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The Study of Blended Learning on a Vocational High School in Taiwan

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***Abstract*—** With the contributions of computer technology, digital learning has evolved into a stage of mobile learning. However, school classes require teachers to perform face-to-face humanized lectures. Digital learning remains to function as a tool for assisted teaching. Few studies have investigated what proportions digital learning should occupy in teaching activities. In this study, to investigate the optimal proportion of face-to-face instructions and digital learning, we conducted a one-semester teaching experiment on two classes of students in the informatics department in a public vocational high school in Taipei City. In addition, the Kruskal-Wallis one-way analysis of variance was adopted for the statistical analysis to determine the optimal blending proportions. Our results indicate that optimal effects are achieved at a time ratio of 2:1 of traditional face-to-face teaching to digital learning.

***Index Terms*—** Blended learning, Digital leaning, Kruskal-Wallis

I. INTRODUCTION

Since the emergence of computer-assisted teaching in the 1980s and the progress in computer technology and the Internet, digital learning has become a novel model for teaching activities [1]. However, because learners typically lack self-learning impetus, skills related to time management, and communicative capacities, digital learning remains an assistant learning method that cannot fully replace in-class courses [2]. In addition, Parker [3] considered traditional face-to-face teaching to be an effective method for cognition construction that provides instantaneous responses between teaching and learning, thereby enhancing learning results. Consequently, since 2000, scholars have proposed blended learning, which combines the advantages of traditional face-to-face learning and digital learning [4,5], to improve teaching effects[6,7-8].

The learning field of blended learning includes the traditional classroom and digital learning, and blended learning's teaching ideals, subject content, teaching media, student maturity, and learning hours are mutually influential. Several studies have examined the blending of synchronous and asynchronous teaching[9,10,11], cooperative and conventional learning[11], physical and digital courses[12,13,14], and digital teaching media[15,16,17], most of these studies have focused on the learning processes of learners[18,19,20,21,22]or the construction of digital platforms[23,24,25]. In addition, the blending of materials [26,27] or delivery[6,7-8,28] have been investigated. However, the number of studies on the blending proportions of face-to-face and digital teaching remains insufficient. In this study, we attempted to identify the optimal blending proportion for the elevation of learning results.

II. INVESTIGATION OF BLENDED LEARNING

Blended learning is a popular teaching method that facilitates the effectiveness of educational training in addition to digital learning [6,7,8]. Numerous studies have contended that blended learning can effectively solve the problems identified by teachers and learners during the promotion of digital learning, including frustrations experienced during learning, criticisms incurred, and the suspension of development. Furthermore, blended learning is considered the most potential method for digital learning promotion[26]. Despite its relative newness, the concept of blended learning has been adopted in educational applications for years, including face-to-face educational training aided by video conferencing, extension of discussions or educational training fields through email or listservs, and multi-site live broadcasting through TV.

A. The meaning of blended learning

Western scholars have attempted numerous investigations on blended learning. Bersin[6] proposed a method of blended learning that includes the application of differing types of learning tools, such as real-time cooperative learning software, self-regulated Internet courses, electronic performance support systems (EPSS) adopted in work environments, and knowledge management systems. Blended learning integrates event-based activities such as face-to-face in-class learning, real-time digital learning, and self-oriented learning. Therefore, blended learning typically combines traditional instructor-led training, synchronous online conferences or training, asynchronous self-oriented learning, and structured on-the-job training guided by experienced instructors. In addition, Valiathan[28] contended that blended learning is a learning method that integrates various delivery methods of educational training, such as applications of cooperative learning software, online courses, EPSS, and knowledge management tools, thereby blending various event-based learning activities, including face-to-face in-class learning activities, real-time digital learning, and self-oriented teaching activities. Consequently, blended learning integrates miscellaneous learning media, including instructor-led courses, software for Internet-assisted teaching, teaching simulations, job aids, Webinars, or documents, by incorporating these media into a specific and complete training plan to fulfill the goal of the training plan and to resolve specific problems encountered by organizations [6]. The greatest advantage of blended learning, in addition to being cost-effective, is its capability of providing diverse and abundant learning channels and social interactions for learners to discover more pathways leading to their desired knowledge. In addition, Smith[7-8] defined blended learning as a method of integrating information technology (e.g., satellite TV, Internet, and videoconferencing) with traditional educational training to achieve distance learning. Consequently, learners can engage in independent learning that is flexible and not restricted in time and space, and obtain the content of educational training through multiple channels. Troha [29] and Bersin [6] further regarded blended learning as the evolution product of digital learning, that is, blended learning is the combination of digital learning and other forms of training delivery methods (typically face-to-face education training). Summarizing the aforementioned definitions, we consider blended learning as a method that synthesizes two or more teaching media or educational training methods to facilitate the initiation of learning. Because of the rapid development of teaching technology and continuous changing teaching methods, blended learning is increasingly defined as a teaching method that integrates traditional in-class courses with online learning and offers efficient and effective learning experience to learners with integrated and diverse delivery modalities of educational training. Furthermore, blended learning provides an alternative route of leaning for learners who are used to or prefer traditional lectures but are in environments with thriving development that are being influenced by the digital learning trend.

Because blended learning has been commonly applied to standard, non-standard, and unofficial learning activities, numerous organizers of teaching activities and related researchers have paid close attention to the question how a blended learning method can be appropriately organized to maximize its effect. According to Bersin [6], blended-learning planning should consider and evaluate the following six relevant conditions: audience, time, scale, application, content, and resources. In addition, to devise a successful plan for blended learning, organizers must meticulously assess the following four variables:

1. Training condition
2. Available resources
3. Target audience
4. Content characteristics

Summarizing the mentioned suggestions for the development of blended learning, in this study, in addition to combining the principles of these suggestions, we considered the particularity of learners and the characteristics of electronics, a basic subject in engineering school education. We defined the questions and procedures that formed our objectives, designed and developed an optimal blended learning model, and analyzed relevant applications to devise the optimal blended learning model and an optimal blended learning promotion mechanism to assist college students in achieving optimal personal and professional development and to effectively support the management of electronics in schools and resolve relevant problems.

B. Relevant studies on blended learning

According to Cheng[30] and Bersin[6], if actual operations are involved in digital teaching, a real environment should be simulated for teaching. The requirement to transform materials containing only texts and graphical information to actual operations is highly difficult and ineffective for learners. Therefore, a simulated teaching environment should be provided for the teaching of science, technology, and skills.

Jaakkola[31] randomly separated 66 students who were 10 to 11 years old into three groups: only LOs (learning objects); only traditional materials; a combination of traditional materials and LOs. A pre-test was administered before the teaching experiment on the basics of electricity commenced. The results showed that the combination group had the best teaching results.

Huang et al. [17] adopted methods that include the construction of teaching websites, online test examinations, group discussions, and a questionnaire survey to examine the correlation among four factors of blended learning (i.e., learning community, learning motivation, course content, and learning results), learners' backgrounds (i.e., gender, department, grade), average time of computer usage, and motivations of computer usage. The results showed that learners in various departments and with different motivations for computer usage significantly differed in learning results.

No significant differences exist in learning communities regarding gender,and learning motivations and course content are positively correlated. In addition, Huang et al. suggested that learners' progresses should be recorded online and analyzed to determine their learning difficulties.

Lin [30] used the case study method and selected two successful and representative online courses, e-learning theory and practice and computer networks, to conduct his study. The research data were collected using an observational survey and an interview survey. After the data were encoded, and relationships between the index terms were recombined, Lin interpreted the data and proposed five synchronous blended teaching models and a superior method for teaching environment design in synchronous blended classrooms.

Chen [13]examined the influences on learning results of applying online blended learning to an Introduction to Computer Networks class, in which 41 college freshmen were chosen as the participants. These results were influenced by online learning frequency and peer interaction within groups. In-class courses include lectures by teachers and actual operations of relevant network equipment by groups of students according to weekly learning subjects. Online courses provide a teaching platform to which digital materials designed based on weekly subjects can be uploaded, and students can learn related knowledge on the Internet.

Summarizing the mentioned conclusions and suggestions of previous studies on the development of blended learning, we identified the optimal blending proportions of traditional learning to digital learning.

III. EXPERIMENTAL DESIGN

A. Research structure

To examine the learning results and satisfaction degrees regarding electronics courses using blended learning strategies of various proportions, we defined our independent variables as the blending proportions (i.e., 3:1, 2:1, and 1:1) of traditional in-class learning to digital learning, and our dependent variable as learning effects. Figure 1 shows our research structure.

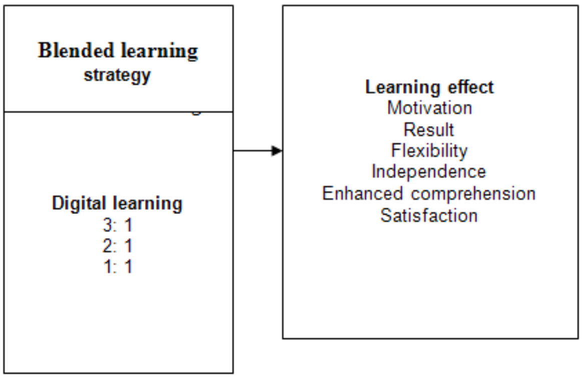

Figure 1: Research structure

B. Methods

In this study, we adopted the mixed-sample nonequivalent pretest-posttest design and conducted a questionnaire survey to elucidate how students react under various blended learning strategies. The experiment group in this study consisted of students learning with different blending proportions, and the control group comprised students who listened to traditional lectures. Following 18 weeks of blended teaching experiments, we ascertained the differences in students' motivations, results, flexibility, independence, enhanced comprehension, and satisfaction by conducting questionnaire surveys.

C. Participants

The participants of this study comprised students from two classes in the electrical department in a public industrial vocational high school in Taipei City, with an experiment group of 38 students and a controlled group of 36 students for a total of 74 students. Students who studied in this electrical department passed the Basic Competence Test for Junior High School Students and were placed in this school, in which students were randomly assigned to classes. Therefore, this study corresponded to random and normalized distribution. Carryover effects were small because the participants engaged in experimental teaching with differing contents. In addition, the students who were not involved in the entire process were regarded as attrited samples, thereby reducing the number of participants to 31 students in the experiment group and 35 students in the controlled group for a total of 66 students.

D. Limitations

This study examined the influence of differing proportions of blended learning strategies on learning effects. In addition, we examined learning results through self-reported scales to assess the learning effects in various learning models rather than drawing a comparison using quantified grades. Therefore, this study focused on the comparison of students' degrees of subjectivity following the experiments. Because our target was electronics departments in vocational high schools, our results should not serve as a basis for other subjects.

E. Experimental procedures

Differing amounts of time for in-class learning and digital learning were blended. For example, "3:1" indicated a proportion of 3h of in-class learning to 1 h of digital learning. Therefore, more time was spent on face-to-face lectures. If the proportion was 1:1, the two learning methods occupied the same amount of time. To test the responses of the same learner under various blending proportions, only one participant was tested in each stage.

We divided the content of an electronics class into three stages for our teaching experiments. These stages were as follows:

Stage 1: This 6-week stage had a blending proportion of 3:1, that is, 15 sessions of traditional courses and 5 sessions of digital courses. The content in Stage 1 consisted of “Introduction to Waves,” “Intrinsic, P-, and N-Type Semiconductors,” “Biased Diodes,” “The I-V Curves of Diodes,” “The Equivalence Circuits of Diodes,” “Zener Diodes,” “Light-Emitting Diodes,” and “Rectifier Circuits.”

Stage 2: This 6-week stage had a blending proportion of 2:1, that is, 16 sessions of traditional courses and 8 sessions of digital courses. The content in Stage 1 consisted of “Filter Circuits,” “Voltage Doubler Circuits,” “Wave-Carrying Circuits,” “Clamping Circuits,” “Bipolar Transistors,” “Transistor Amplification,” and “Transistor as Switches.”

Stage 3: This 6-week stage had a blending proportion of 1:1, that is, 12 sessions of traditional courses and 12 sessions of digital courses. The content in Stage 3 consisted of “DC Operating Point,” “Fixed Bias Circuits,” “Feedback Bias Circuits,” “Voltage Division Bias Circuits,” “The Principles of Transistor Amplifiers,” “AC Transistor Equivalence Circuits,” “Common Emitter Amplifier Circuits,” “Common Collector Amplifier Circuits,” and “Common Base Amplifier Circuits.”

F. Research Tools

Consulting relevant studies on learning effects, we constructed our research tool, that is, questionnaire of the current status of blended learning for electronics in vocational high schools. This questionnaire consisted of six dimensions (i.e., motivation, result, flexibility, independence, enhanced comprehension, and satisfaction), and each dimension comprised four learning strategies (i.e., 3:1, 2:1, and 1:1 blended strategies and traditional learning). Participants underwent assessment through retrospection and answered the questionnaire according to a scale in which 4 denoted 4“totally satisfied,” 3 “very satisfied,” 2 “Somewhat satisfied,” and 1 “ little satisfied.” A higher score indicated that students agreed that the specific learning strategy could elevate learning effects and satisfaction. This research tool possessed validity because the adequacy, text structures, and text fluency of its questions were assessed by experts.

IV. STATISTICAL ANALYSIS

This study used the Kruskal-Wallis one-way analysis of variance to test for differences of order in learning effects influenced by learning strategies of various proportions. The results of our statistical analysis are shown in Table 1. The summarized results of the six dimensions are provided below.

1. Regarding motivation, $\chi2 = 52.301$ and $p = .000 < .05$, and a significant difference existed. Blended learning strategies of various proportions showed significant differences in elevating students’ motivation, and the effect levels of the strategies, in a descending order, were 2:1, 1:1, 3:1, and traditional learning.

2. Regarding learning results, $\chi2 = 45.416$ and $p = .000 < .05$, and a significant difference existed. Blended learning strategies of various proportions showed significant differences in elevating students’ learning results, and the effect levels of strategies, in a descending order, were 2:1, 3:1, 1:1, and traditional learning.

3. Regarding learning flexibility, $\chi2 = 52.213$ and $p = .000 < .05$, and a significant difference existed. Blended learning strategies of differing proportions showed significant variations in elevating students’ flexibility, and the effect levels of the strategies, in a descending order, were 2:1, 1:1, 3:1, and traditional learning.

4. Regarding learning independence, $\chi2 = 44.003$ and $p = .000 < .05$, and a significant difference existed. Blended learning strategies of various proportions showed significant difference in elevating students’ independence, and the effects levels of the strategies, in a descending order, were 2:1, 3:1, 1:1, and traditional learning.

5. Regarding enhanced comprehension, $\chi2=11.873$ and $p =.000 <.05$, and a significant difference existed. Blended learning strategies of various proportions showed significant differences in elevating students’ comprehension, and the effect levels of the strategies, in a descending order, were 2:1, 3:1, 1:1, and traditional learning.

6. Regarding learning satisfaction, $\chi2 = 33.499$ and $p = .000 < .05$, and a significant difference existed. Blended learning strategies of various proportions showed significant differences in elevating students’ satisfaction, and the effect levels of the strategies, in descending order, were 2:1, 3:1, 1:1, and traditional learning.

Table 1： Test results for the differences of order in learning effects influenced by learning strategies of various proportions.

Dimension	Blending proportion	Mean rank	χ2	df
Motivation	3:1	76.50	***52.301	3
	2:1	100.50		
	1:1	79.50		
	Traditional learning	33.50		
Results	3:1	85.50	***45.416	3
	2:1	100.50		
	1:1	63.50		
	Traditional learning	40.50		
Flexibility	3:1	77.50	***52.213	3
	2:1	100.50		
	1:1	78.50		
	Traditional learning	33.50		
Independence	3:1	83.50	***44.003	3
	2:1	96.50		
	1:1	73.50		
	Traditional learning	36.50		
Enhanced comprehension	3:1	76.50	***11.873	3
	2:1	89.50		
	1:1	59.50		
	Traditional learning	64.50		
Satisfaction	3:1	85.50	***33.499	3
	2:1	90.50		
	1:1	73.50		
	Traditional learning	40.50		

V. CONCLUSIONS AND SUGGESTIONS

The inclusion of informatics is inevitable for teaching, and, in the digital era, students of the S-generation can be described as digital aboriginals because of their habits and fascination in the utilization of computer networks. Methods for vitalizing teaching and providing adequate assistance for learners have become a critical profession that requires more attention in the education reform. To facilitate practical reforms in the educational field, further suggestions for the science of educational fields should be proposed in addition to active promotion.

A. Conclusions

Conclusions are provided according to our results and statistical analyses. The conclusions are as follows:

1.Blended learning strategies outperforms traditional in-class learning :In all experiments conducted in our study using various blending proportions of traditional in-class learning to digital learning (3:1, 2:1, and 1:1), digital learning outperformed traditional learning in all six dimensions (motivation, results, flexibility, independence, enhanced comprehension, and satisfaction). We propose that blended learning not only improves students' learning performance, but learners can attempt self-dependent learning to resolve confusion. Learners are therefore provided with the opportunity of self-regular learning, which allows them to engage in broader and more in-depth learning experiences.

2.The optimal blended learning proportion of in-class learning to digital learning is 2:1 :In this study, we found that the optimal blended learning proportion of in-class learning to digital learning was 2:1, followed by 1:1 and 3:1. This indicates that, regarding lectures taught by teachers in school, traditional face-to-face teaching fails to optimize students' results. However, digital learning can yet to replace the role of an "instructor." Therefore, the optimal blended learning integrates the major learning method (traditional face-to-face learning) with the assistant learning method (digital learning) to construct a teacher-student teaching-learning strategic model with the optimal blending proportion (2:1) of in-class learning to digital learning.

B. Suggestions

Based on our conclusions, we provide several suggestions for future studies, educational administrative institutions, subject advisory groups, and schools in putting our study to practical use. The suggestions are as follows:

a) For future researchers

This study can be expanded to examine learners' non-intellectual factors, including learning style and prior knowledge under differing blended-learning proportions. This assessment can be used to study these non-intellectual factors' roles as mediators or moderators under differing proportions.

b) For educational administrative institutions

Educational administrative institutions can perform research on blended learning methods of various proportions in schools of different counties with differing styles to determine the optimal blending proportion for these schools.

c) For subject advisory groups

Advisory groups of different subjects can adopt studies on the optimal blending proportions for various subjects.

d) For schools

To achieve optimal blended learning results, schools can perform research on blended learning with different subjects, grades, and proportions.

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