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Exploring learners' learning performance, knowledge construction, and behavioral patterns in online asynchronous discussion using guidance scaffolding in visual imagery education

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ABSTRACT: The purposes of this study were to explore students' learning performance, knowledge construction, and behavioral patterns in computer-supported collaborative learning (CSCL) online discussions with/without using Form+Theme+Context (FTC) model guidance scaffolding in visual imagery education. In the online learning activities, the control group did not use the FTC model guidance scaffolding, while the experimental group did. This study employed quantitative content analysis and sequential analysis to investigate the discussion content and behavioral patterns of 63 students from a private university in Taiwan during online discussion learning activities. Results showed that the learning performance of the students in the experimental group outperformed that of students in the control group. Moreover, the study revealed that the two groups of students were primarily sharing or comparing information during discussion. More behaviors of exploring opinions and concepts and communicating or constructing knowledge among group members were observed in the experimental group. Secondly, students in the experimental group participated more in knowledge construction than did students in the control group, and their behavioral patterns were more diverse. Accordingly, this study shows that incorporating the FTC model into learning with sufficient guidance from the instructor could be useful for improving students' visual imagery analysis abilities.

Keywords: Behavior analysis, Computer-supported collaborative learning, Knowledge construction

1. Introduction

The increasing number of computers and the mixed use of online or distance learning in learning fields has sparked interest in non-traditional methods of curriculum design among educators (Resta & Laferrière, 2007; Roberts, 2005). For example, over the past 2 decades, there has been an increasing trend in the use of computer-supported collaborative learning (CSCL) in a variety of educational environments (Jeong et al., 2019). Researchers have indicated that CSCL can combine information and communication technologies to support collaborative learning to facilitate group learning, knowledge sharing, and co-construction (Dillenbourg & Fischer, 2007; Santosa et al., 2020). Additionally, CSCL methods and techniques can provide learners with the benefits of learning at any time and in any place. Generally, during traditional course teaching activities in the classroom, student-to-student and student-to-instructor interactions are often constrained because of time, space, and the nature of the course. CSCL methods and techniques can solve these limitations of traditional classrooms for improving students' social interactions and learning in visual imagery education. Rojprasert et al. (2020) showed that using the CSCL method of teaching in photography courses can improve students' learning performance.

However, photographic education is usually narrow in terms of training techniques and does not look at photography from a broader intellectual perspective (Newbury, 1997). As Sartorius (2000) pointed out, traditional basic photography education is a purely hands-on course that teaches students the skills of shooting, developing, and outputting photographs. Nowadays, photographic images are widely used in many fields such as various media, education, medicine, crime detection and entertainment activities (Azahari et al., 2019). Photographic images appear "in all forms and levels of meanings" (Barry, 1997, p. 72), and their forms can be informational, ideological, or manipulative. Therefore, the meaning of photographic images (visual images) needs to be explored, identified, read, and analyzed (Clarke, 1997; Tagg, 1993). Consequently, Barnett (2000) suggested that any discussion of the message or viewpoint of a photograph should include several basic elements: subject matter (e.g., main theme and person), form (e.g., composition), medium (e.g., type), and causal environments (e.g., including creator information, creation time, and social context). Therefore, knowledge can be acquired by learners through the process of discovery and interaction with images which are of the constructivism type of learning (Azahari et al., 2019). Moreover, these elements (i.e., subject matter, form, medium, and causal environment) are similar to the form (F), theme (T) and context (C) models proposed by Sandell (2006) for exploring and analyzing artworks. In other words, art educators have adopted the FTC model to help art subject students develop abilities such as creativity, and to analyze the meanings of an artwork in art education. Several studies have pointed out that the FTC model is useful for encouraging art subject students to actively engage in studying artworks (Ho & Yen, 2011; Reverman, 2013). However, the importance of photography is underestimated by educational institutions, and is seen as a discipline that produces skilled photographers and technicians (Azahari, 2006). Therefore, our study sought to suggest a possible solution to fill this gap by proposing an FTC model to guide scaffolded teaching strategies to improve their ability to interpret visual images in photography courses.

Moreover, past research has rarely examined students' abilities and processes of reading, interpreting, analyzing and deconstructing photographs. Therefore, to enrich this research, we further wanted to explore the ability and process of knowledge construction when students analyze visual images in the CSCL environment under the instructional framework of the FTC model. Consequently, to capture students' ability level of analyzing images during the online discussion, this study adopted the interaction analysis model (IAM) which was developed by Gunawardena et al. (1997). Then, we examined the knowledge construction process of students in analyzing photographic images. This study also added lag sequential analysis (LSA) to understand their learning behaviors. In this study, the experimental group with FTC model guidance scaffolding online discussion was compared to the control group without FTC model guidance scaffolding online discussion.

2. Literature review

2.1. Computer-supported collaborative learning (CSCL)

CSCL has been recognized as one of the key research trends in the social interactions of collaborative learning in e-learning environments (Hernández-Leo et al., 2006). According to Lipponen (2002), "CSCL is focused on how collaborative learning supported by technology can enhance peer interaction and work in groups, and how collaboration and technology facilitate sharing and distributing of knowledge and expertise among community members" (Lipponen, 2002, p. 72). In CSCL studies, it has been found that CSCL techniques could effectively trigger changes in the way group members share and construct knowledge due to the design of the learning activities (Ludvigsen et al., 2010) and can influence individual as well as group performances (Salomon et al., 1991). Additionally, the CSCL environment could help instructors comprehend the learners' interaction process and facilitate learners' performance on more concrete tasks in the collaborative learning process (Heo et al., 2010).

However, student disengagement in learning has been a common problem in education (Drigas et al., 2014). Collaborative learning in the CSCL environment also cannot ensure that students will be positive about participating and engaging in learning activities. For example, researchers have revealed that students' participation rates in online discussion are influenced by individual time-management skills (Kerr et al., 2006; Michinov et al., 2011), and competences of collaborative learning in web-based environments (Liu & Tsai, 2008). Furthermore, the low participation rate in online discussion has been determined as one of the main problems (Kreijns et al., 2007). Therefore, strategies for facilitating participation in online discussion are worthy of attention.

To improve students' participation rates and positive engagement in online discussion, many instructors seek different solutions. For example, researchers have found that teachers' guidance strategies could encourage students to participate in online discussion activities (Tagg & Dickinson, 1995) and would influence the quality of online discussion (Guan et al., 2006). Additionally, more guidance from teachers could encourage students to positively engage in online collaborative learning (Holliman & Scanlon, 2006). Consequently, considering the above reasons, the present study adopted the teachers' guidance strategies to improve the online discussion performance of students in both the control group and the experimental group.

2.2. The FTC model as an analytical image method and scaffolding

Nowadays, in the 21st Century, various types of visual imagery (e.g., photographs, cartoons, drawings, typography) fill our surroundings. Images are gradually substituting for text that used to convey messages and emotions (Meyer, 2010). Harper (2002) proposed that photographic works tend to involve multi-level meanings, for example, the topic or form of a photographic work may inspire people to understand social and human development, and may even evoke emotions, social, and cultural messages. Therefore, good photographic education should help learners to comprehend multi-level messages of visual imagery (Palmquist, 2008). Visual images (photographs) do not only focus on the passive act of "seeing," but also involve the active process of "looking," that is, the process of identification, reading and analysis (Clarke, 1997). The art behind the photograph is not limited to the surface of the image, but includes what lies beyond the surface of the image. Therefore, many art critics have proposed concepts for the interpretation of photographic images; for example, Barthes proposed a new method of analyzing images at the level of denotation and connotation which combines the signifier and the signified in the photographic images (Bouzida, 2014). The most widely used is the symbolic theory proposed by Peirce in which icon, symbol and index are used to analyze photographic images (Robins, 2014). It is related to the study of semiotics and involves the understanding of any image representation. However, it requires a certain level of intelligence to be able to analyze and comprehend these photographs intelligently and rationally (Azahari et al., 2019).

Therefore, Sandell (2009) proposed the FTC model as a practical alternative for the comprehension and promotion of creativity in artworks (e.g., drawings). The FTC model involves the three main connotations of Form, Theme, and Context. Form (F) refers to the idea that the appearance of artworks is shown through the visual arts' principles, elements, and skills. First, people can understand the manifestations of artworks through form. Second, Theme (T) is the main concept of the artwork. Theme can be explored and connected to other relations of art and non-art as viewers examine the topic. Last, Context (C) means the purpose of the creator through the creation of a selected relative background (e.g., creative time, creative place, and people), so that viewers can discern the external environment through the background, and further understand the correlation between the artwork and the creator (Sandell, 2006; Sandell, 2009). Therefore, the FTC model can not only decode (interpret) and encode (create) artworks by form, theme, and context, but can also motivate students to have deep reflection and criticism and can provide students with different ways of thinking when they are creating visual imagery.

In recent years, the FTC model has become a teaching approach in art education (Sandell, 2006; Sandell, 2009). For example, Ho and Yen (2011) guided five undergraduates to apply the FTC model to conduct practice-led art research, and found that it was useful for increasing students' logic, critical thinking, and artistic skills in the creative process, and improved the quality of their artworks. Moreover, Reverman (2013) implemented the FTC model to require students to analyze a visual artwork in a Visual Arts course. The study found that the FTC model helped students more clearly understand visual artworks, and encouraged them to engage in peer debates. Photographic works and visual arts share the same visual characteristics, meaning that photographic works could also use the FTC model analysis framework.

According to the above reasons, the FTC model seems to be more suitable for less experienced photography learners to analyze images than semiotics. Additionally, few studies have explored the effects of the FTC model on learner knowledge construction and behavior. Therefore, this study adopted the FTC model as a guiding scaffold teaching strategy to explore how it affects learners' knowledge construction levels and behavioral patterns when discussing and analyzing the multi-level meaning of photography in online learning activities.

2.3. Knowledge construction and behavioral patterns

Social constructivism holds that learning and cognition depend on the interaction between the individual and the setting (Wegner & Nückles, 2015). The individual learner receives new information in social interaction and processes it through existing knowledge to form a new cognitive structure (Floren et al., 2020). Knowledge construction usually refers to learners generating new ideas or new understandings of certain phenomena, situations, and concepts through interaction with people and things in their surroundings (Van Aalst, 2009). Therefore, knowledge construction is often one of the important pieces of evidence to be collected in collaborative learning. In other words, in the CSCL environment, knowledge co-construction is an important learning goal for group members (Kuhn, 2015). Previous research has found that the level of knowledge construction is related to collaborative skills (Farrokhnia et al., 2019), online searching behavior skills (Lin et al., 2016), and learning achievement (Yang et al., 2018). Therefore, it is important to analyze the level of learner knowledge construction when learners are engaged in online collaborative problem-solving tasks.

One of the earliest frameworks for describing learners' level of knowledge construction during online learning tasks was the Interaction Analysis Model (IAM) proposed by Gunawardena et al. (1997). The IAM consists of five phases: (1) sharing and comparing the information, (2) discovering and exploring inconsistency in ideas, concepts, or statements among participants, (3) negotiating meaning/co-construction of knowledge, (4) testing and modifying proposed synthesis or co-construction, and (5) agreement statement(s)/applying constructed meaning. These processes can be divided into hierarchies from the initial phases (e.g., sharing and comparing the information) to more advanced phases (e.g., testing and modifying the proposed project or meanings). Each stage involves a series of learning processes. Nowadays, the IAM model has been applied in many online discussions in higher education settings. However, most of those studies have found that the percentage of students' knowledge constructs that appear at more advanced phases is generally lower than the initial phases of knowledge constructs (Koh et al., 2010). Therefore, to enhance learners' knowledge construction, research in the past decade has shown that various mechanisms have emerged, such as role-playing (Chen & Yeh, 2021), scaffolding (De Weerd et al., 2017; Schmitt & Weinberger, 2019), group-level regulation (Zabolotna et al., 2023), and so on. Among these mechanisms, scaffolding is a useful teaching strategy. For example, De Weerd et al. (2017) found that the use of concept maps as learning scaffolds can facilitate greater conflict-oriented, negotiation and consensus building among learners. This type of constructivist learning is well suited to the learning process of photography (Azahari et al., 2019). However, in previous research on photography education, constructivist pedagogy has rarely been found to be used in the teaching of photography courses. Therefore, this study adopted the scaffolding (i.e., FTC model) mechanism to improve students' knowledge construction in online learning tasks.

Additionally, IAM-based analysis of knowledge construction behavior provides percentage and frequency information to comprehend the quality of learners' interactive communication, but lacks in-depth comprehension of the learners' interaction processes. The IAM approach only reveals where improvements can be made, not how to enhance the individual's move from the lower rung of the knowledge-construction ladder to the higher rung. In contrast, LSA can help solve this problem by showing the temporal dynamics of the knowledge construction behavior, and allows researchers and educators to explore whether a particular knowledge-building behavior is likely to lead to other behaviors (Bakeman & Gottman, 1997). Nowadays, LSA is being widely used in the analysis of behavior patterns in online discussions (Hou, 2011; Zhang et al., 2022). We have therefore included LSA in our analysis and look forward to a more in-depth discussion of the research questions.

In sum, our research purposes were to compare students' learning performance, knowledge construction, and behavioral patterns with and without FTC model guidance scaffolding in online asynchronous discussion in a photography course. Therefore, the three research questions that this study aimed to address are as follows:

- Do online learning activities assisted by the FTC model guidance scaffolding enable students to achieve better learning performance (i.e., photographic works' form, theme, and context) in the CSCL environment?
- What are the characteristics of and differences in the social knowledge construction in the CSCL environment discussion activities of the control group and the experimental group?
- What are differences in the sequential patterns of social knowledge construction in the CSCL environment discussion activities of the control group and the experimental group?

3. Methodology

This study combined quantitative content analysis and sequential analysis to explore the learning performance, knowledge construction, and behavioral patterns of learners in the control group (without the FTC model guidance scaffolding) and the experimental group (with the FTC model guidance scaffolding) in asynchronous online discussion during a photography course. To understand the students' processes of social knowledge construction, the IAM was adopted to encode the discussion content of all students during the online learning activities.

3.1. Participants

Participants in this study were 63 communication-major freshmen enrolled in a photography course at a 4-year university in northern Taiwan, mostly between the ages of 18 and 20. The participants had not taken any photographic courses before this study. The purpose of the course was to introduce the multi-level meanings of photographic work and applications of photographic skills. During the course, students were divided into two groups, with 33 students randomly assigned to the experimental group, and the remaining 30 assigned to the control group in the asynchronous online discussion study. Each group of students was then divided into several small discussion groups, each subgroup consisting of three students. Both groups of students were taught by the same teacher.

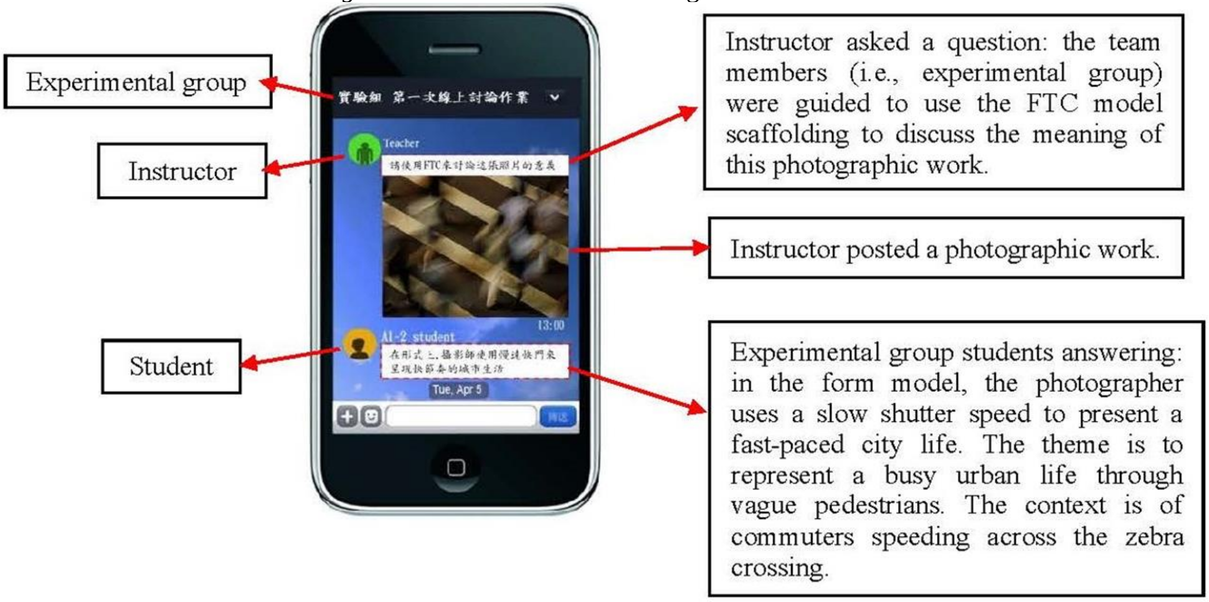
3.2. Experimental design

To explore the effectiveness of the FTC model guidance scaffolding in terms of the students' learning performance, social knowledge construction, and behavioral patterns in a photography course, a two-group experimental design was conducted. In this study, one group was assigned to use the FTC model guidance scaffolding, while the other group did not use it. The students' interaction patterns in the CSCL environment, the level of students' performance of photographic works (i.e., form, theme, and context), social knowledge construction, and behavioral patterns were evaluated. The study design had been reviewed and approved by a research ethics committee; participants' personal information was kept confidential during the study process to protect their personal privacy.

3.3. Online learning environment

This research used the Line app as a tool for the learning activities. The Line learning platform can record the process of all the discussions. Moreover, Line is very popular among college students in Asia today (Eun-ji, 2015), and its features allow sending audio, text messages, and archives to provide learners with learning at any time and in any place (Chen & Li, 2010). Wu et al. (2017) found that LINE can provide students with a positive perception of system characteristics, material characteristics, perceived ease of use, perceived usefulness, attitude toward the use, and behavioral intentions in the learning process. On the other hand, Line's social media characteristics seem to be beneficial to facilitating a realistic communicative environment and sustaining student self-direction, leading to effective interaction, providing privacy protection, and allowing the instructor to engage with and monitor the student interaction process in the learning activities (Marek & Wu, 2012; Wu et al., 2017). Additionally, the Line learning platform can be applied to a smartphone or a computer device to support learners' online discussion. Figure 1 presents an interface of the "Photography Course Learning Activity" in Line. On this platform, students could look at the photographic work and read the questions which were posted by the instructor. Then, the team members engaged in discussion activities. For example, the instructor posted a photographic work and asked the two groups' members to discuss and analyze the multi-level meanings of the photographic work. The experimental group members were guided to use the FTC model to discuss the meaning of this photographic work. On the other hand, members of the control group were not guided to use the FTC model guidance scaffolding to discuss the meaning of the photographic work.

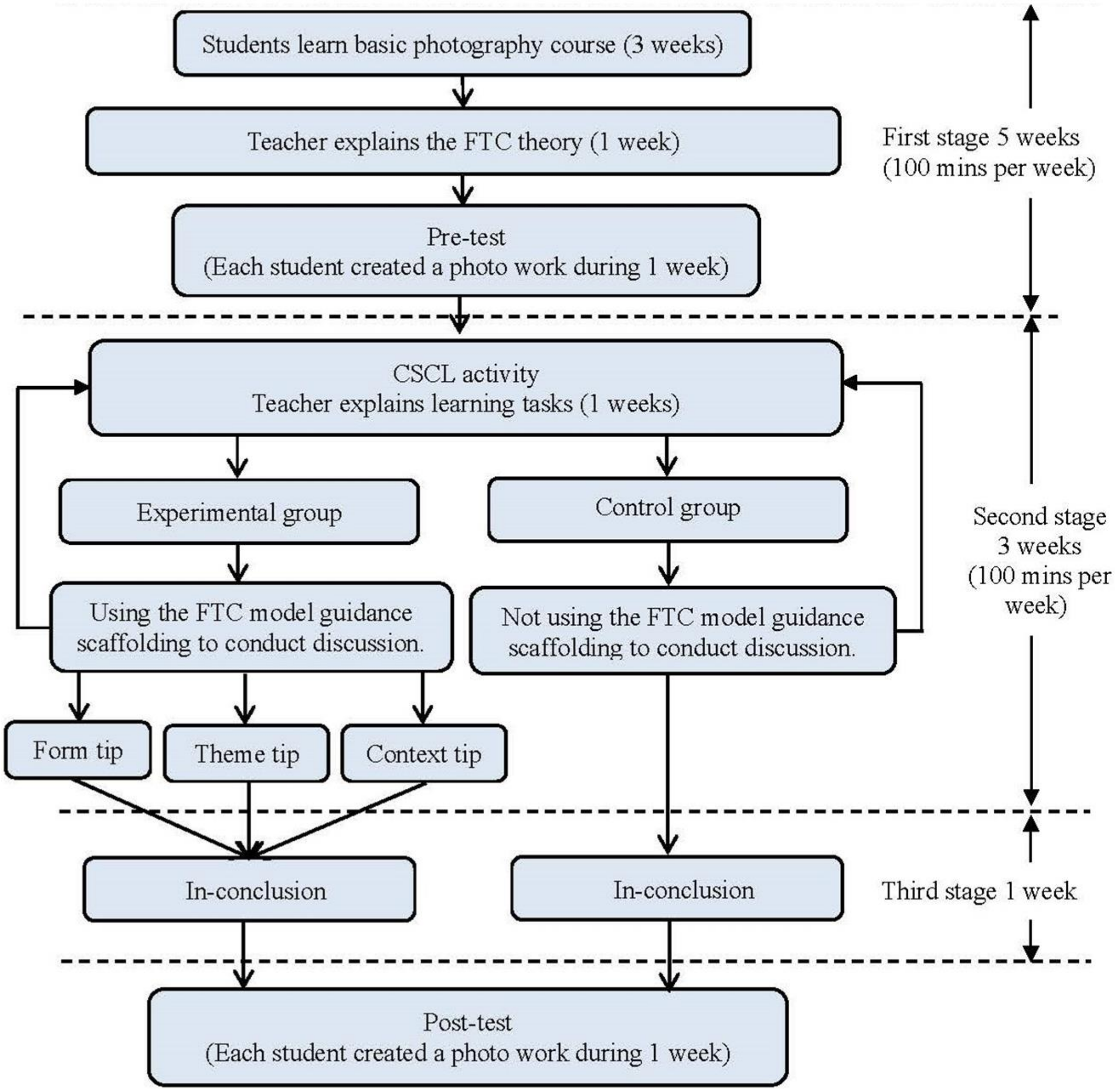
Figure 1. The interfaces of learning activities on Line



3.4. Experimental design

There were three stages of learning activities in the experimental design, namely the traditional classroom teaching basic photography knowledge stage, the CSCL activity stage, and the evaluation stage. After the experiment, the students' learning outcomes, discussion content, and behavior patterns were analyzed. Figure 2 shows a flowchart of the experiment.

Figure 2. Diagram of experiment design

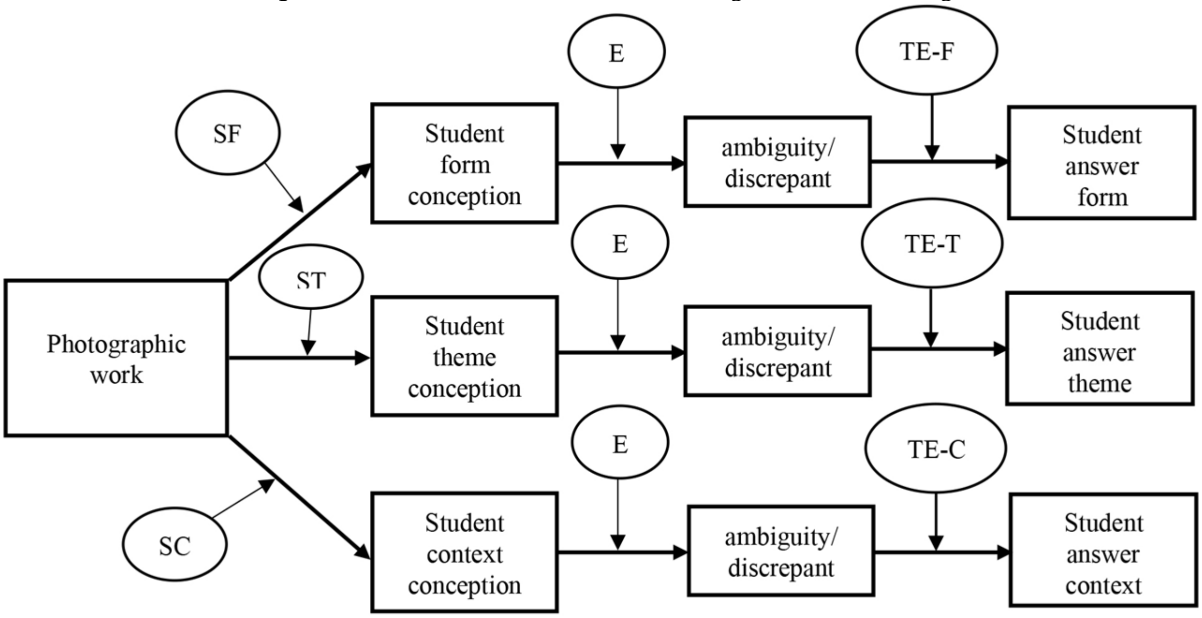


In the first stage, all participants took a 3-week course on the basic conceptions (i.e., aperture, shutter, sensitivity, composition, aesthetics) of photography in a traditional classroom, which is a part of the existing curriculum. Next, the teacher spent 1 week explaining the meaning (i.e., form, theme, and context) of the FTC model to the students. The course focused on training students' logic, critical thinking, and artistic skills in the process of creating photographic works using the FTC model. Then, each student must create a photographic work and text to describe the meaning of the work as a pre-test during 1 week.

In the second stage, the teacher spent 1 week explaining the learning tasks in the CSCL environment. Students were then randomly assigned to the experimental and control group to conduct online discussion activities. The experimental group and the control group were given the same problem, for example, would you please explain the meaning of this photograph? Thereafter, they were given 2 weeks for asynchronous discussion of the photograph. They were asked to share their viewpoints on the photographic work and to shape the main ideas in group discussions. The experimental group added the FTC mode guidance scaffolding to reflect on the photographic works. For example, the teacher would further examine the content of the students' answers; if there was any ambiguity, the teacher would then use the FTC mode guidance scaffolding (i.e., guidance of Form, Theme, and Context scaffolding or giving tips) to guide the students to think about the form, theme, and context of the photographic work, and then ask the students to answer the question again. Figure 3 shows the framework of the FTC model guidance scaffolding.

The control group did not have the FTC model guidance scaffolding to guide them in reflecting on the photographic works. For example, in a discussion activity, the teacher also checked the responses of the students in the control group, but if there was any ambiguity, the teacher would only ask the students to re-answer the question and did not use the FTC mode guidance scaffolding to guide students to think about the multi-level meanings of the photographic work.

Figure 3. The framework of the FTC model guidance scaffolding



Note. SF: Students analyze the form of photographic works; ST: Students analyze the theme of photographic works; SC: Students analyze the context of photographic works; E: Teacher reviews the content of students' discussion; TE-F/T/C: Teacher guides the students to think about the form/theme/context of the photographic works.

In the third stage, during 1 week, each student was asked to create a photographic work and text to describe the Form, Theme, and Context of the photograph, indicating their post-test learning result.

3.5. Rubrics for evaluating students' learning performance

The FTC model for decoding and coding art is a well-balanced and easily analyzed model for artworks (Sandell, 2009). Therefore, the FTC model is suitable for analyzing various types of artwork. To enhance the evaluation of photographic works, this study invited an instructor and two photography experts who possess over 10 years of teaching experience to review and refine the form, theme, and context indicators of artwork proposed by Sandell (2009). Additionally, both experts have 12 and 15 years of experience in professional photography and have developed a wealth of expertise in photography creation. Therefore, the category indicators of the FTC from Sandell (2009) were discussed to come up with the most concise coding category indicators by the instructor and these two photography experts. It should be noted that the form category indicators of the FTC from Sandell (2009) involved a broad range of creative forms, such as art elements, design principles, 2D or 3D qualities, materials, methods, skills, style, and others. However, the photographic works of the students in this study do not contain 2D or 3D computer-modified creative forms. Therefore, we removed the 2D and 3D representations from the form indicators and modified the indicators to those of photographic creation, such as composition, aperture, shutter speed, sensitivity, and style (Langford, 2000), to suit the goals of this study. Additionally, the themes (i.e., what the work is about) and contexts (i.e., when, where, by whom, and why the work was created) of Sandell's (2009) FTC model are applicable to all types of artwork. Hence, their indicators are also appropriate for assessing the photographic works of the students in this study. Finally, the revised indicators for form, theme, and context, which serve as rubrics for evaluating student learning performance (i.e., photographic works' form, theme, and context), are presented in Table 1. These rubrics range from the lowest 2 points to the highest 8 points for each of the three items of form, theme, and context. Thereafter, these two photography experts scored the tasks done (pre- and post-test) by the 63 students, and inter-rater reliability was calculated.

3.6. Measurement

The measurement in this study included students' learning performance, the level of knowledge construction, and the behavior patterns which students conducted to discuss the multi-level meanings of the photographic works using the FTC model as the instruction strategy in the CSCL environment.

Additionally, to investigate the effectiveness of the FTC model guidance scaffolding and the improvement in students' learning performance (i.e., photographic works' form, theme, and context), the pre- and post-test required students to freely create a photographic work. Two experienced photography experts scored the students' photography work according to the rubrics which consisted of three evaluating dimensions, namely form, theme, and context, with a perfect score of 24. To avoid potential scoring bias, the two experts were not informed which students were in the experimental or control groups. Pearson's correlation was used to determine the inter-rater reliability. A correlation coefficient less than 0.5 is indicative of poor reliability, values between 0.5 and 0.75 indicate moderate reliability, values between 0.75 and 0.90 indicate good reliability, and values greater than 0.90 indicate excellent reliability (Koo & Li, 2016). In the present study, the pre- and post-test Pearson correlation coefficients for the two raters were 0.82 ($p < .05$) and 0.84 ($p < .05$) respectively, showing good reliability.

Moreover, to understand the level of knowledge construction and behavior patterns in the CSCL activity, this study adopted quantitative content analysis and sequential analysis of all the interaction data. Regarding the coding scheme of the quantitative content analysis, this study adopted IAM proposed by Gunawardena et al. (1997); the validity of this coding scheme has been proven in previous studies (Floren et al., 2020; Hou & Wu, 2011). Moreover, for the characteristics of the FTC model in the CSCL activity, we referred to studies of online interaction discussion (Hou & Wu, 2011) and added task coordination (i.e., FTC guidance scaffolding) and social interaction (i.e., task explanation) to the knowledge construction coding scheme. Thus, we proposed a revised coding scheme for the content analysis of knowledge construction and social interaction of the FTC model in the online-discussion-based learning activity. As shown in Table 2, the coding scheme covers three dimensions of discussion: knowledge construction (KC), FTC scaffolding (FTCS), and task explanation (TE), where each code represents a discussion behavior. To ensure the inter-rater agreement, two experts coded all the discussions based on the knowledge construction coding scheme. The kappa coefficient of inter-rater reliability was calculated to examine the reliability of this coding scheme.

Table 1. The rubric for evaluating students' learning performance

Aspect/Rating	Define	8 points (excellent)	6 points (good)	4 points (fair)	2 points (poor)
Form	Form refers to the ability to use photographic techniques, such as composition, aperture, shutter speed, sensitivity, and style.	This photographic work has excellent performance in terms of form.	This photographic work has good performance in terms of form.	This photographic work is just passable in terms of form.	This photographic work is bad in terms of form.
Theme	Theme refers to the issues, ideas, visual sources, and other artistic relevance expressed in a photographic work.	This photographic work has a unique theme and perspective.	This photograph has a good theme and perspective.	The theme and perspective of this photograph are vague.	The photograph lacks theme and perspective.
Context	Context refers to the way the photographic work applied living environment, society, culture, history, art, education, politics, religion, etc. to express the purpose of its creation.	This photograph is well-designed to express the creative purpose in the context.	This photograph makes good use of context.	This photograph uses only a small part of the context to express the creative purpose.	The context of this photographic work cannot express the creative purpose.

In 2 weeks, a total of 63 students conducted online discussion activities that resulted in more than 1,125 codes. The Kappa value of the inter-rater reliability for the control group was 0.75 ($p < .01$), and for the experimental group it was 0.85 ($p < .01$), which shows good consistency between the two coders. Therefore, the coding results were used for sequential analysis to understand the behavior patterns of students during their knowledge construction.

Table 2. The coding schemes for the content analysis of knowledge construction and social interaction

Dimension	IAM Code	Category	IAM-FTC Code	Description
Knowledge construction (KC)	KC1	Sharing or comparing of information about discussion topics	KC1-F KC1-T KC1-C	Presenting and comparing the information of photographic works or personal opinions. This information or opinion is about the Form, Theme, and Context of photographic works named KC1-F, KC1-T, and KC1-C, respectively.
	KC2	Exploring opinions and concepts among group members	KC2-F KC2-T KC2-C	Find out or identify disagreement about the meaning of photographic works among participants. The opinions and concepts are about the Form, Theme, and Context of photographic works named KC2-F, KC2-T, and KC2-C, respectively.
	KC3	The meaning of communicating or constructing knowledge	KC3-F KC3-T KC3-C	Negotiating the proposed ideas through questioning, explaining, or arguing the meaning of photographic works among members. The content is about the Form, Theme, and Context of photographic works named KC3-F, KC3-T, and KC3-C, respectively.
	KC4	Testing and modification of proposed synthesis or co-construction	KC4-F KC4-T KC4-C	Examining or modifying the proposed ideas based on collecting information about the content of photographic works. The ideas are about the Form, Theme, and Context of photographic works named KC4-F, KC4-T, and KC4-C, respectively.
	KC5	Agreement statement(s) / application of newly constructed meaning	KC5-F KC5-T KC5-C	Applying the proposed ideas and summarizing the suggestions about the meanings of photographic works. The ideas are about the Form, Theme, and Context of photographic works named KC5-F, KC5-T, and KC5-C, respectively.
FTC scaffolding (FTCS)	TE-FTC	The teacher leads or gives FTC guidance scaffolding tips	TE-F TE-T TE-C	The guidance or suggestions are about the Form, Theme, and Context of photographic works named TE-F, TE-T, and TE-C, respectively.
Task explanation (TE)	TE	The teacher explains learning tasks	TE	When students encounter difficulties in carrying out tasks, they could ask the teacher to explain the learning tasks again.
Off-topic (OT)	OT	Messages irrelevant to the discussion task	OT	Discussion not relating to the assigned topics or tasks.

4. Results

4.1. Effects of different teaching strategies on students' learning performance for the two groups

To examine the effects of different teaching strategies on students' learning performance for the two groups, a one-way ANCOVA was conducted to compare the effect of students' learning performance in the two groups while controlling for the pre-test score. The Levene's test was performed and the assumption of homogeneity was satisfied.

The result of analyzing the two groups of students' learning performance is shown in Table 3. From the Form scores, the results showed that the students in the experimental group performed significantly better than the students in the control group ($F = 5.53$, $p < .05$). However, for the Theme scores ($F = 3.11$, $p > .05$), there was no significant difference between the two groups' performance for the photographic work. In contrast, in the performance indicators of Context, there was a significant difference between the experimental and control groups ($F = 13.96$, $p < .001$), with a large effect size (η^2) of more than 0.14 (Cohen, 1988).

These findings are consistent with previous studies that demonstrated that the FTC model could guide learners to concentrate on analyzing the multi-level meanings of visual images (e.g., photographic images) and perform better on producing photographic works (Ho et al., 2013; Sandell, 2009).

Table 3. Describe data, ANCOVA, and effect sizes of the post-test results

	Group	*N*	Mean (adjusted)	Standard error	*F*-value	*p*	η^2
Form	Experimental	33	5.446	0.167	5.531^{*}	0.022	0.084
	Control	30	4.887	0.175			
Theme	Experimental	33	5.379	0.168	3.114	0.083	0.049
	Control	30	4.950	0.176			
Context	Experimental	33	5.399	0.161	13.960^{***}	0.000	0.189
	Control	30	4.528	0.169			

Note. $^{*}p < .05$; $^{***}p < .001$.

4.2. Comparison of social knowledge construction in the online discussions of the two groups of students

To answer the second research question, the two experts coded the text content of each paragraph in the online activities based on the IAM codes in Table 2. When the text content included two or more codes, the codes were listed in chronological order. That is, if the first and second paragraphs of the text content were KC1 and KC3 respectively, they would be encoded as KC1 and KC3 sequentially. According to the above-mentioned method, the context of each paragraph of text was coded, and each topic in a paragraph was given a set of knowledge construction codes. The count and percentage of knowledge constructs in the control and experimental groups during the online learning activities were analyzed, and chi-square tests were performed to determine significant differences in the distribution of the two groups. These results are shown in Table 4.

Table 4. Distribution of knowledge constructs in the control and experimental groups

Categories	Control *n* (% = *n*/256)	Experiment *n* (% = *n*/471)	Chi-square[a]
KC1	239 (93.40%)	345 (73.25%)	19.24^{**}
KC2	15 (5.86%)	80 (16.96%)	44.47^{**}
KC3	2 (0.78%)	42 (8.92%)	36.36^{**}
KC4	0	4 (0.85%)	

Note. $^{**}p < .01$; [a]Separate comparison for each category of difference by group

From the perspective of code distribution in knowledge construction, this study showed that the most common behavior in the two groups was KC1, followed by KC2 then KC3. It is notable that KC5 did not occur in either of the two groups. In the cross-group comparison, the category of KC1 illustrates that the control group obtained higher percentages, while the experimental group obtained lower percentages. Moreover, in the category of KC1, the percentage distributions showed significant differences by group level (χ^2 (2, N = 584) = 19.24, $p < .01$). This revealed that the experimental group performed more sharing and comparing of information (KC1) than the control group. In contrast, the categories of KC2 and KC3 illustrate that the experimental group obtained higher percentages, while the control group obtained lower percentages. Additionally, the percentage distributions showed significant differences by group level (χ^2 (2, N = 95) = 44.47, $p < .01$ and χ^2 (2, N = 44) = 36.36, $p < .01$, respectively). This revealed that the experimental group was more involved in exploring opinions and concepts among group members (KC2) and conducted the meaning of communicating or constructing knowledge (KC3), while the control group expressed fewer exploring opinions, and less co-construction occurred.

In terms of social interaction, the count and percentage of social interaction in the control and experimental groups are shown in Table 5. When comparing the percentage of off-topic discussion content of the control and experimental discussion groups, we can see that the proportion of off-topic discussions (OT) in the control group was 26.85%, which was higher than the 4.42% in the experimental group. In the category of OT, the percentage distributions show significant differences by group level (χ^2 (2, N = 51) = 16.49, $p < .01$). This indicates that the use of online discussions needs to give control groups more complementary mechanisms to promote social interaction. Additionally, it should be noted that in this study the experimental group received the FTC model guidance scaffolding strategy, while the control group did not. Therefore, we can see the percentage of “the teacher leads or gives FTC scaffolding tips” (TE-FTC) was 61.85% for the experimental group, whereas the percentage of “TE-FTC” for the control group was 0% in the entire discussion. By providing this scaffolding, learners may easily know how to dissect the meaning of photographic images and not easily get lost in discussion. This result confirms that the experimental group in the online learning activity had more discussion of the main topic than did the control group.

Table 5. Count of codes for social interaction in the control and experimental groups

Categories	Control *n* (% = *n*/149)	Experiment *n* (% = *n*/249)	Chi-square[a]
TE	109 (73.15%)		3.24 (n.s.)
TE-FTC	0		
OT	40 (26.85%)		16.49**

Note. **$p < .01$; n.s.= non-significant; [a]Separate comparison for each category of difference by group.

This finding indicates that the FTC model guidance scaffolding can help learners understand multi-level meanings of photographic images and concentrate on their discussions.

4.3. Sequential analysis of the online discussion of the control group and the experimental group

To answer the third research question, we further separately conducted lag sequential analysis to explore the behavior patterns in the social construction of knowledge in the two groups. The adjustment residuals (z-score) tables of the control group and the experimental group in the online learning activity are shown in Table 6 and Table 7, respectively. Each row represents an initial behavior, and each column represents a subsequent behavior. A z-score greater than 1.96 indicates that a behavior sequence reaches statistical significance ($p < .05$) (Bakeman & Gottman, 1997).

The results that achieved significant sequences in the control group were KC1-F→KC1-F, KC1-F→KC1-T, KC1-T→KC1-C, KC2-T→KC2-C, KC2-T→KC3-T, and KC2-C→KC2-T. Additionally, the results that reached significant sequences in the experimental group were KC1-F→KC1-F, KC1-T→KC1-C, KC1-C→KC4-C, KC2-F→KC3-F, KC2-T→KC2-C, KC2-C→KC3-F, KC3-F→KC2-C, KC3-F→KC3-T, KC3-T→KC3-C, KC3-C→KC3-F, KC4-F→KC2-F, and KC4-C→KC1-C. These two groups' statistically significant sequences were then plotted as a behavioral transition diagram in Figure 4.

Table 6. The results of sequential analysis for behaviors in the control group

	KC1-F	KC1-T	KC1-C	KC2-F	KC2-T	KC2-C	KC3-T	OT
KC1-F	2.05*	3.48*	-1.91	-0.57	0.02	-1.00	-0.81	-0.38
KC1-T	-1.14	-0.32	4.60*	-0.46	-0.92	-0.79	-0.65	-1.44
KC1-C	-1.60	-1.34	1.10	-0.46	-0.92	-0.79	-0.65	-1.44
KC2-F	0.96	1.28	-0.65	-0.10	-0.20	-0.18	-0.14	-0.46
KC2-T	-1.08	-0.90	-0.92	-0.14	-0.29	3.90*	4.86*	-0.66
KC2-C	-0.93	0.79	-0.79	-0.12	8.04*	-0.22	-0.18	-0.57
KC3-T	-0.76	-0.63	-0.65	-0.10	-0.20	-0.18	-0.14	-0.46
OT	-1.38	-1.47	-2.14	-0.34	-0.68	-0.58	-0.48	8.10*

Note. *Indicates that the z-score is greater than 1.96, which is statistically significant (*$p < .05$).

Figure 4. The behavioral transition diagram of the control group and experimental group

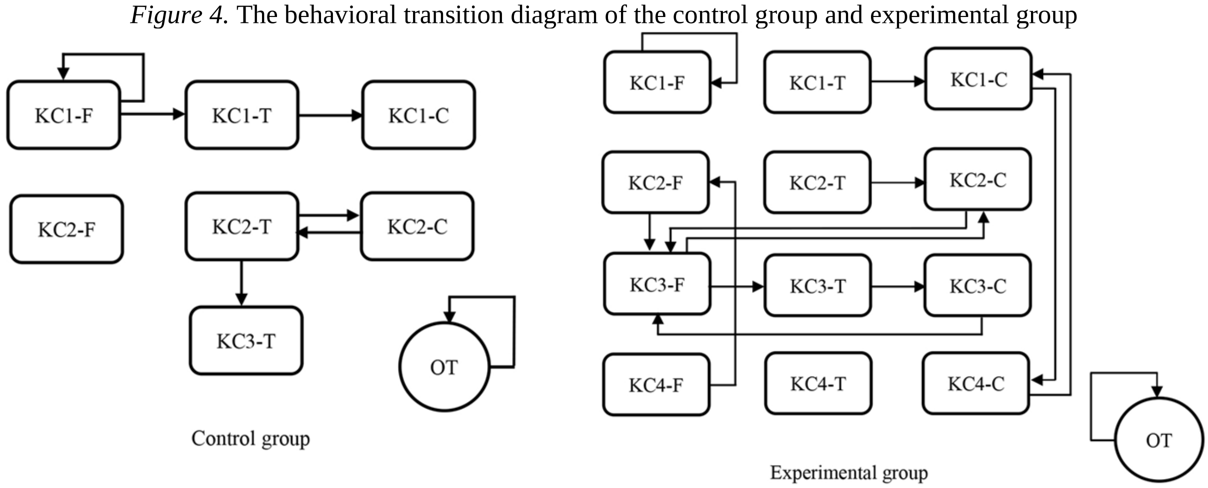


Table 7. The results of sequential analysis for behaviors in the experimental group

	KC1-F	KC1-T	KC1-C	KC2-F	KC2-T	KC2-C	KC3-F	KC3-T	KC3-C	KC4-F	KC4-T	KC4-C	OT
KC1-F	3.61*	1.89	-1.45	-0.40	0.75	-0.50	-1.67	-1.32	-1.02	-0.58	-0.58	-0.58	-1.71
KC1-T	-1.58	-0.18	2.20*	-0.32	-0.89	0.24	-1.13	-0.89	-0.68	-0.39	-0.39	-0.39	-0.79
KC1-C	-0.08	0.85	-2.76	-0.49	-0.96	-1.06	-0.24	1.53	-0.74	-0.43	-0.43	2.34*	-1.70
KC2-F	-1.10	0.44	-1.48	-0.64	1.92	1.67	3.19*	-0.45	-0.35	-0.20	-0.20	-0.20	-0.79
KC2-T	0.11	-0.80	1.85	-0.38	-0.27	3.25*	-0.34	-0.27	-0.21	-0.21	-0.12	-0.12	-0.47
KC2-C	-0.36	1.41	-1.09	1.80	-0.33	-0.36	2.11*	-0.33	-0.25	-0.15	-0.15	-0.15	-0.58
KC3-F	-0.70	-0.10	-0.28	-0.54	-0.38	2.11*	1.71	7.90*	-0.29	-0.17	-0.17	-0.17	-0.67
KC3-T	0.11	-0.80	0.48	-0.38	-0.27	-0.29	-0.34	-0.27	9.76*	-0.12	-0.12	-0.12	-0.47
KC3-C	-0.94	0.99	-0.76	-0.33	-0.23	-0.25	3.26*	-0.23	-0.18	-0.10	-0.10	-0.10	-0.41
KC4-F	-0.54	-0.40	-0.44	5.31*	-0.13	-0.15	-0.17	-0.13	-0.10	-0.06	-0.06	-0.06	-0.23
KC4-T	-0.54	-0.40	-0.44	-0.19	-0.13	-0.15	-0.17	-0.13	-0.10	-0.06	-0.06	-0.06	-0.23
KC4-C	-0.54	-0.40	2.88*	-0.19	-0.13	-0.15	-0.17	-0.13	-0.10	-0.06	-0.06	-0.06	-0.23
OT	-1.00	-0.90	-1.11	-0.78	-0.54	-0.60	-0.69	-0.54	-0.42	-0.24	-0.24	-0.24	10.67*

Note. *Indicates that the z-score is greater than 1.96, which is statistically significant ($^*p < .05$).

Based on the above results, we found that there are some similarities and differences between the two models. The results are shown in Table 8. Each row represents an initial behavior, and each column represents a subsequent behavior. Comparing the knowledge construction of the two groups, the students of the two groups have three similar initial phases of behaviors of knowledge construction (i.e., KC1-F→KC1-F, KC1-T→KC1-C, KC2-T→KC2-C). However, there were six more advanced phases of behaviors of knowledge construction (i.e., KC3-F→KC2-C, KC3-F→KC3-T, KC3-T→KC3-C, KC3-C→KC3-F, KC4-F→KC2-F, KC4-C→KC1-C) that occurred in the experimental group, whereas none of these behaviors occurred in the control group. This means that adopting the FTC model guidance scaffolding could better stimulate students to conduct more advanced phases of behaviors of knowledge construction (i.e., KC3-F→KC3-T, KC3-T→KC3-C, KC3-C→KC3-F). Additionally, the experimental group tended to put forward different opinions on the Form, Theme, and Context of the photography images, and then further entered testing and modification of the proposed synthesis or co-construction behavior (i.e., KC1-C→KC4-C, KC4-C→KC1-C). On the other hand, these behavioral patterns mean that the FTC model guidance scaffold can help learners to move from lower to higher levels of cognition. This may be due to the fact that the FTC model guidance strategies can motivate students to engage in peers' debate, critical thinking, and more interaction (Ho & Yen, 2011; Reverman, 2013).

Table 8. Results for the similarities and differences in the knowledge construction behaviors of the two groups

	KC1-F	KC1-T	KC1-C	KC2-F	KC2-T	KC2-C	KC3-F	KC3-T	KC3-C	KC4-F	KC4-T	KC4-C	OT
KC1-F	CEG*	CG*											
KC1-T			CEG*										
KC1-C												EG*	
KC2-F							EG*						
KC2-T						CEG*	CG*						
KC2-C					CG*		EG*						
KC3-F						EG*		EG*					
KC3-T									EG*				
KC3-C							EG*						
KC4-F				EG*									
KC4-T													
KC4-C			EG*										
OT													CEG*

Note. CEG* represents similar behavior of the two groups in terms of knowledge construction; CG* represents the significant knowledge construction behavior in the control group; EG* represents the significant knowledge construction behavior in the experimental group. *Indicates that the z-score is greater than 1.96, which is statistically significant ($^*p < .05$). Abbreviations: CG, control group; EG, experimental group.

5. Discussion

This study used FTC model guidance scaffolding to help students learn conceptual knowledge in a photography course by combining an online discussion forum on the Line social media platform. Scaffolding was designed on the FTC model framework to support students' learning in the experimental group. Using the FTC model guidance scaffolding, students engaged in more discussions and better understood the multi-level meanings of photographic works and advanced knowledge construction.

In response to research question 1, “Do online learning activities assisted by the FTC model guidance scaffolding enable students to achieve better learning performance (i.e., photographic works’ form, theme, and context) in the CSCL environment?”, this study found that students in the experimental group performed better in terms of the Form and Context of their photographic works than students in the control group. This result may be similar to Reverman’s (2013) study, which revealed that the FTC model can provide students with specific frameworks and applications to support and improve their scores on visual arts examinations, as well as encouraging them to think about how form and context can support their chosen theme. Additionally, there was no significant difference in the “theme” performance of the photographic works of the control and experimental groups. As Ho and Yen (2011) found, it is not easy for learners to express an appropriate theme using the FTC model scaffolding. This may be because students have difficulty synthesizing these concepts (i.e., form, context) with appropriate themes in a short period of time (Ho et al., 2013; Hou et al., 2015; Scherling, 2011). Therefore, future research could develop complementary teaching strategies to improve students’ ability to integrate form and context to construct an appropriate theme.

In response to research question 2, “What are the characteristics and differences of social knowledge construction in the CSCL environment discussion activities of the control group and experimental group?”, we found that the main characteristics of the online discussions in the two groups was knowledge sharing. The sharing and comparison of these opinions may inspire students to further explore knowledge (Hou et al., 2008). Previous studies in similar contexts have also found similar results (Hou et al., 2015). However, the students in the experimental group were more intent on asking and answering questions to clarify disagreement about questions (KC2) and to negotiate the meaning or co-construct knowledge (KC3) than were the control group students. Moreover, students in the experimental group with the FTC model guided scaffolding had more discussion behavior codes than students in the control group without the scaffolding. In other words, the FTC model, as a guiding mechanism for the creation of artificial art, implies a process of knowledge construction. As Rojprasert et al. (2020) indicated, the construction of artefacts “promote[s] the internal activity of constructing knowledge through the external activity of constructing a representation or manipulation of that knowledge” (Clinton & Rieber, 2010, p. 764). Additionally, the higher level of knowledge construction (i.e., KC4, KC5) was still relatively limited in the experimental group. This may be due to the fact that the discussion period for this study was limited to 2 weeks, and students may have taken a less cognitively loaded approach to the discussion. Previous research has shown that providing sufficient time for online discussions helps to promote higher level thinking, as students may need more time for reflection (Hou et al., 2015; Scherling, 2011). Therefore, this situation might lead to a lack of higher-level knowledge construction in the discussion. These results may provide teachers with recommendations to improve the design of teaching experiments in the future.

In response to research question 3, “What are the differences in the sequential patterns of social knowledge construction in the CSCL environment discussion activities of the control group and the experimental group?”, we found that the behavioral sequences KC1-F→KC1-F and KC1-T→KC1-C reached statistical significance in the online discussions of the two groups of students. This means that the two groups found it easy to reach agreement as a result of sharing knowledge and ideas (Zhang et al., 2022). However, this study also revealed that the experimental group showed more advanced phases of discussion behaviors (i.e., KC3-F→KC2-C, KC3-F→KC3-T, KC3-T→KC3-C, KC3-C→KC3-F, KC4-F→KC2-F, KC4-C→KC1-C). Our findings are similar to those of previous researchers who noted that integrating effective learning strategies into the flipped classroom has the potential to promote students’ higher-order thinking (Chiang, 2018; Hwang & Chen, 2019). Additionally, it is interesting that more exchange of information occurred in the experimental group, such as KC2-F→KC3-F, KC3-F→KC2-C, KC1-C→KC4-C, and KC4-C→KC1-C, indicating that they engaged in more interaction and focused on co-constructing new knowledge during the activity. As Hou et al. (2008) suggested, during in-depth discussion, new questions might be created at the KC2, KC3, and KC4 stages to form a more in-depth dynamic discussion model. As a result, the FTC model guidance scaffolding is one of the key elements to help learners conduct reflection and knowledge construction.

In summary, the study provided a better overall process of discussion activities using the FTC model guidance scaffolding including the differences between the control group and the experimental group. Therefore, in the practice of photography education, the FTC model guidance scaffolding offers instructors a new discussion strategy to enhance learners’ ability of knowledge construction when analyzing the meaning of photographic works.

6. Conclusions and suggestions

In this research, we proposed a pedagogical design of FTC model guidance scaffolding to help students learn conceptual knowledge in a photographic course. Although Sandell (2006) proposed the FTC model to help learners create and identify layers of meaning in artworks, there seems to have been no investigation into the impact of the FTC model on learners identifying the level of meaning of visual artworks and behavior patterns of knowledge construction. Therefore, the main implication of this study is the introduction of the FTC model guidance scaffolding to support online asynchronous discussions on the multi-level meanings of visual imagery, and further comparison of differences in knowledge construction and behavioral patterns between the experimental group (i.e., using the FTC model guidance scaffolding) and the control group (without the FTC model guidance scaffolding). This study also shows that students who use the FTC model guidance scaffolding to support their online discussion activities can improve their performance. Therefore, this study can be used as a pedagogical reference for teachers of visual literacy and photography education to enhance students' ability to construct knowledge about the multi-layered meanings of visual images.

Through sequential analysis and the quantitative content analysis of knowledge construction, this study found that more discussions took place in the experimental group, especially "exploring opinions and concepts or the meaning of communicating." In a further analysis of online discussion behavior, this study revealed the behavior sequence of the experimental group, realizing more discussion behaviors and a diverse social knowledge construction process. However, the interaction at the level of knowledge construction in KC5 was not present in either of these two groups. Although the FTC model to some extent facilitated students' interactive behaviors and knowledge construction, their higher level of knowledge construction still had room for improvement. Moreover, the small sample size and exploratory nature of this study may limit the generalizability of the findings. Therefore, some suggestions are provided as follows.

First, Line was used as the online discussion platform for this study. By using Line, students can easily interact and share information (e.g., pictures, videos, texts, etc.) via different digital devices (e.g., smartphones) without the constraints of time and space (Chen & Li, 2010; Marek & Wu, 2012; Wu et al., 2017). However, with the development of new technological tools and the popularization of information networks, many new tools have been provided for online collaborative learning, such as online discussion forums and mobile instant-messaging apps. Studies have shown that these tools show different results in terms of knowledge construction and affective aspects when promoting collaborative learning; for example, the use of the Knowledge Forum can promote more knowledge-building communication than mobile instant messaging applications, but mobile instant messaging applications support more affective interaction (Sun et al., 2018). It is therefore suggested that future research could investigate whether the FTC model combined with other discussion platforms (e.g., Knowledge Forum) with some specific functions and applications could enhance the construction of higher levels of knowledge.

Secondly, future research will increase the analysis of the content of off-topic discussions. Social interaction includes conversations that are or are not related to the topic of learning. However, off-topic discussion provides an activator for creating the team atmosphere and cohesion. Several studies have shown that off-topic social interactions are not only related to interpersonal relationships but also to cognitive level and social knowledge construction (Lin et al., 2016; Hou & Wu, 2011; Kreijns et al., 2007). Therefore, it is necessary to further analyze the non-thematic types of social interactions; future research can be carried out on the qualitative analysis of off-topic content and the impact of topic deviations on collaborative online learning.

Finally, this study did not explore the reasonable effects of individual differences such as age and gender; therefore, future studies are encouraged to consider various individual characteristics as the control variables setting in the designed model.

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