + E blended learning" was immediately conducted after the completion of learning of the material.

During the production of the teaching material, it was found that due to the convenience of modern information technology, such as multimedia, hyperlinks, and interactive responses, the production quality of the material for computer-assisted programmed instruction was substantially increased. After the teaching experiment was conducted for one month, the two groups were asked to take the same learning performance test. ANCOVA was performed in order to analyze their posttest scores. It was found that the scores of the students receiving "C + E blended learning" were better than those receiving traditional classroom learning. In other words, in terms of statistics instruction, the use of material for computer-assisted programmed instruction developed in this study improves students' learning performance more than traditional classroom learning.

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