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Creativity Development Conception and Execution in Chinese High School ICT Classes

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This study aims at integrating technical creativity development into Chinese ICT classes. In order to achieve it, we proposed an explicit technical creativity teaching by comprehensively considering levels of creativity, learners' level and subject context three factors. To certify its teaching effectiveness, we integrated it into a general teaching and compared its learning outcomes with those of the general teaching. We executed these two methods in Chinese ordinary high school ICT classes, and rated students' products by a rubric. Results indicated that 1) the explicit technical creativity teaching was more effective in developing lower-level students' technical creativity compared with the general teaching; 2) regarding the knowledge application which is the basic teaching objective of SACs, the technical creativity group performed equally with the general group in applying knowledge that is integral in the productive process. However, application of detailed knowledge might be affected by intense concentration on creativity.

Keywords: creativity development, technical creativity, explicit teaching, software application classes

Introduction

Along with the advent of the knowledge economy, creativity has received increasing emphasis. According to the Partnership for 21st Century Skills, creativity is a key component of 21st century learning and innovative skills. Therefore, developing students' creativity has become an important educational objective, and many countries and regions are launching creativity education (Cheng, 2010; Lin, 2011; Poon, et al., 2014; Zampetakis, et al., 2007).

In the 1990s, China advocated creativity education with an emphasis of promoting scientific and technological innovation. Initially, extension of creativity education was encouraged to be included in higher education. Furthermore, in 2010, national creativity education policies began to focus on primary and secondary education. The 12th five-year plan (2011–2015) emphasized that teachers should "get innovative with educational methods" and "develop students' creative thinking" (Pang & Plucker, 2013).

To date, the effects of active learning techniques, such as brainstorming, mind mapping, and synectics, on generating new ideas or solutions have been widely acknowledged. Therefore, they are often used in higher education. However, in Chinese primary and secondary education, they are seldom used in daily teaching, for the following reasons: 1) Teachers' limited time and energy. From teachers' perspectives, creativity education requires developing a special environment, a task which demands much of their time and energy (Davies, et al., 2013). This is true, especially for teachers who have little knowledge of creativity and its development. Heavy instructional tasks, and limited time, energy, as well as competence prevent teachers from learning and attempting creativity education. 2) Teachers' professional qualities. When reforming pedagogical methods, the teacher must balance the requirements of the syllabus with the new, extra teaching objective (in this case, creativity development). This is a challenge for most teachers. Furthermore, they also face the challenge of aligning creativity development teaching methods with educational realities, for instance, the limited instructional time, materials, devices, equipment as well as other factors. 3) Students. Chinese students are accustomed to receiving clear and direct instructions from their teachers. They tend to lack creative consciousness and creative thinking ability. Their original thinking and learning habits and low motivation have resulted in undesirable performance in active learning, lesson. Thus, teachers face a challenge in moving creative lessons forward (Cheng, 2010).

Therefore, teachers in Chinese primary and secondary schools insist on using traditional teaching methods. Moreover, researchers never give up developing higher-order thinking skills by traditional teaching methods, e.g., explicit teaching (Fogarty, 1993; Zohar, et al., 2003, 2007, 2008).

Literature Review

Explicit teaching

Explicit teaching is a method in which students are guided through the learning process with clear explanations and supported practice until independent mastery has been achieved (Archer & Hughes, 2011). It is an effective, efficient teaching method for maximizing students' academic growth. Its core procedure includes 1) clear and detailed interpretation of knowledge; 2) modeled practice to give students direct experience; and 3) mindfully independent application (Figure 1). Explicit teaching is derived from strategies for teaching concepts or skills in mathematics and reading (Flick, 1995).

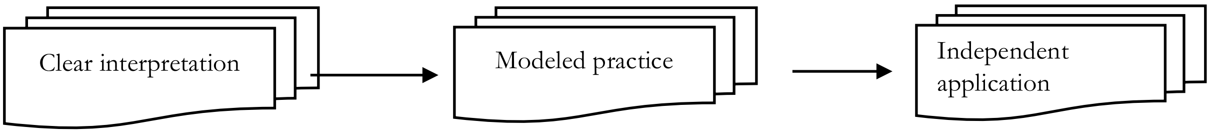

Figure 1. Core procedures of explicit teaching

The clear interpretation in mathematics and language learning is that a teacher explicitly interprets a theorem or a concept by naming it, modeling its use, describing it, and explaining its function. In addition to teaching objective knowledge, explicit teaching is also used to teach higher-order thinking strategies (Fogarty, 1993), and meta-strategic knowledge (MSK), e.g., control of variables (Zohar et al., 2003, 2007, 2008). However, the interpretation of thinking skills still focuses on the objective explanation of strategies, such as naming the thinking strategy, and explaining rules about when, why and how such a thinking strategy should be used.

In Fogarty's study (1993), "the creative skills of generating and producing ideas" is a higher-order thinking skill. Therefore, the explicit teaching of skills in creativity is considered identical to other higher-order thinking skills. However, unlike other higher-order thinking skills, creativity often "arises spontaneously from an individual's free mind" (Niu & Liu, 2009). The "Free mind" refers to the psychological process involved in creativity, which has a low level of explicability. This means that, in explicit teaching of creativity, explaining related strategies and rules only (Fogarty, 1993; Zohar et al., 2003, 2007, 2008) is not enough. Explicitly teaching creativity requires making its psychological processes explicit to students. Paradoxically, the low level of explicability makes it impossible to demonstrate all of its related psychological processes clearly. Therefore, in this study, making creativity's psychological processes explicit to students is to make students understand how to be creative, and thus ensure the utilization of their "Free minds".

Levels of creativity

A precondition of creativity development is that teachers clearly understand the implications of creativity within their subject matter. However, teachers' concepts of creativity tend to be narrow (Newton, 2013; Pang & Plucker, 2013). In fact, creativity is a complex, multidimensional set of personal dispositions, involving cognition, motivation, attitudes, knowledge, and other attributes (Taylor, 1975; Barron & Harrington, 1981; Cheng, 2010). Creativity can be understood from different approaches, for instance, mystical, psychoanalytic, and pragmatic (Sternberg & Lubart, 1999). Hence, defining creativity precisely is difficult. Despite this, creativity's products are supposed to be relatively novel and appropriate.

Taylor (1975) perceived creativity as a highly multi-ordinal concept, ranging from spontaneous feeling to abstract scientific or artistic formulations. He categorized creativity into five distinct psycholinguistic clusters —expressive, technical, inventive, innovative, and emergent creativity (Liu & Schonwetter, 2004). Each cluster involves different psychological processes and stands for a different level (Taylor, 1975). We interpreted the five levels based on other researchers' explanations (Taylor, 1975; Liu & Schonwetter, 2004; Wilson, n.d.).

- Expressive creativity is the ability to generate unique ideas with no concern about their quality.
- Technical creativity involves the ability to create products by applying existing skills, knowledge, and principles; through their application, however, expression of personal intention is restricted.
- Inventive creativity is the ability to explore different paths by revising present patterns or breaking particular rules or principles.
- Innovative creativity is the ability to modify something already in existence through alternative approaches, based on understanding of foundational principles. At this level, a product becomes more original.

• Emergent creativity is the most complex form, involving the most abstract ideational principles underlying a body of knowledge. This very novel type often emerges suddenly and is not necessarily predictable from prior knowledge.

The higher the creativity level, the more complicated its psychological processes. And correspondingly, its development becomes more difficult.

Consequently, to develop students' creativity through daily instruction, teachers must establish an appropriate target level of creativity, in line with realistic educational conditions. This study was conducted in high school software application classes (SACs) within the information and communications technology (ICT) subject area. In these classes, students are asked to explore and create individual products by applying learned knowledge and skills, which accords with the environment of technical creativity development. Therefore, setting a target level of technical creativity in high school SACs is feasible. The meaning of technical creativity in high school SACs is the ability to apply learned knowledge and software-related skills to make personal products that are novel and appropriate (Sternberg & Lubart, 1999), at least for students themselves.

Creativity development

Many studies have discussed how to increase creativity. In higher education, active learning and creativity techniques have become popular, while in psychology, just the two-word explicit instruction– "be creative" is considered effective in increasing participants' creative performance (Harrington, 1975; Chen et al., 2005; Niu & Liu, 2009; O'hara & Sternberg, 2000–2001). In psychological studies, "be creative" has worked as a direction to participants for the qualitative scoring criteria and as a goal leading them to produce novel, worthwhile responses (Harrington, 1975). However, Datta (1963, 1964) found that the explicit instruction– "be creative" only improved the performance of highly creative individuals. Some researchers also found that facilitation effects of explicit instruction to less gifted students were lower than for gifted students (Chen et al., 2005). This is because lower-level students have no idea how to be creative even though they have been told that they should be creative (Niu & Sternberg, 2003). Therefore, Niu & Liu (2009) proposed that instruction should be detailed enough to show lower-level students how to be creative. Their results confirmed that detailed instruction on being creative was effective in increasing lower-level students' creativity, but the two–word explicit instruction "be creative" was ineffective. However, these researchers did not provide examples of detailed instruction in their study.

Considering the general level of learners, teaching circumstances, and the effect of explicit teaching just discussed, we thus aim to customize explicit teaching into the detailed instruction of psychology to improve lower-level students' technical creativity, and to test the teaching effectiveness of detailed instruction in authentic classes.

Explicit Technical Creativity Teaching

In an environment where technical creativity is explicitly taught (it will be called explicit technical creativity teaching hereafter), the teacher will make technical creativity explicit to students by interpreting the kinds of individual thinking that technical creativity involves and by elaborately displaying a whole individual thinking process for developing products through technical creativity.

Based on technical creativity's definition in high school ICT, individual minds involved in technical creativity are concerned with the interrelationship between a personal intention and the application of principles. Consequently, in the clear interpretation activity, a teacher directly explains the interrelationship by interpreting its representations, that is, its finished products. Through these finished products, students can also learn visually what a product of technical creativity could be. During lesson planning, a teacher needs to select several excellent finished products and explicitly interpret their designers' intentions and creative application of principles.

In addition, according to previous research findings in psychology (Niu & Sternberg, 2003; Niu & Liu, 2009), the development of lower-level students' creativity requires detailed instruction showing them how to be creative. Correspondingly, in explicit technical creativity teaching, increasing lower-level students' technical creativity also requires detailed and elaborate instruction, showing to them in a clear manner how to achieve a product of technical creativity. In this study, we treat elaborative instruction as a model practice of explicit teaching to provide students with direct experience.

In the elaborative instruction, a teacher prepares a concrete creative task, and displays in detail the whole individual thinking process involved in completing the task. To lead students to produce novel and appropriate products, the whole thinking process should be flexible and easy to approach. Taking Web design as an example, the process is proposed in three steps: 1) generating a personal intention, 2) identifying a design prototype to express the intention, and 3) designing an orderly series of elements to realize the prototype through application of learned principles. Generating a personal intention is a process of identifying a style for the targeted product. Intention is generated from the designer's personal preference, experience, association, imagination and other personal thinking. The intention works like a product's keynote for designers. After identifying a personal intention, to express the keynote in a novel way, the designer must identify a personal design prototype for a product. Identifying a design prototype is a process of seeking a concrete representation for the intention through comparison, analogy, association, forced connection and other techniques. Notably, the design prototype of the elaborative instruction should be concrete and familiar enough to lower-level students that it can be used for guidance. With identification of the design prototype, a designer could match parts of the representation with each element and design them by applying relevant design principles. The whole personal thinking process comes from the teacher's practical experience. The teacher needs to plan lessons around actually modeling the practice.

In independent application, students are asked to create a novel and appropriate product by simulating the thinking process taught in elaborative instruction. Certainly, higher-level students can directly begin mindful application.

Figure 2 displays the framework of explicit technical creativity teaching.

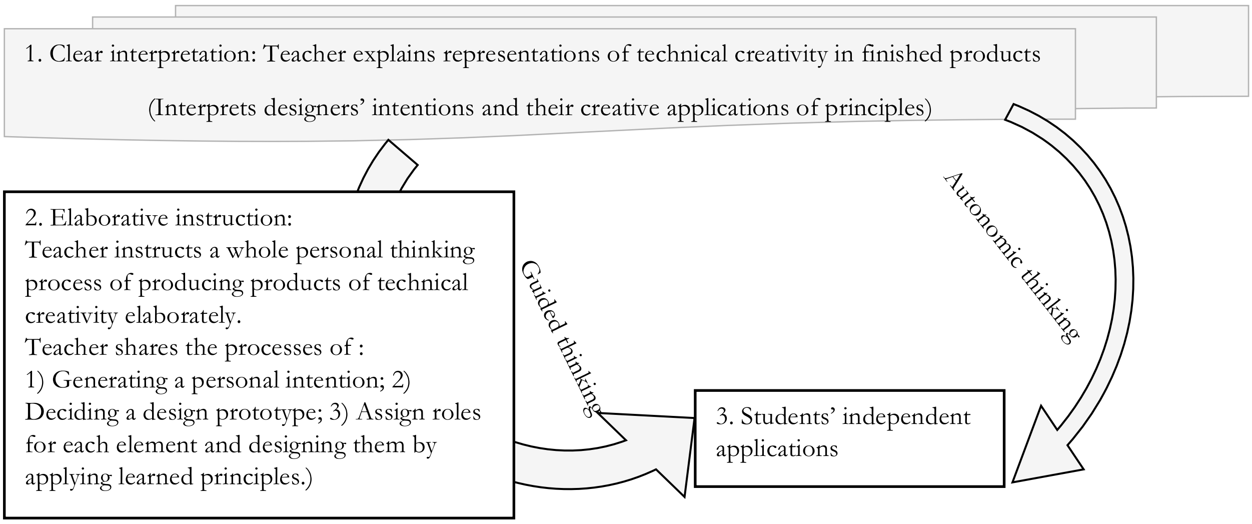

Figure 2. A framework of explicit technical creativity teaching

To ensure the effectiveness of explicit technical creativity teaching, this study designed a lesson plan for one software application class based on the framework, executed it in authentic classrooms, and compared its learning outcomes with those of general teaching. In the following sections, the lesson plan, its execution, and learning products' evaluations are presented. In addition, the study's findings are discussed.

Method

Participants

Participants were 10th graders (freshmen) of Linyi No. 4 High School in Shandong Province, China. About 80% of these 10th graders were 16 years old, and about 20% were 17. Linyi No. 4 High School had 16 classes in the 10th grade. The students' general ability and level of every class were similar. From eight classes taught by our collaborating teacher, four classes were randomly selected. Every two classes formed a learning group, and each class had about 50 students.

Since the high school is an ordinary school, students' general academic achievements were in the mid and lower levels. Before the lessons, participants had no knowledge of FrontPage 2003 and Web design. However, they were familiar with the basic operation of other Microsoft Office software, for instance, Word 2003 and PowerPoint 2003.

Teaching contents

Teaching contents were Web design and website making, usually taught during the second term of 10th grade (March–July). Our experiment's date and the cooperating school's instructional progress determined the

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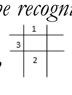
teaching contents. In this learning unit, students had the following three objectives: 1) learn basic knowledge about Web design, such as the basic elements of a webpage, the general process of Web design, the basic structure of layout, and use of color; 2) learn to use FrontPage 2003 software; and 3) design and produce a website by applying learned knowledge (design principles and software skills). In this study, we focused on the third objective, designing and producing a Web site.

Templates of lesson plans

Explicit technical creativity teaching can be integrated naturally into daily instruction of high school SACs. In this study, we added it to general teaching to compare the two methods' teaching effectiveness. Table 1 provides templates of two lesson plans.

Table 1. *Templates of Two Lesson Plans*

Lessons	Technical Creativity Group	General Group
1st (45min)	Knowledge Learning: (a local teacher) • Basic knowledge about web design: basic elements of a webpage; the general process of web design; basic structure of the layout; color; website making software; • Principles of web design (contents are alternative): Color: #Using analogous color & contrast color to express artistic effects; #Using color lumps to help compose the layout; Using color to deliver different feelings; Color matching; Layout: #Designing unique layout by emphasizing the design of navigation; #Using lines or other shapes to compose an irregular layout; Integrating the sub-navigation & header together to make the layout; * After instructing principles, several typical applying examples will be shown to students;	
2nd (45min)	Objectives: students could apply common tools of FrontPage to make a simple static website.	
	Students learn to use FrontPage software; (an instructional designer) (Details are ignored.)	A local teacher demonstrates how to use FrontPage software; Students determine a theme & contents; then prepare materials;
3rd & 4th (90min)	Explicit Technical Creativity Teaching (an instructional designer) (about 20min) • Clear Interpretation: -A teacher selects finished works which implies the creative application of learned principles. (In this lesson, we selected four works which implied the 4 principles marked with "#" in the first lesson.) -A teacher interprets designers' intentions and how they used related principles to express their intentions. A sample of an interpretation: *"The website is an ultra-compact personal website. Some people see the personal website as another home. This website can be interpreted from the concept of a house. Its layout can be deconstructed as the graphic below. The designer put the title and the body into the upper and the lower ends (1&2) of the middle column. The left space is helpful to construct the space feeling of a house. To make it concise, the title and the contents of body are just composed by text. In the top left corner (3), the designer placed the navigation and stretched it to the space between "title" and "body" a little, which can help to construct the feeling of depth. The navigation was designed by applying independent color lumps. The selection of colors may cater to designer's different feelings. These color lumps scatter orderly. And combining with a few shapely curves surrounding them, a dynamic feeling appears. …… The background color is the gradient of gray, which can be recognized as the wall of the hours in a sense. When you design, you can… ."*  • Elaborative Instruction: -A teacher displays a task of website making; -A teacher interprets a personal thinking process of doing	Independent Application: (a local teacher) Task Presentation: Task: design and make a novel website by applying layout and color related principles and using the materials prepared in last class; the students who didn't prepare materials can use the contents prepared by teacher. Independent Making: Students make the website by applying learned knowledge and skills; Teachers work as facilitators.

	technical creativity: a process of generating an intention, deciding a design concept and designing by applying related principles. Notice: The contents of this activity come from teacher's practical experience, therefore, contents will be changed with teachers. An simple example of this study: *A task: is the same with students' independent application- design and make a "FrontPage-learning website";* *The explanation of the design process:* *"The website is a learning website, so it's better to build a studying atmosphere for it. As a learner, I prefer a bright learning place and a serious studying atmosphere (personal intention). Therefore, I will design a website based on my preference. To express my intention novelly in the design, I would like to set a design concept for it. Blackboard newspaper in the rear wall of the classroom is my precious memory when I was in school, which stands for a bright and serious learning place for me. What's more, components of blackboard newspaper can be connected with elements of a webpage. Therefore, I would like to regard it as my design concept (students are also familiar with it). To realize it, the background of the website is designed to be a wall of neatly arranged bricks. Since the background emphasizes the oneness, the layout will adapt a visual type (related principles). The title is presented in the shape of sticker paper, and the anchor texts of the navigation are scattering across the bricks…. To express the bright feeling, the background color is the greyish white. The colors of bricks under anchor texts are colorized. However, in order to accord with the background color, the brightness and saturation of those colors will be considered (related principles)……. "*	
	Independent Application: Task & Objective Presentation: *Task*: design and make a "FrontPage-learning website" by applying learned FrontPage knowledge (source materials prepared by the teacher); *Objective*: students could make an unique intention for own works and express it by applying principles of layout and color to make a novel website; Independent Making: Students design the website after the learning and make a novel web by applying learned knowledge and skills; Teachers work as facilitators.	

This unit was planned for completion in four lessons of 45 minutes each. Because of the variety of principles and time limitations, for both the explicit technical creativity teaching group and the general group, students were to design and produce a novel website by applying principles of layout and color. To realize the objective, teachers presented all the required basic knowledge prior to students' beginning of their applications. In the first lesson, teachers presented knowledge about web design, such as a webpage's basic elements, the layout's basic structure, and design principles/standards of layout and color. In the second lesson, students learned how to use FrontPage. In the third lesson, the general group's teacher taught nothing, but showed students the task— design and produce a novel website by applying design principles of layout and color, — and granted them complete freedom to conduct independent work. However, the technical creativity group's teacher took up about 20 minutes of the students' application time to instruct them on the core of technical creativity— how to connect basic design principles of layout and color to create a novel product according to personal intention. In the fourth lesson, students continued creating their webpages.

Because explicit technical creativity teaching took 20 minutes of the students' application time, to save time, the theme and website contents were prepared in advance by the teacher. However, in the general group, to encourage students to be creative in developing their webpage contents, they were given special time in the second lesson to prepare themes and source materials. Therefore, besides the theme and web contents prepared by the teacher, the general group's students could choose to use themes and source materials that they had prepared.

Procedure

For a local teacher, to capture the essence of technical creativity in order to teach them clearly within a short time is by no means easy. Thus, to exert the effect of explicit technical creativity teaching, we proposed that a designer do the explicit technical creativity teaching.

Instruction was executed based on the templates of lesson plans mentioned above. To control possible effects caused by previous knowledge, we asked a local teacher to present the first lesson with the same contents in all four classes. Although two teachers taught the second lesson separately, their teaching objectives were the same: students could apply common tools of FrontPage to make a simple static website. In addition, during students' independent application, two teachers worked as facilitators to help solve operational problems. As a result, we believe that the second lesson's different teachers did not affect students' learning experience. In the third and fourth lessons, the local teacher explained the task to the general group and facilitated them in their independent applications. Except the two tasks done by the general group's teacher, the technical creativity group's teacher took about 20 minutes from the students' independent application time to conduct explicit technical creativity teaching.

During the application, students could freely collaborate with other classmates. At the end of their application time, they submitted their products voluntarily. Finally, the technical creativity group submitted 22 products, and the general group submitted 23 products.

Rubric

We designed a rubric to rate students' products. Based on contents taught in the study, we identified eight categories: Layout-Originality, Layout-Space Allocation, Use of Color, Web Elements, Navigation-Anchor Text, Hyperlink, Website's Directory Structure, and Web Content. In the rubric, most categories, except Layout-Space Allocation, had the following five levels: failed, novice, basic, proficient and exemplary. These levels' corresponding points ranged from 0 to 4. The interval between two points was 1. The basic level was a passable, or acceptable, level; the exemplary level was a remarkable level that students are expected to reach.

This study's objective was to execute technical creativity in layout and color. To evaluate achievements of the objective, three categories – Layout-Originality, Layout- Space Allocation, and Use of Color – were designed. Their different levels focused on differentiating the degree of technical creativity implied in products. The exemplary level stood for students' absolute originality, meaning that students completely discarded influences of the teacher's example. The creativity implied in other levels was relative and partial. The Web Content category was designed for students of the general group to help judge their motivations in preparing original themes and contents. The general application of knowledge is the basic objective of a software application class. Therefore, we designed Web Elements, Navigation-Anchor Text, Hyperlink, and Website's Directory Structure —four categories to assess whether students had mastered knowledge about 1) four webpage elements (header, footer, body and navigation), 2) identification of anchor text, 3) construction of hyperlinks, and 4) directory structure of a static website. Their criteria were objective. The exemplary level of the four categories stood for a unique correct application. For instance, the exemplary level of Web Elements—there are at least three, header (title), navigation and footer elements in the top page—mean that the three elements are essential in any webpage.

Table 2. *Rubric of Three Technical Creativity Related Categories*

Categories	Exemplary	Proficient	Basic	Novice	Failed
Layout-Originality	The layout is unique and attractive (the arrangement is smart, skillful, or artful) compared with teachers';	The arrangement of elements is modified based on teacher's layout;	The layout imitated teacher's layout;	The anchor texts are listed in a column optionally and lonely;	There is no layout because there is no navigation in the top page;
Layout-Space Allocation	The student allocates space for elements and sets them based on the characteristic of materials;	The space allocation of elements is reasonable;	The spacing among elements is large, which seems that they are not associative;	The position of navigation is out of the way;	
Use of Color	1.The added colors match with each other to express a certain feeling; 2.The student make the colors unique and	1.The background is clean and tidy; 2.The text color is bright to read; 3. The color matching of the website meets	The student used various colors in the top page, and 1)Main color systems used in the top page are less than four categories	The student used various colors in the top page, but 1)Colors are added optionally, so the web page looks	The student did not add colors(excluding the content images) to

	attractive by using similar colors and contrasting colors;	principles of color matching but doesn't serve for the expression of some feeling;	generally; 2) It is difficult to discern the text color and background image color;	messy; 2)Main color systems added in the top page are more than four;	the web page;

Coding

45 products of two groups were mixed together and respectively rated by two teachers. An explanation of how to use the rubric was written in a file. Before rating, teachers were informed of the need to read the explanation carefully, and if they had any questions, they could ask for help from researchers.

Because most students had written their names on the webpages, it was impossible to conduct a blind coding. However, to ensure the two raters' objectivity, when their scores for the four objective categories for the same product differed significantly, they were to exchange views and try to reconcile their differences. "Differed significantly" meant that the two teachers' ratings for the same product differed by two or more points. As for the three subjective categories that reflected raters' personal perspectives, significant differences between raters were allowed.

Hypotheses

Comparing two methods, we supposed that, explicit technical creativity teaching would be more effective in developing students' technical creativity.

In addition, knowledge application is the basic objective of a software application class, and all required basic knowledge were taught identically in both groups. Therefore, we also expected no difference in knowledge application between the two methods.

Results

Since two raters rated all students' works separately, firstly, we examined differences between their average scores. Means and standard deviations of eight categories of two groups rated by each teacher are shown in Table 3. The results of one-way within-subjects analysis of variance show that 1) there were no significant differences between two teachers' scores in four objective categories; 2) only in one of the three subjective categories-Use of Color, two raters' scores for both technical creativity group and general group were different significantly. The F value for general group was $F(1, 22) = 5.35$, $p < 0.05$; and the F value for technical creativity group was $F(1, 21) = 8.62$, $p < 0.01$. In order to check each teacher's evaluation for two teaching methods in Use of Color, we measured their scores separately by one-way between-subjects analysis of variance. Results show that there was a significant difference between two teaching methods in both the designer's (T1) score, $F(1, 43) = 10.6$, $p<0.01$ and the local teacher's (T2) score, $F(1, 43) = 7.04$, $p<0.05$.

Table 3.*Two Raters' Means & Standard Deviations of Eight Categories of Two Groups*

Groups	Raters	8 Categories															
		L-O		L-S.A.		U.C.		W.E.		N-A.T.		H.		D.S.		W.C.	
		M	SD	M	SD	M	SD	M	SD	M	SD	M	SD	M	SD	M	SD
Technical Creativity	T1	3.32	.84	3.16	0.83	3.27	.83	2.95	.84	3.09	.97	2.27	1.12	3.36	1.14		
	T2	3.23	.75	2.94	.42	2.91	.75	2.95	1.0	2.95	.72	2.27	1.16	3.27	1.08		
General Teaching	T1	2.61	.66	2.83	.58	2.43	.90	3.78	.60	2.61	.99	2.39	.89	2.87	1.46	2.30	1.15
	T2	2.61	.66	2.58	.51	2.17	1.07	3.70	.76	2.52	.95	2.26	1.05	2.91	1.38	2.22	1.04

Note. L-O =Layout-Originality, L-S.A. = Layout - Space Allocation, U.C. = Use of Color, W.E. = Web Elements, N-A.T. = Navigation-Anchor Text, H. = Hyperlink, D.S. = Website's Directory Structure, and W.C. = Web Content.

The focus of this study was to examine the effectiveness of two teaching methods. We therefore calculated the means of two raters' scores as the final scores of students' products and analyzed them by one-way between-subject analysis of variance (Figure 3). The results are shown in Table 4. In the three technical creativity related categories, there was a significant difference between two groups in both Layout-Originality, F

(1, 43) = 11.32, p<.01, and Use of Color, F (1, 43) = 9.59, p<.01. Average scores of the explicit technical creativity teaching in Layout-Originality and Use of Color were significantly higher than the general teaching's respectively. With regard to the four knowledge application related categories, except in Web Elements, there were no significant differences between two groups. The mean score of Web Elements of the general group was higher than that of the technical creativity group significantly, F (1, 43) = 11.72, p<.01.

Table 4. *ANOVA: Effects of Two Teachings on Different Categories*

Categories		Sum Square	*df*	Mean Square	F	*p*
Layout-Originality	Between Groups	4.96	1	4.96	11.32	.010
	Error (within groups)	18.84	43	0.44		
	Total	23.8	44			
Use of Color	Between Groups	6.96	1	6.96	9.59	.010
	Error (within groups)	31.19	43	.73		
	Total	38.14	44			
Web Elements	Between Groups	6.92	1	6.92	11.72	.010
	Error (within groups)	25.39	43	.59		
	Total	32.31	44			

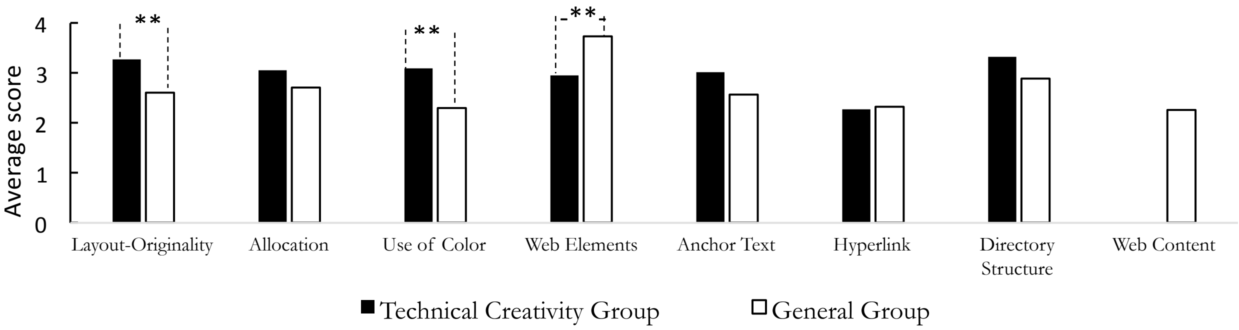


Figure 3. Means of two teaching methods' products

Signif. codes: ** p< .01; * p< .05.

Discussion

In this study, we statistically examined the different perspectives of two raters and the different effectiveness of two teaching methods.

First of all, findings of one-way within-subjects ANOVA indicated that, it was only in Use of Color that the two raters had significantly different perspectives. However, even if viewed from their different perspectives separately, the two teaching methods' effectiveness in Use of Color differed significantly. That is, although the two teachers had different perspectives on color, it would not affect them in differentiating the two methods' teaching effectiveness. Both teachers agreed that the effectiveness of explicit technical creativity teaching was better than that of general teaching for applying colors.

In addition, to discuss differences between the two methods, we needed to confirm the following two hypotheses.

Hypothesis 1: Compared with general teaching, explicit technical creativity teaching will be more effective in developing students' technical creativity.

In this study, technical creativity was limited to the creative application of layout and color relevant design principles. The explicit technical creativity teaching attempted to show students how to connect principles of layout and color to a personal intention. For more details, in the clear interpretation, the teacher interpreted intentions of good designs' layout and color matching to demonstrate what a creative layout could be and how colors were used to help express the intention. In the elaborative instruction, the teacher interpreted a personal divergent thinking process for designing a creative website: generating an intention, identifying a design prototype and designing an original layout and matching colors to express the intention to guide students' creative thinking in layout and color. The space allocation of Web Elements was not explicitly explained, but was implied in teaching layout composition.

From students' performances in these three categories, we learned that, in Layout-Originality and Use of Color, the technical creativity group performed significantly better than the general group. This demonstrated that explicitly interpreting the creative application of layout and color -design principles was effective in increasing lower-level students' technical creativity. However, since space allocation wasn't taught directly, the two groups' performances in Layout-Space Allocation showed no significant difference.

During examining the two teachers' scores for the Layout-Originality category respectively, we found that, the products in the technical creativity group (22 in all) that reached the exemplary level were 11 and 9. In contrast, the products in the general teaching group (23 in all) was both 2. The exemplary level of Layout-Originality was that, compared with teachers' examples, layouts of students' products were unique and attractive. Therefore, we inferred that after learning what an original layout could be and how to be creative in layout, more students tried to ignore the influences of the teacher's examples and began to form personal intentions to create unique works, even though these works might be unique for no one but themselves.

In Use of Color, the two teachers had significantly different perspectives. In spite of that, both teachers agreed that the technical creativity group performed better than the general group. Comparing the two groups' performances, we found that most technical creativity group students were in the proficient level: In other words, their websites' color-matching met principles of color-matching, but did not serve for the expression of some intention. Conversely, the general group's performances were mostly at the basic level: students selected colors based on personal preferences, not on related color principles.

Students' performances in Layout-Originality and Use of Color demonstrated that explicit technical creativity teaching succeeded in establishing circumstances that stimulated students' thinking and guided their creative applications. Accordingly, we concluded that explicit technical creativity teaching was more effective in developing lower-level students' technical creativity than general teaching.

However, from students' performances in Layout- Space Allocation, we found that only when the teacher clearly taught technical creativity—creative application of some knowledge and how to attain technical creativity did lower-level students increase their technical creativity.

Hypothesis 2: Students' knowledge application in explicit technical creativity teaching will be the same as that in general teaching.

The two groups did not differ significantly between application of Navigation-Anchor Text, Hyperlink, and Website's Directory Structure. However, the general group performed significantly better in application of Web Element than did the technical creativity group. This might be because in the website-producing process, application of Navigation-Anchor Text, Hyperlink, and Website's Directory Structure was integral, but application of Web Elements was not. In this study, Web Elements comprised four basic elements of a webpage: header (title, image), navigation, footer, and body (including image). The footer was often ignored because it was not important for expressing the designer's intention. Investigating students' websites, we found that in 22 products of the technical creativity group, only 6 added footers; in the general group, 20 of the 23 websites had footers. A reason might be that, within a limited time, students absorbed creative application through explicit technical creativity teaching, and this circumstance resulted in ignorance of application of "dispensable" knowledge.

In the study, Hyperlink's application was unsatisfactory. Two raters' mean scores were both lower than 2.5, implying that most students' Hyperlink applications were at the basic level: There were incorrect hyperlinks, but their rate was lower than 30%. The learning objective of hyperlink is that students could add hyperlinks exactly and without loss links. The reason for the lower application level of Hyperlink might also be limited time. These students were asked to design and develop a website in 90 minutes (for the technical creativity group, about 70 minutes). Completing their websites in such limited time was very difficult. Generally, students did not pay much attention to building hyperlinks before their webpages were complete.

Moreover, the two raters' average scores for Web Content were both lower than 2.5, indicating that these students lacked the ability and autonomy to complete creative work even when they were given complete freedom and sufficient time. This result is consistent with Niu's research: Chinese high school students need more elaborate clues on how to be creative (2010), and accords with our initial concern, "lower-level students lack creative consciousness," even though they had complete freedom to create individual products.

Conclusion

In this study, we focused on customizing explicit teaching to develop lower-level students' technical creativity and then examining this method's effectiveness. To achieve this objective, we proposed a framework of explicit technical creativity teaching and designed a lesson plan based on a framework for a Chinese ordinary high school software application class. Comparing explicit technical creativity teaching with general teaching methods, we hypothesized that: 1) explicit technical creativity teaching would be more effective in developing students' technical creativity compared with general teaching; 2) students' knowledge application in explicit technical creativity teaching would be the same as that in general teaching. Comparative instruction was executed in Chinese high school ICT classes to confirm these two hypotheses.

Results verified the effectiveness of explicit technical creativity teaching in developing students' technical creativity. However, in application of knowledge, which is integral in the productive process, the technical creativity group performed equally with the general group. Application of detailed knowledge after explicit technical creativity teaching might be affected by intense concentration on creativity.

The present study contributes to the integration of creative thinking development in ICT instruction. However, in this study, two different teachers used two teaching methods. These circumstances might affect teaching effectiveness.

In the future, we hope to confirm the effects of explicit technical creativity teaching in other software application classes, e.g., Photoshop. Additionally, in developing students' technical creativity, their thinking styles and personalities might play a part. In further research, we will clarify these relationships.

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