

The Effects of Cognitive Apprenticeship and Co-Regulated Learning on Improving Student Computer Problem-Solving Skills and Learning Motivation: A Quasi-Experiment in an “Applied Information Technology: Office Software” Course

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ABSTRACT

This study makes use of online teaching in this environment and adopts it for use in a required computer skills course with cognitive apprenticeship (CA) and co-regulated learning (CRL) teaching methods to improve students' computer skills, learning motivation, and experience of online learning. The subjects of this study are first-year students of a non-information-related department at a private university in Northern Taiwan. A total of four classes comprising 111 students participated in the research. The CRL and CA group (C1, n=24) concurrently received CRL and CA treatments, the non-CRL and CA group (C2, n=25) received only the CA teaching method, and the CRL and non-CA group (C3, n=40) received only the teaching method of CRL. The non-CRL and non-CA group (C4, n=22) served as the control group. The results show that the use of CA can significantly improve students' computer skills; however, the expected effects of CRL were not found in this study.

KEYWORDS

Co-Regulated Learning, Cognitive Apprenticeship, Computer Skills, Experience of Online Learning, Learning Motivation

1. INTRODUCTION

Since late 2019, due to the rapid spread of the COVID-19 epidemic around the world, many schools have chosen to temporarily suspend on-campus teaching activities and switch from face-to-face teaching to online teaching. In addition, with the development of Internet and technology, the Ministry of Education in Taiwan encouraged teachers to adopt online or mobile platforms for students' learning (Chao, Wu & Tsai, 2021). This study conducted an instructional experiment under these conditions.

DOI: 10.4018/IJTHI.299355

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The researchers hope that by adopting the teaching strategies of cognitive apprenticeship (CA) and co-regulated learning (CRL), existing problems in the teaching field can be improved, and students may achieve better learning outcomes.

1.1 The Need for Cognitive Apprenticeship

In most traditional computer courses, the teaching mode is primarily teacher-centered; these skills-oriented courses are often taught in a didactic fashion. Students merely memorize and practice the content taught by the teacher; achieving high grades is the starting point for learning. However, in the teaching process of many traditional courses, out-of-date teaching examples that are not sufficiently practical are often used, which cannot truly help students deal with the real problems they will encounter in the workplace (Tsai, 2014; Tsai & Lee, 2012). Thus, traditional computer courses may cause graduates to lack competitiveness in the workplace.

In order to try to solve the aforementioned problems arising in traditional computing courses, this study searched the literature and compiled relevant papers, so as to adopt appropriate teaching methods to help students acquire practical computer skills in an online teaching environment. CA has the characteristic of solving problems in information courses and is widely used in various fields (García-Cabrero et al., 2018). Moreover, CA is a teaching method that refers to the guidance and guidance of experts in a specific field to develop skills in this field, promote contextual learning and improve learning outcomes (Calongne, Stricker, Truman, & Arenas, 2019). Therefore, in order to help students develop computer skills, this research adopts the CA teaching method in an online course to help them achieve good learning outcomes.

1.2 The Need for Co-Regulated Learning

As online courses are implemented, it is seen that they have many advantages compared with in-person teaching, but related problems and limitations have also emerged. For example, online teaching still lacks some of the benefits of in-person teaching, leading to such problems as: (1) the lack of physical interaction in online teaching can easily cause students to feel alienated, which may further lead to insufficient engagement in the course. Although the popularization of online courses is convenient, there is still a lack of interaction between students and teachers (Al Tawil, 2019); (2) when students encounter problems, it is difficult to solve them immediately, which may lead to absenteeism, withdrawal, and failing grades, etc.; (3) the popularization of mobile devices (mobile phones, tablets, and phones) may result in students being unable to concentrate on learning, causing problems such as poor academic performance (Tsai et al., 2018).

In order to help students develop regular learning habits and improve their online learning results, this research explores possible solutions and teaching methods, such as CRL, in an online course. This learning method entails learners and their partners jointly regulating their cognition, motivation, and behavior (Allal, 2020). Therefore, the researchers in this study adopted CRL to develop students' computer skills, learning motivation, and experience of online learning in an online computing course.

In this current study, the researchers integrated CA and CRL in an online course and explored their effects on improving students' computer skills, learning motivation, and experience of online learning. Thus, a quasi-experiment in 'Applied Information Technology: Office Software' course was conducted to explore the effects of CA and CRL. In addition, the best combination of the two teaching methods was also investigated in this research.

2. LITERATURE REVIEW

2.1 Cognitive Apprenticeship

CA is an instruction method that can help teach complex skills through real tasks. In CA, it is necessary to specify the process of consciousness and thinking, and identify whether it can be used

in problem-solving. The consciousness and thinking process must be communicated between teachers and students. Through these processes, students can observe and develop professional skills with the assistance of their teachers (Lave, 1988; Neba, 2019).

In addition, some educators and scholars have pointed out that CA is a theory based on teaching and learning. This theory has been widely used in the framework of designing learning environments and the analysis of teaching practice (Pimmer et al., 2012; Woolley & Jarvis 2007; Saucier et al., 2012; Stalmeijer et al., 2009; Lyons et al., 2017). CA provides students with the opportunity to learn, participate in practical training under the guidance of experts, and acquire competencies; thus, CA is considered to be a teaching method that helps improve learning effectiveness. Its main purpose is to pass on how to deal with professional and complex tasks from experts to teach apprentices (Begi, 2017; Kumazhege & Abdulhamid, 2020).

In terms of classroom teaching, reading, and writing, the CA approach is more effective than traditional teacher-centered methods, as it can more effectively improve students' knowledge and train their cognitive skills (Kumazhege & Abdulhamid, 2020). Therefore, this research adopts CA in an online course to analyze its influence on the learning outcomes of students in an information course.

2.2 Co-Regulated Learning

CRL developed from self-regulated learning (SRL) (Chan, 2012). Hadwin et al. (2011) define CRL as promoting the cooperation and adjustment between learners and the group, which can be used between individuals or groups to complete tasks. CRL entails learners and their learning partners jointly regulating their cognition, motivation, and behavior (Allal, 2020); it emphasizes the process of communication between students during learning. Through the process of CRL, learners can share ideas, combine different types of professional knowledge, and jointly make decisions about tasks. Although learners have different learning goals or effort levels, the independent learning skills of all learning participants can be developed to some degree (Hadwin et al., 2011; Hadwin & Oshige, 2011; Volet et al., 2013; Saariaho et al., 2019).

Through CRL activities, learners support each other in the process of learning through interaction, the development of self-regulation ability is promoted, and students are transformed into lifelong learners, which will optimize relevant skills in their careers (Bransen et al., 2020). Thus, the researchers in this study integrated CRL in an online computing course and explored its effects on improving students' computer skills, learning motivation, and experience of online learning.

2.3 Computer Skills

Computer skills are defined as learning skills related to computers, that is, the ability to effectively communicate, collaborate, and solve computer-related problems and tasks. Computer skills can also be regarded as a kind of work competence, which has the nature of integrating people, things, data and information (Ama & Emetarom, 2020). Computer skills are also very important for college students, especially when completing classroom assignments and reports. Students often encounter problems and difficulties when learning computer skills in computer application courses, especially when they are asked to perform more complex tasks (Kardipah & Wibawa, 2020). Gradually, computer skills have come to be regarded as one of the key elements of human capital, as an indispensable competence in the workplace. Related literature indicates that computer skills can effectively improve the work efficiency and productivity of employees, and even contribute to developing new fields of business (Benbasat, Dexter, & Mantha, 1980; Levina & Xin, 2007; Hitt & Brynjolfsson, 1996; Fairlie, 2006; Peng, 2017). In order to effectively cultivate students' computer skills, this research applies CA and CRL in an online course and analyzes whether it can effectively improve students' computer skills.

2.4 Learning Motivation

Learning motivation is defined as the willingness to participate in and learn from the content taught in a course or development plan (Noe, 1986). Learning motivation is also defined as an internal

thinking process, which can catalyze learners to achieve specific physical or psychological goals, and voluntarily invest their own efforts, while maintaining the motivation to perform throughout the learning process (Stipek et al., 1995; Wu & Lee, 2017).

If students have good learning motivation, they can do more learning activities and do them faster; compared with those whose motivation is lower, highly motivated learners will attain better academic performance (Prayitno, 1989; Alhadi & Saputra, 2017). Learning motivation prompts students to prepare for learning, can enhance their absorption of new knowledge, and increase their attention. Students with stronger learning motivation can discover better preparation skills for learning than students with weak learning motivation (Yilmaz et al., 2010; Wang et al., 2011; Wu & Tai, 2016). Therefore, this study adopts CRL and CA to help students improve their learning motivation.

2.5 Experience of Online Learning

With the popularization of online teaching, in addition to students' learning outcomes, students' learning experience in online courses has also gradually received attention. Thus, some studies have taken students' experience of online learning as one measurement indicator (Tsai & Shen, 2013). Experience of online learning refers to students' views and attitudes after participating in an online course (Tsai, 2020). Experience of online learning can serve as a reference for better future teaching practices (Kamp, 2016; Jorge, Dopfer & van Valkenburg, 2015).

Learners with more experience of online learning will tend to continue to participate in online courses in the future and demonstrate higher levels of task value and critical thinking (Artino & Stephens, 2009; Shen et al., 2013). Although the above literature points out the importance of having experience of online learning, some studies point out the importance of having a good experience of online learning (Shen, Lee & Tsai, 2011). Therefore, this research adopts CRL and CA to help students improve their experience of online learning.

3. METHODOLOGY

3.1 Participants

The participants in this research were 111 undergraduates from four classes taking a compulsory course titled "Applied Information Technology: Office Software", in northern Taiwan. Students in the CA and CRL class (C1, n=24), the CA and non-CRL class (C2, n=25), the non-CA and CRL class (C3, n=40), and the non-CA and non-CRL class (C4, control group, n=22) were all from the Department of Finance. Learners from non-computer field departments in Taiwan usually do not have the appropriate skills to use application software well (Tsai, 2015a). The students participating in the experiment were those who had not earned the computer certification required as a part of this course prior to the start of the course, and they did not possess the ability to operate the relevant software proficiently. The mean age of students in this involved course was about 18 years old.

3.2 Course Design

The experiment in this study was conducted in a computer skills course, the content of which is to teach the functions of Microsoft PowerPoint and Word. At present, many colleges and universities in Taiwan attach great importance to students obtaining computer skills certifications related to the respective courses, so they establish relevant course regulations and graduation benchmarks (Tsai & Shen, 2011). In this computer skills course, the university and faculty stipulate that students must take the computer skills certification examination before the end of the course. Therefore, the students in this experiment took the respective certification examinations in the 11th and 17th weeks of the semester.

3.3 Experimental Design and Procedure

The experimental design was a 2 × 2 factorial one with four groups of students participating. The three experimental groups included: CRL and CA group (C1) which simultaneously received CRL and CA teaching methods, non-CRL and CA group (C2) which received only the CA intervention, and the CRL and non-CA group (C3) which received only the CRL intervention. The non-CRL and non-CA group (C4) served as the control group and received the traditional computer course teaching method. The experimental design for the four groups in this research is illustrated in Figure 1.

3.3.1 The Treatment of Cognitive Apprenticeship

For implementing CA in C1 and C2, this research adopted the web-based cognitive apprenticeship model (WBCA) proposed by Liu (2005). Based on CA, WBCA is designed based on the characteristics of web-based learning. It is divided into three stages, namely Modelling-Observing, Scaffolding-Practicing and Guiding-Conceptualization. Generalizing.

3.3.1.1 Modelling-Observing

In the modeling and observation stage, the teacher first demonstrated the operation of the PowerPoint and Word software in Microsoft Office. The teacher gradually disassembled the sample questions that simulate real situations to help students understand how to disassemble complex problems encountered in real life, then gradually solve them. The teacher also guided students through basic concepts, and students develop their own computer skills by observing the teacher’s problem-solving process.

3.3.1.2 Scaffolding-Practicing

After the teacher’s modeling of problem-solving, the teacher immediately asked the students of C1 and C2 to practice, and the system scored their attempts. In addition to the evaluation results, the scoring system also pointed out the incorrect parts. Students could use this scoring system to learn to reflect and revise, as well as to seek assistance from the teacher. In addition, students were required to upload complete files (solution results and scores) to the course website (Moodle) so that the teacher could observe students’ learning status by the status of their submitting documents, and provide necessary feedback and scaffolding assistance to students. As time went by, the teacher gradually reduced the level of assistance to cultivate students’ independent reflection and problem-solving ability.

3.3.1.3 Guiding-Generalizing

Through the operation of Microsoft PowerPoint and Word, the teacher expressed his/her own thinking, skills and practical knowledge to guide students in understanding the process and concepts of problem-solving. In addition, the teacher instructed students on the general problems that they may

Figure 1. Experimental design for this research

	CRL	non-CRL
CA	Most significant effect (C1)	Medium effect (C2)
non-CA	Medium effect (C3)	No difference (C4)

encounter in real situations based on their own experience, or how to flexibly apply relevant skills in the workplace or daily life. At this stage, more emphasis was placed on helping students develop their conceptualization capabilities, so as to increase students' flexibility and application ability in the production and design of computer documents or slides.

3.3.2 The Treatment of Co-Regulated Learning

High level CRL comprises two elements, including that students manage themselves and co-regulate their own and other's learning (McCaslin, Sotardi & Vega, 2014). In addition, the social (society or group) interaction is emphasized in CRL (McCaslin, 2004). CRL is related to the degree of student input; for example, more frequent interaction and collaboration of group members will help improve the overall ability of the group (Chan, 2012; Tsai, 2016). Therefore, the approach used in this study to implement CRL for C1 and C3 was as follows:

3.3.2.1 Learning Groups

For C1 and C3 in this study, students were divided into small groups, each consisting of five to six members. The students established their learning groups through social networking software such as LINE, WeChat, or Facebook, and set the learning goals of each group. Regular weekly discussions, collaboration, mutual peer assistance, learning, and reminders took place within the group. The teacher also required students to regularly submit the progress and situation of each group discussion every week to confirm that each group of students is indeed performing CRL.

3.3.2.2 Personal Homework and Team Project

Students were required to submit individual assignments and group assignments to the course website (Moodle) within two days after the class. Once the deadline arrived, the system automatically closed the submit function. Therefore, due to time constraints, when students encountered problems during practice, they usually sought assistance from members of their learning group, and team members could provide timely assistance.

3.3.2.3 Self-Regulated Learning and Co-Regulated Learning

Students were required to record information such as the topic, time, place, and results of group discussions so that the teacher could provide students with self-directed learning skills through group discussion records and assignments. In order to complete group assignments, students reviewed their learning history and discussion records through the course website, as reviewing learning history helps promote cognitive development and improve learning effectiveness (Ramdass & Zimmerman, 2011).

3.4 Evaluation and Data Collection

3.4.1 Computer Skills

Measurement of students' computer skills in this research was based on their scores on the PowerPoint and Word computer license examinations, respectively, in the 11th and 17th weeks. Scores were analyzed to investigate if there were any differences in computer skills for students who received CA or CRL.

3.4.2 Learning Motivation

This study adopted the Motivated Strategies for Learning Questionnaire (MSLQ) scale proposed by Pintrich and De Groot (1990), which is a 7-point scale questionnaire. It was conducted as a pre-test before the start of the experiment; and again as a post-test at the end of the experiment. After collecting information on the learning motivation of students, the researchers analyzed whether the learning motivation of students who received CA or CRL differed from that of students in the control group.

3.4.3 Experience of Online Learning

In the post-test of the experiment, the online learning experience scale used by Boyle, Bradley, Chalk, Jones and Pickard (2003) and Tsai and Shen (2013) was adopted. This 5-point scale questionnaire measured students' experience of online learning after a semester-long online course and the online teaching methods set by the teacher. Researchers in this study analyzed the differences in the experience of online learning of the four groups of students at the end of the semester.

4. RESULTS

4.1 Pretests

Before implementing the CA and CRL teaching approaches in the involved online computing course, a pretest was conducted to prevent the possibility of students' original differences causing a bias in the evaluation of their learning. The researchers in this study first checked students' skills and experience in using Microsoft PowerPoint and Word, and their learning motivation, before the experiment started. In the first week of the semester, the teacher in this involved course asked and checked whether students from the four classes had learned PowerPoint and Word, or earned related computer certifications already before they entered this course. Students who had already learned to use PowerPoint and/or Word before were removed from this research, although they still remained in the original classes. Finally, the 111 students who had not learned PowerPoint and Word were regarded as participants in this research.

In addition, a pretest adopting one-way ANOVA was also conducted to analyze students' learning motivation before they received CA or CRL in this study. The analysis indicates that there was no significant difference in the students' learning motivation among these four groups. Furthermore, as students in this study had not had the experience of online learning yet, the researchers did not conduct the pretest of their experience of online learning.

4.2 Post-tests

4.2.1 The Effect of Cognitive Apprenticeship

To explore the effects of CA, the independent samples *t*-test was used to analyze and compare students' skills in using PowerPoint and Word, learning motivation, and their experience of online learning between the CA group (C1 and C2) and non-CA group (C3 and C4). As the data in Table 1 shows, the CA group's PowerPoint certification score (94.7551) and Word certification score (77.9184) in the post-test are significantly higher than the PowerPoint certification score (90.9839) and Word certification score (58.8548) of the non-CA group. In addition, the average scores of the two computer licenses of the CA group (86.3367) were significantly higher than that of the non-CA group (74.9194) ($p < 0.05$). According to the research results, the computer license scores of students who received CA were significantly higher than those of the students who did not receive the CA method.

Regarding the effects of CA on students' learning motivation and experience of online learning, Table 2 indicates that no significant difference was found between students' learning motivation between CA group (4.6386) and non-CA group (4.6925). In addition, students' experience of online learning between the CA group (3.7918) and non-CA group (3.9258) did not show significant difference. That is, the expected effects of CA on students' learning motivation and experience of online learning were not identified in this study.

4.2.2 The Effect of Co-Regulated Learning

With regard to the effect of CRL in improving students' learning, the researchers in this study explored the difference in students' skills of using PowerPoint and Word, learning motivation, and their online learning, between the CRL group (C1 and C3) and non-CRL group (C2 and C4) via the independent samples *t*-test. Table 3 shows that neither the PowerPoint license score (93.1250) and

Table 1. Analysis of computer license scores of students in the CA and non-CA groups

Module	Group	n	Mean	S. D.	F	t-value	df	p
PowerPoint	CA	49	94.7551	7.87806	4.182	2.224	109.000	0.028*
	non-CA	62	90.9839	9.98440				
Word	CA	49	77.9184	26.99061	1.683	3.447	108.087	0.001*
	non-CA	62	58.8548	31.22307				
Average	CA	49	86.3367	15.04590	2.546	3.551	109	0.001*
	non-CA	62	74.9194	18.09791				

* $p < 0.05$

Table 2. Analysis of learning motivation of students in the CA and non-CA groups

Module	Group	n	Mean	S. D.	F	t-value	df	p
Learning motivation	CA	49	4.6386	0.79772	2.089	-0.312	109	0.756
	non-CA	62	4.6925	0.98212				
Experience of online learning	CA	49	3.7918	0.71059	0.338	-9.67	109	0.335
	non-CA	62	3.9258	0.73528				

Table 3. Analysis of computer license scores of students in CRL and non-CRL groups

Module	Group	n	Mean	S. D.	F	t-value	df	p
PowerPoint	CRL	64	93.1250	8.64191	0.456	0.630	109	0.530
	non-CRL	47	92.0000	10.11886				
Word	CRL	64	66.1250	29.55785	1.120	-0.455	109	0.650
	non-CRL	47	68.8298	32.68514				
Average	CRL	64	79.6250	16.57929	1.468	-0.231	109	0.817
	non-CRL	47	80.4149	19.26907				

Word license score (66.1250) of the CRL group, and the PowerPoint license score (92.0000) and Word license score (68.8298) of the non-CRL group, reached statistically significant difference. In addition, the differences in the average score for the two computer licenses of students in the CRL group (79.6250) and the two computer licenses of students in the non-CRL group (80.4149) are not statistically significant. According to the results of this research, students who received CRL did not have higher computer certification scores than students who did not.

As for the effects of CRL on students' learning motivation and experience of online learning, the data shown in Table 4 indicates that students' learning motivation in CRL group (4.6830) was higher than those in non-CRL group (4.6493), though insignificantly. However, the results in Table 4 report significant difference in CRL students' experience of online learning (3.7375) compared with those in the non-CRL group (4.0426). Overall, the expected effects of CRL are not found in this study.

Table 4. Analysis of learning motivation of students in CRL and non-CRL groups

Module	Group	n	Mean	S. D.	F	t-value	df	p
Learning motivation	CRL	64	4.6830	0.92743	0.071	0.194	109	0.847
	non-CRL	47	4.6493	0.87531				
Experience of online learning	CRL	64	3.7375	0.71437	0.525	-2.232	109	0.028*
	non-CRL	47	4.0426	0.70764				

* $p < 0.05$

4.3 The Effect of Cognitive Apprenticeship and Co-Regulated Learning

In order to explore the combined effects of CA and CRL, one-way ANOVA was applied to compare students' computer skills, learning motivation, and experience of online learning under different conditions. In Table 5, it is shown that the C1 computer license score (84.6458) and the scores of the other three groups (C2 = 87.9600; C3 = 76.6125; C4 = 71.8409) did not reach statistically significant difference ($p < 0.05$). Therefore, according to the analysis result, the students who simultaneously adopted both CA and CRL did not experience significant improvement in their average score on the certificate.

Based on the analysis results shown in Table 6 and Table 7, C1 students' learning motivation (4.5618) was not significantly higher than in the other three groups (C2 = 4.7123; C3 = 4.7556; C4 = 4.5777). In addition, C1 students' experience of online learning (3.4833) was not significantly better than the other three groups (C2 = 4.0880; C3 = 3.8900; C4 = 3.9909). That is, the combined treatment of CA and CRL did not contribute to the better development of students' learning motivation or experience of online learning.

Table 5. One-way ANOVA: Posttest of computer license scores

Post test Scheffe	(I) Groups	(J) Groups	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound
	1	2	-3.31417	4.81596	0.924	-16.9939	10.3656
		3	8.03333	4.35125	0.338	-4.3264	20.3931
		4	12.80492	4.97419	0.091	-1.3243	26.9341
	2	1	3.31417	4.81596	0.924	-10.3656	16.9939
		3	11.34750	4.29652	0.079	-0.8568	23.5518
		4	16.11909*	4.92638	0.017*	2.1257	30.1125
	3	1	-8.03333	4.35125	0.338	-20.3931	4.3264
		2	-11.34750	4.29652	0.079	-23.5518	0.8568
		4	4.77159	4.47316	0.768	-7.9344	17.4776
	4	1	-12.80492	4.97419	0.091	-26.9341	1.3243
		2	-16.11909*	4.92638	0.017*	-30.1125	-2.1257
		3	-4.77159	4.47316	0.768	-17.4776	7.9344

*Mean difference is significant at the .05 level.

Table 6. One-way ANOVA: Posttest of students' learning motivation

Post test Scheffe	(I) Groups	(J) Groups	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound
	1	2	-0.15043	0.26013	0.953	-0.8893	0.5885
		3	-0.19382	0.23503	0.878	-0.8614	0.4738
		4	-0.01588	0.26867	1.000	-0.7791	0.7473
	2	1	0.15043	0.26013	0.953	-0.5885	0.8893
		3	-0.04339	0.23207	0.998	-0.7026	0.6158
		4	0.13455	0.26609	0.968	-0.6213	0.8904
	3	1	0.19382	0.23503	0.878	-0.4738	0.8614
		2	0.04339	0.23207	0.998	-0.6158	0.7026
		4	0.17793	0.24161	0.909	-0.5084	0.8642
	4	1	0.01588	0.26867	1.000	-0.7473	0.7791
		2	-0.13455	0.26609	0.968	-0.8904	0.6213
		3	-0.17793	0.24161	0.909	-0.8642	0.5084

Table 7. One-way ANOVA: Analysis of students' experience of online learning

Post test Scheffe	(I) Groups	(J) Groups	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound
	1	2	-0.60467*	0.20035	0.032*	-1.1738	-0.0356
		3	-0.40667	0.18102	0.175	-0.9209	0.1075
		4	-0.50758	0.20694	0.118	-1.0954	0.0802
	2	1	0.60467*	0.20035	0.032*	0.0356	1.1738
		3	0.19800	0.17874	0.747	-0.3097	0.7057
		4	0.09709	0.20495	0.973	-0.4851	0.6792
	3	1	0.40667	0.18102	0.175	-0.1075	0.9209
		2	-0.19800	0.17874	0.747	-0.7057	0.3097
		4	-0.10091	0.18609	0.961	-0.6295	0.4277
	4	1	0.50758	0.20694	0.118	-0.0802	1.0954
		2	-0.09709	0.20495	0.973	-0.6792	0.4851
		3	0.10091	0.18609	0.961	-0.4277	0.6295

*Mean difference is significant at the .05 level.

5. DISCUSSION

This study redesigned an online course in an online teaching environment, using innovative teaching methods to help students develop the necessary computer skills, as well as improve their learning motivation and experience of online learning. The research makes contributions in three aspects. First, this study is one of the first attempts to investigate the use of CA in computer courses in the Internet environment. Through CA, teachers instruct students based on their own experiences. This

exposure to the problems that students may encounter in real situations will help students apply computer skills more flexibly, and improve their computer skills. Secondly, students using CRL in the online environment share, discuss, and reflect on their learning experiences regularly during the learning process, which helps to develop SRL habits. Finally, through the integration of CA and CRL in a multi-channel technological learning platform, students' learning motivation is stimulated, their learning experience in the online course is enhanced, and they adopt innovative educational strategies. Internet technology promotes the development of students' computer skills and also cultivates their ability to self-regulate and co-regulate learning.

5.1 The Effect of Cognitive Apprenticeship

According to the research results, students who received CA significantly improved their computer skills. These results are similar to those of Liu (2005), Wu, Shen, Chen & Tsai (2016), Matsuo & Tsukube (2020), and Eze, Obidile & Okotubu (2020). That is, CA is shown to be beneficial in elevating student learning effectiveness. Based on this, this research suggests that teachers may consider applying CA or web-based CA models in the curriculum when planning future computer skills courses in an online teaching environment, so as to facilitate the development of students' computer skills.

However, the adoption of CA did not significantly improve students' learning motivation or experience of online learning. From the existing literature and teaching experience of the researchers, it is observed that many students in Taiwan have primarily received traditional didactic instruction (Lee, Shen & Tsai, 2008). In the limited time of one semester, students are faced with an innovative teaching model for the first time and need to spend time adapting. The non-CA group received the didactic instruction that they are accustomed to and only needed to memorize and be proficient in the content taught by the teacher. Even though they did not score well on the computer skills test, students did not need to invest time in cognition, reflection, and the construction of their own conceptual model, as required by CA, so they adapted well to learning. This learning background may lead to the lack of significant difference in learning motivation and experience of online learning between the CA and non-CA groups.

5.2 The Effect of Co-Regulated Learning

According to the results of this study, the computer scores of the students in the CRL and the non-CRL groups did not reach statistically significant differences. In addition, this study also found that the learning motivation of the students in the CRL group was not significantly higher than that of students in the non-CRL group after one semester of this teaching experiment. That is, CRL failed to significantly improve the learning motivation of the students. These study results are similar to the findings of Tsai (2015b) and Wu, Chao & Tsai (in press) that CRL does not significantly improve students' learning outcomes and learning motivation. Researchers speculate that although students form learning groups according to the teacher's arrangement, there is a gap in the participation of students in the group work.

Moreover, students' experience of online learning in the CRL group is significantly lower than that of the students in the non-CRL group. Researchers infer that teachers in other courses may still use traditional teaching methods, and it may be difficult for students to efficiently shift into CRL or SRL. Some students' willingness to even cooperate and participate in CRL is low, which affects the possible benefits of CRL. In addition, the experimental period of this study is one semester, and Lai & Hwang (2016) pointed out that a short-term teaching experiment may be insufficient to effectively promote the production of research results, especially if students have long been accustomed to traditional teaching methods.

5.3 Limitations of This Study

Although the researchers in this study conducted a pretest to prevent the bias from students' initial differences, before the start of the research, the teacher explained that a teaching experiment will be

implemented in this course, which may result in the Hawthorne effect. That is, the subjects know that they are being studied, which may lead to abnormal or enhanced learning effects (Diaper, 1990; Chiesa & Hobbs, 2008); that may be one of the factors affecting the expected results of this research.

6. CONCLUSION

Since the rapid spread of COVID-19 around the world, many governments have announced that universities will temporarily close their campuses. Hence, the mode of teaching has changed from traditional face-to-face teaching to online teaching mode. This is undoubtedly a great migration from the traditional teaching environment, a great challenge. Following the global crisis of the novel coronavirus outbreak, online learning has become the next current in education, and the quality and quantity of teaching have shown a linear growth trend (Chaker & Impedovo, 2021). As a learning tool and medium, the internet has gradually become the new mode in teaching and learning applications (Lin & Ward, 2011) with more and more studies pointing out the importance of online teaching (Cheng et al., 2013; Tsai, 2013; Tsai, Shen, & Fan, 2013; Tsai, 2016), Therefore, this research redesigned an online course and adopted innovative teaching methods to help students develop what they need to improve their learning motivation and experience of online learning.

After a semester of course experiments, researchers collected and analyzed experimental data. This study found that the use of CA in an online teaching environment can significantly improve students' computer skills with the support of scaffolding, students' reflection and self-exploration through the process of handing in personal homework, and the flexible application of computer skills taught by the teacher in other classes. According to the results of this experiment, the use of CA in an online course has a positive and significant impact on students' computer skills.

In addition, the results of this research point out that adopting CRL in an online teaching environment did not significantly improve students' computer skills or learning motivation, and the outcome of the research did not achieve the expected results. Moreover, as the teaching strategy of CRL includes students' SRL, it is difficult to change students' learning habits in a short period of time. This may also lead to students' psychological conflict with the course experiment. Still, the researchers in this study expect that these results regarding the treatments of CA and CRL can provide insights for online educators who plan to provide practical and effective teaching methods for their students, during the COVID-19 pandemic.

FUNDING AGENCY

Publisher has waived the Open Access publishing fee.

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