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Effects of Semi-Finished Products as a Scaffolding on University Liberal Art Students' Learning of Multimedia Technology and Webpage Producing

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Abstract

This paper presents a study carried out at Beijing Normal University with the aim of investigating whether semi-finished products could affect liberal arts students' *mastery of knowledge*, *mastery of operational skills* and *ICT self-efficacy* in multimedia creation. The literature has argued that obstacles in creating multimedia artifacts lead liberal arts students to have low ICT self-efficacy. Semi-finished products are used as a scaffolding to facilitate liberal arts students' creation of multimedia artifacts, such as Flash animations and interactive web-pages. However, empirical research on the effects of such scaffolding is lacking. We conducted a quasi-experiment in which we compared an experimental class of 117 students majoring in History with a control class of 102 students majoring in Chinese Language and Literature who took a Multimedia Technology and Webpage Producing (MTWP) course. The experimental class (revising condition) used semi-finished products to develop animations and web-pages while the control class (creating condition) developed animations and web-pages from scratch. Data were collected through a Knowledge and Skill Test and a Scale on ICT self-efficacy. T-tests were used to compare outcomes of the two conditions. Results revealed that students' *mastery of knowledge* in the revising condition was significantly higher than students in the creation condition, but there were no significant differences between the two conditions in terms of students' *mastery of operational skills*. Results also showed that there were significant differences between the two conditions in terms of students' *ICT self-efficacy*. Further analysis indicated that students' *ICT self-efficacy* in the revising condition improved significantly from pre-test to post-test, while those in the creating condition declined, but it was not significant. Implications for ICT teaching in higher

education were discussed.

Keywords

Multimedia, Webpage, Semi-Finished Products, Creating from Scratch, ICT Self-Efficacy

1. Introduction

Information and Communication Technology (ICT) literacy was defined as the ability of "using digital technology, communications tools, and/or networks to access, manage, integrate, evaluate, and create information in order to function in a knowledge society" (Panel, 2002). ICT literacy is not only required by ICT practitioners but essential for every digital citizen. In order to equip students with necessary ICT competency, ICT related courses are widely taught to students in various schools at all levels, ranging from elementary schools to universities. In China, universities have offered a set of common required ICT courses to their students, aiming to improve students' ICT skills, computational thinking and design thinking. At Beijing Normal University (BNU), Multimedia Technology and Webpage Producing (MTWP) is one of the common required ICT courses offered to liberal arts students, while science and engineering students learn to program.

The Design-Based Learning (DBL) strategy is commonly adopted as an effective strategy by many MTWP teachers. In this approach, students are required to design multimedia artifacts with specific software tools, such as Photoshop, Flash and Dreamweaver. Some teachers prefer to require students to create new works from scratch, while some others prefer to provide students with existing semi-finished products as a scaffolding.

However, empirical investigations addressing the effects of such scaffolding are lacking. Such empirical investigations would provide concrete prescriptions for improving both MTWP teaching and learning. In order to address this gap, a quasi-experiment was designed and conducted to investigate whether students in the revising condition (revising semi-finished products) could achieve better results than those in the creating condition (creating artifacts from scratch) in terms of students' mastery of knowledge, mastery of operational skills and their ICT self-efficacy when learning to design Flash animations and web-pages. More specifically, this study aimed to answer the following three research questions:

1) Which type of DBL, *revising semi-finished products* or *creating from scratch*, had a better effect on students' *mastery of knowledge* about MTWP?
2) Which type of DBL, *revising semi-finished products* or *creating from scratch*, had a better effect on students' *mastery of operational skills* about MTWP?
3) Which type of DBL, *revising semi-finished products* or *creating from scratch*, had a better effect on students' *ICT self-efficacy*?

2. Literature Review

2.1. Teaching MTWP in Universities

In recent years, ICT courses, in which MTWP is an important component, have been paid more and more attention in various schools at all levels. In precollege period, ICT have already been taught to students as compulsory courses. However, due to its absence in all levels of entrance examinations, the effects of ICT courses implemented in primary, secondary and high schools are not that high. As revealed by the placement tests on computer proficiency organized annually by Beijing Normal University for freshmen at the very beginning of their campus lives, a large proportion of students were relatively short of ICT knowledge and skills.

According to the interviews with some students and ICT teachers, two key reasons are revealed to be responsible for this "high input but low output". From one hand, MTWP courses have been implemented as theoretical courses rather than skills-oriented ones in many schools. Students just need to simply memorize and recite declarative knowledge required by examinations while ignoring hands-on skills. Since systematic knowledge was usually separated into fragmented knowledge points, students' ICT skills did not improve significantly even they got very high score in exams. From another hand, in order to overcome the theorizing of skill-oriented course, artifacts design approach has been widely adopted in MTWP teaching. However, many students have difficulties in getting the work started when designing relative complex artifacts. In return, students' self-confidence and ICT self-efficacy are negatively affected.

2.2. Design-Based Learning

Borrowing features from problem-based learning and project-based learning (Puente, Van Eijck, & Jochems, 2011), design-based learning (DBL) is an instructional approach which enables students to learn domain knowledge and real-life skills through engaging in designing project-like works in contextual and authentic situations (De Vries, 2006). DBL is first employed in higher engineering education (Puente, Van Eijck, & Jochems, 2011). Gradually, DBL has been studied in secondary science education (Ellefson, Brinker, Vernacchio, & Schunn, 2008). Recently, DBL has also been applied to computer education (Ke, 2014).

DBL has several advantages. First, students are motivated to learn more to imply their knowledge to make good design. Second, DBL is an active learning process which can change the teachers' role from lecture to students' tutor, guider and partner. Besides, students construct their own knowledge instead of memorizing and doing exercises or homework through DBL process. Third, DBL is typically a tem activity, thus promoting collaborations among students (Doppelt, Mehalik, Schunn, Silk, & Krysinski, 2008). Finally, DBL promotes students to combine "hands-on" and "hands-in" activities with meaningful learning in the process of creating works (Doppelt & Barak, 2002).

However, DBL may encounter some difficulties and challenges for students'

learning. The prior research revealed that students can be engaged in design visual or technical works rather than content exploration or the development of formal knowledge (Kafai, 2012; Kolodner et al., 2003). It is challenging to correctly link the design activities to the targeted domain content (Ke, 2014). Besides, research by De Vries (2006) pointed out that the open-ended nature of design may leave the low-achievers behind.

DBL has been applied in MTWP in BNU for several years. Generally, students are asked to design a Flash animation or Webpage from scratch within a given theme such as an introduction of their hometowns. This teaching model has caused some problems for the students. Firstly, due to the unfamiliar with the basic knowledge and operation skills, the works designed by students rarely have high quality. Secondly, difficulties in designing works have led to a decrease in students' self-efficacy in multimedia learning. Thus, the design process and scaffolding need careful consideration.

2.3. ICT Self-Efficacy

Self-efficacy is an individual's belief about their ability to achieve goals (Bandura, 1982), while ICT self-efficacy is defined as an individual's belief towards his/her own ability to utilize ICT, and has a significant and positive effect on decisions relevant to ICT adoption and usage (Compeau & Higgins, 1995; Hsu & Chiu, 2005). In this study, students' ICT self-efficacy is related to their belief about their ability to design Flash animations or webpages. Compared with traditional competence in specific ICT skills, ICT self-efficacy is considered to be far more important. With the constantly changing of ICT technology and applications, individuals with high ICT self-efficacy would have sufficient confidence and flexibility to adapt (Rush, 1998; Sam, Othman, & Nordin, 2005). The people who have strong ICT self-efficacy believe that the difficulties in using ICT can be challenged and achieved, and they will put more efforts into solving difficulties (Bandura, 1993).

Design-based learning is the only road for students to learn MTWP course. However, as is well known, Chinese students are skilled at performing regular tests in which only memorizing concepts and repeating operational steps are required. When it comes to hands-on tasks or authentic problem solving, students always feel uneasy. Most students complained it was difficult to design a multimedia work from scratch although teachers had taught related theoretical knowledge and operational steps in detail. The obstacles they met will affect their ICT self-efficacy absolutely and negatively. Thus, providing students with appropriate scaffoldings is necessary.

2.4. Semi-Finished Products as a Scaffolding

Instructional scaffolding is the support provided by a teacher/parent, peer, or a computer- or a paper-based tool that promotes students to meaningfully engage in and obtain skills at a task that they might be unable to complete without any

aid (Spector, Merrill, Elen, & Bishop, 2013). A scaffold should be an integrated concept system, with the starting knowledge level be slightly higher than students' existing level, rather than the knowledge they have already mastered (Wu, Song, & Huang, 2007). With the help of scaffoldings, students can complete tasks independently, thus improving their cognitive abilities gradually and continuously (Liu, Liu, & Lu, 2010).

The concept of "semi-finished products" derived from the field of industrial production. It is a product that has completed the production process of one workshop or several workshop in an industrial enterprise, has been checked and accepted into storage, but still needs to be processed or assembled in other workshops. Semi-finished product was first introduced into China in 2005 as a teaching method applied in ICT classrooms, aiming to construct a real problem solving environment by provided a "semi-finished" learning materials (Wang, 2005).

Semi-finished products can be seen as context-specific scaffoldings, which are tailored to the content related to the unit (Spector et al., 2013). In ICT courses, a common semi-finished product usually requires students to fill in the key knowledge point and the key operating steps according to the learning objectives. By completing the "semi-finished products", students can get a high-quality work, understand knowledge points completely and master the key operational skills (Cui, 2011). The "semi-finished products" scaffolding can combine part and system, which would be helpful for students to make high-quality works quickly and conveniently, enables them to experience the joy of success and stimulate their learning motivation.

3. Methods

3.1. Participants

A total of 219 freshmen who took a MTWP course at BNU participated in this study. The age of the sample ranged from 17 to 18, and 87% of participants were female. Among them, 117 students majoring in History were set as the experimental class (*the revising condition*), while the other 102 students majoring in Chinese Language and Literature were set as the control class (*the creating condition*). These two majors were selected due to their similarities in terms of their enrollment quality and academic backgrounds. Two classes were taught by the same instructor, who was an associate professor with over 20 years of teaching experience.

3.2. Materials

3.2.1. Curriculum Materials

MTWP is one of the common required ICT courses offered to freshmen of liberal art majors (such as language, history and philosophy) at Beijing Normal University. The course aims to empower students with capabilities of dealing with digital materials and designing works with multimedia software including Pho-

toshop, Flash and Dreamweaver. Students who took the course before complained that it was difficult to design multimedia artifacts with Flash or Dreamweaver though teachers had taught related theoretical knowledge and operational skills in detail. So this study mainly focused on Flash animation and Webpage design.

This course combined a traditional teaching method and a design-based learning approach together. The teacher first introduced general concepts and knowledge about multimedia technology and operational skills of the software. Then, the students were required to design a comprehensive work and complete their design reports in dyads.

A series of learning tools and resources were provided through an online learning platform to support students' design process. Some key concepts, operational steps and typical cases were provided as short instructional videos, guiding students to operate software step by step while encountering difficulties. Meanwhile, concepts, short videos, tasks and multimedia materials of each chapter were linked together through a knowledge map so that students can easily retrieve the learning resources needed (**Figure 1**).

3.2.2. Semi-Finished Products

In order to scaffold students' artifact design, six semi-finished products (three for Flash and three for Webpage) covering different knowledge points were provided to students in revising condition. The difficulty of these semi-finished products increased gradually. An example of design task based on a semi-finished product was like:

The given webpage is about the Health Festival, Its interface is shown in **Figure 2**. *Please set D:\Web*1 *as the root directory of the website and finish the following steps.*

1) *Set the page title to "Starting the first Health Festival" and set the background color of the entire webpage to "#ddffee".*
2) *Link additional style sheet file to "main.css";*
3) *Set the sentence "Focus on health, everyone is responsible" as a subtitle scrolling from left to right;*
4) *Insert image "zhuanti.jpg" at the left middle of the page.*
5) *Set "*39 *Health Day Special Action—Refueling for the Disaster Area" in the format of "Title* 2".
6) *Link "link.html" to text "[Details]".*
7) *Set the alignment of the text "Action Hosting" to "Center".*

3.2.3. Instruments

1) Knowledge and Skill Test

The BNU Computer-based Knowledge and Skill Test (BNU-CKST) was used to evaluate students' learning performance of the course MTWP. The test was consisted of objective items (i.e., single choices, multiple choices, and true or false), which aimed to measure students' mastery of knowledge, and hands-on

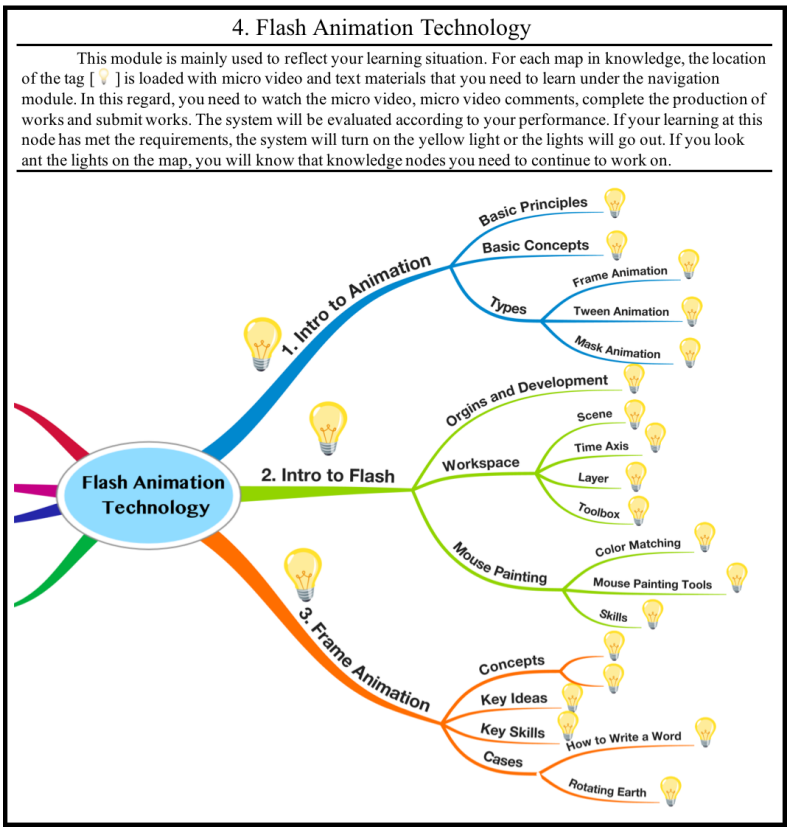

Figure 1. A sample of knowledge map (accessible at http://cen.bnu.edu.cn/commit/courses/CCMED/daohang/KMProgress.asp?id=4).

Figure 2. A semi-finished webpage in Chinese provided by the teacher.

tasks (i.e., Photoshop design, Flash animation design and webpage design), which aimed to measure students' mastery of operational skills. Objective tasks and Dreamweaver tasks were automatically scored by an examination system which had been used in BNU for several years, while Flash design tasks and Photoshop design tasks were scored by two experienced teachers due to the

technical limitations of the system. The test had been implemented as MTWP's final examination at BNU for more than five years and had considerable reliability and validity.

The full marks of single choices, multiple choices, true or false, Photoshop design, Flash animation design and Webpage design were 25, 5, 5, 18, 31, and 16, respectively. Since Photoshop was not included in this study and multiple choice items were mainly designed to measure students' understanding of Photoshop, this research used the sum of single choices, and true and false as the indicator of students' mastery of knowledge, and the sum of Flash animation design and Webpage design as the indicator of students' mastery of operational skills. Thus, the total score of students' mastery of knowledge and mastery of operational skills were 30 and 47, respectively.

2) ICT Self-Efficacy Test

An online scale (MACSS) was employed to measure students' motivation, attitude, confidence, and ICT self-efficacy. The scale was revised from Learning and Study Strategies Inventory (LASSI) (Weinstein & Palmer, 2002) and College and University Classroom Environment Inventory (CUCEI) (Treagust & Fraser, 1986). The questionnaire was reviewed and modified by two associate professors in order to improve the readability and content validity. Both of them had been actively engaged in ICT teaching for more than ten years. Then the questionnaire was pilot tested with several students who enrolled the course MTWP and further modified prior to being used for data collection.

This study only focused on students' ICT self-efficacy. The subscale for ICT self-efficacy were consisted of two questions, which were designed in a five-point Likert style as following: "1 (Strongly Disagree)", "2 (Disagree)", "3 (Neutral)", "4 (Agree)" to "5 (Strongly Agree)". The Cronbach's alpha of ICT self-efficacy subscale in pre-test is 0.923, which suggested an acceptable reliability.

3.3. Procedure

This research followed a quasi-experiment method. Before getting started to learn Flash animation and Webpage design, all the participants performed the pre-test on ICT self-efficacy through an online questionnaire (MACSS) in 20 minutes. Then the participants were taught with basic knowledge and operational skills of Flash animation and Webpage design. After that, the participants were asked to design their multimedia works in dyads. In creating condition, students were asked to design Flash animations and Webpages from scratch directly. While in revising condition, students were asked to revise and complete three semi-finished products provided by the teacher first. After completed these three semi-finished products, the students in revising condition began to finish the same tasks as students in creating condition. At the end of learning, all participants took the post-test on self-efficacy as same as the pre-test in 20 minutes. At the end of the semester, all participants took the Knowledge and Skill Test, a computer-based examination organized by the university, in 1.5 hours. The procedure was shown in **Figure 3**.

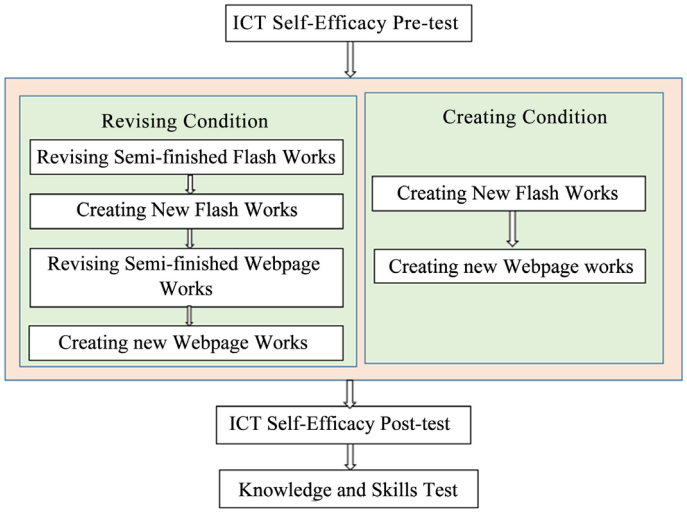

Figure 3. Procedure of study.

The study lasted for 7 weeks (4 weeks for Flash animation, and 3 weeks for Webpage design), starting in early May 2018 and ending in early July 2018. There were four class periods in each week, two of which were lectures and the other two of which were hands-on practice.

3.4. Data Collection and Analysis

Data of students' learning performance were collected through the Knowledge and Skill Test organized by the university (BNU-CKST) as final examination of MTWP, and data of students' self-efficacy were collected through an online MACSS scale after the learning. All students participated the final examination, a total of 438 responses of the MACSS questionnaire were received, in which 50 copies were invalid or incomplete. Thence, 388 valid and complete samples (194 pre-test, 194 post-test) were analyzed in this study. All data were calculated with Excel and analyzed with SPSS 23.0.

4. Results

4.1. Analysis of Learning Performance

As revealed by the Knowledge and Skill Test, in the *revising condition*, students' *mastery of knowledge* and *mastery of operational skills* averaged 24.37 (SD = 3.5) and 37.48 (SD = 9.07) respectively, while in the *creating condition*, students' *mastery of knowledge* and *mastery of operational skills* averaged 22.12 (SD = 2.95) and 38.28 (SD = 6.54) respectively.

An independent sample t-test was conducted to explore whether there were differences between two conditions in terms of students' learning performance. Results showed that students in *revising condition* performed significantly better than those in *creating condition* in terms of *mastery of knowledge* related to Flash and Webpage design [$t = 4.8$, $p < 0.001$, Cohen's $d = 0.70$]. Results also showed that students in the *creating condition* performed slightly better than

those in the *revising condition* in terms of *mastery of operational skills* related to Flash and Webpage design, but no significant differences existed between two conditions [t = −0.72, $p = 0.474$, Cohen's d = −0.10] (Table 1).

4.2. Analysis of ICT Self-Efficacy

Table 2 shows the mean scores, the standard deviations and t-test results of pre- and post- tests of *ICT self-efficacy* between two conditions. In the pre-test, the mean of ICT self-efficacy of the *revising condition* and the *creating condition* were 3.21 (SD = 0.98) and 3.12 (SD = 0.95), respectively. In the post-test, the mean scores of the two conditions were 4.00 (SD = 0.92) and 2.94 (SD = 1.32), respectively. An independent sample t-test on the pre-test of ICT self-efficacy showed that there were no significant differences existing between the two conditions [t = 0.608, $p = 0.544$, Cohen's d = 0.09], while a significant difference was found on the post-test on ICT self-efficacy [t = 6.37, $p < 0.001$, Cohen's d = 0.93]. This result indicates that the students in the *revising condition* reported higher ICT self-efficacy at the end of the course than those in the *creating condition*.

A paired sample t-test was conducted to explore how students' ICT self-efficacy changed from pre-test to post-test (Table 3 & Figure 4). The results showed that students' ICT self-efficacy in the *revising condition* increased significantly from pre- to post-test [t = 8.30, $p < 0.001$, Cohen's d = 0.83], while those in the *creating condition* decreased but not significantly [t = −1.59, $p = 0.115$, Cohen's d = −0.16].

Table 1. Comparisons of mastery of knowledge and operational skills by conditions.

Test	revising (N = 104) Mean (SD)	creating (N = 90) Mean (SD)	t value (p)	Cohen's d
knowledge (max = 30)	24.37 (3.50)	22.12 (2.95)	t = 4.80 ($p < 0.001$)	0.70
operational skills (max = 47)	37.48 (9.07)	38.28 (6.54)	t = −0.72 ($p = 0.474$)	−0.10
total (max = 77)	61.84 (11.53)	60.40 (7.98)	t = 1.02 ($p = 0.308$)	0.15

Table 2. Independent sample t-test results of ICT self-efficacy scores by conditions.

ICT self-efficacy	revising (N = 104) Mean (SD)	creating (N = 90) Mean (SD)	t value (p)	Cohen's d
pre-test	3.21 (0.98)	3.12 (0.95)	t = 0.61 ($p = 0.054$)	0.09
post-test	4.00 (0.92)	2.94 (1.32)	t = 6.37 ($p < 0.001$)	0.93

Table 3. Paired sample t-test of pre- and pos-ttest self-efficacy scores by conditions.

ICT self-efficacy	pre-test Mean (SD)	post-test Mean (SD)	t value (p)	Cohen's d
revising (N = 104)	3.21 (0.98)	4.00 (0.92)	t = 8.30 ($p < 0.001$)	0.83
creating (N = 90)	3.12 (0.95)	2.94 (1.32)	t = −1.59 ($p = 0.115$)	−0.16

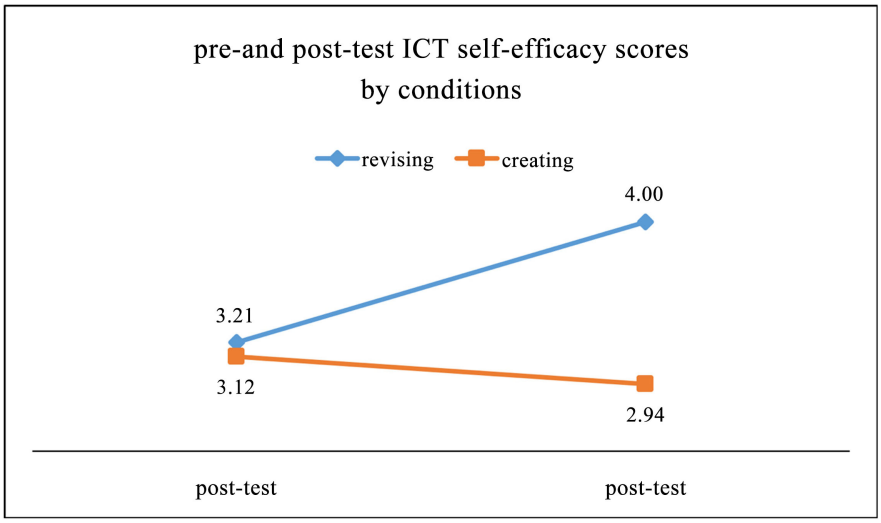

Figure 4. Students' ICT self-efficacy in pre- and post-test by conditions.

5. Discussion

5.1. Revising Yielded More Knowledge Mastery than Creating

Considering the two groups of freshmen were similar in terms of their enrollment quality and academic background, it was thought that there was no significant difference in terms of their prior knowledge about Flash and Dreamweaver before this study. Results showed that students in the revising condition performed significantly better than those in the creating condition in terms of mastery of knowledge. This was due to the increased time spent on knowledge learning. With the scaffoldings of semi-finished products, students in the revising condition felt much easier to deal with hands-on practice, so they were able to have more time in reviewing basic knowledge from the textbook, knowledge maps, and instructional videos, and this yielded more knowledge mastery compared with the creating condition.

According to the classroom observation, there were more students in the creating condition, than in the revising condition, was at a loss during the hands-on practice. This verified the effectiveness of semi-products on students' practice of operational skills. However, no significant difference appeared in terms of students' mastery of operational skills between two conditions. This might be due to the "training effects" enhanced by the final examination. Test questions of the model tests, which were accessible to all students a month before the exam, were extracted from the same question bank as the Knowledge and Skill Test did. Most students practiced a lot before taking the exam and this might have offset the effects caused by the conditions.

5.2. Revising Semi-Finished Products Enhanced Students' ICT Self-Efficacy

The results indicated that in the creating condition, students' ICT Self-efficacy decreased slightly from pre-test to post-test. This finding was consistent with the

interviews with several students conducted at the end of the semester. Students in the creating condition were confused about the design task at the beginning. Some students said "it is not easy to find a clue" and "I don't know where to get started". Some other students complained "I don't know how to do even if I have already understood all theoretical knowledge". These revealed that students in the creating condition had a relatively higher cognitive load and had difficulties in concentrating on the design itself.

The results also indicated that in the revising condition, students' ICT self-efficacy improved significantly from pretest to posttest. This met our expectations of the semi-finished products. In the design process, the "semi-finished work" was actually a scaffold or a guidance, which not only guided knowledge points and operational skills in MTWP course, but also guided students to design artifacts. This guidance could make students feel less anxiety and bring students more pleasure of success. Students in both conditions reported their attitude and confidence about Flash and webpage works through the online MACSS questionnaire at the end of learning. As the survey revealed, 15% of students in the revising condition thought that Flash animation design was difficult compared to 37% students in the creating condition, 41% students in the revising condition were confident about designing high-quality Flash animation works (or webpage works) independently compared to 34% in the creating condition.

Students majoring in History or Chinese Language and Literature had no strong prior experience of ICT. It was difficult for them to make artifacts with ICT without assistance. In a classroom, students are afraid to complete comprehensive learning tasks from scratch. With the aid of semi-finished products as a scaffolding, students can experience the sense of accomplishment from "semi-finished product" to "finished product", which would improve their self-efficacy and stimulate their learning motivation.

5.3. Implications for ICT Teaching

As revealed by this study, students' ICT self-efficacy may be damaged by tasks like creating artifacts from scratch. This suggested that ICT teachers should provide scaffoldings to students to protect their ICT self-efficacy. This study verified the effectiveness of using semi-finished products as a scaffolding to improve liberal arts students' ICT self-efficacy in the MTWP course. This suggested the importance of well-designed semi-finished products scaffoldings. Future work should focus on what will be good semi-finished artifacts that look like and how to design them. Furthermore, the effectiveness of different artifacts is to be investigated.

6. Conclusion

This study examined the effects of two different forms of DBL strategies, i.e., revising semi-finished products and creating from scratch, on students' learning about Flash animations and Webpage design. Results revealed that students'

mastery of knowledge in the revising condition was significantly higher than students in the creating condition, but there were no significant differences between two conditions in terms of students' mastery of operational skills. Results also showed that there were significant differences between the two conditions in terms of students' ICT self-efficacy. Further analysis indicated that students' ICT self-efficacy in the revising condition improved significantly from pre-test to post-test, while those in the creating condition declined, but it was not significant. The conclusion may be extended to other ICT courses, in which students often get frustrated when designing artifacts. This study made an important contribution to discerning the differences of two DBL strategies frequently adopted by ICT teachers and provided an insight into ICT teaching.

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Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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