

論文 / 著書情報
Article / Book Information

| | |
|-------------------|--|
| 題目(和文) | |
| Title(English) | A practical study of effective instructional methods to develop technical creativity |
| 著者(和文) | 王世娟 |
| Author(English) | Shijuan Wang |
| 出典(和文) | 学位:博士(学術), 学位授与機関:東京工業大学, 報告番号:甲第10573号, 授与年月日:2017年3月26日, 学位の種別:課程博士, 審査員:室田 真男,前川 眞一,中山 実,林 直亨,山岸 侯彦 |
| Citation(English) | Degree:Doctor (Academic), Conferring organization: Tokyo Institute of Technology, Report number:甲第10573号, Conferred date:2017/3/26, Degree Type:Course doctor, Examiner:,,,,, |
| 学位種別(和文) | 博士論文 |
| Type(English) | Doctoral Thesis |

A PRACTICAL STUDY OF EFFECTIVE INSTRUCTIONAL METHODS TO DEVELOP TECHNICAL CREATIVITY:

BASED ON CASES OF CHINESE HIGH SCHOOLS

Shijuan Wang



Supervisor: Prof. Masao Murota

Examiners : Prof. Shin-ichi Mayekawa

Prof. Minoru Nakayama

Prof. Naoyuki Hayashi

Assoc. Prof. Kimihiko Yamagishi

Submitted to the

**Department of Human System Science,
Graduate School of Decision Science and Technology,
Tokyo Institute of Technology**

**For the Degree of
DOCTOR OF PHILOGOPHY**

FEBRUARY 13, 2017

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Chapter 1 Introduction

1.1 Background

How students learn is always being focused on and argued by educators. That's because what students should be equipped is always changing with the social development. In the 21st century, society needs students to master a set of learning abilities and skills that can help to increase their competitive power to succeed in the information age. The partnership for 21st century skills summarized these learning skills into critical thinking, creative thinking, collaboration, and communication (Kay, 2010). Integrating their developments into various academic subjects has been gaining increasing attention in the practice and research of education (Laura, 2012).

As one of 21st century skills, creativity was acknowledged as the number one leadership competency of the future in Po Broson and Ashley Merryman's poll of 1,500 CEOs. Correspondingly, creativity development has become one important educational objective. In order to achieve the objective, many countries & regions call on teachers to do classroom reforms (Cheng, 2010).

1.2 Statement of the problem

To date, the effects of active learning techniques, such as brainstorming, mind mapping, and synectics, in generating new ideas or solutions have been widely acknowledged. Therefore, they are often used in higher education. However, the popularization of creativity education in primary and secondary schools faces too many dilemmas 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 methods with

educational realities, for instance, the limited instructional time, materials, devices, equipments, and other factors. In addition, several studies have noted that teachers' concepts of creativity tend to be narrow (Newton, 2013; Pang & Plucker, 2013). If teachers cannot clearly understand the implications of creativity within their subject matter, it is difficult for them to promote the creativity education. 3) Students' features. The majority of primary and secondary students tend to lack creative consciousness, creative thinking ability, and "being creative" experience. Their original thinking—learning habits and low motivation could result in undesirable performance in active learning, which would be a challenge for teachers to move creative lessons forward (Cheng, 2010).

These issues present the need to perform practical research that aims at exploring the possibilities and limitations of integrating creativity techniques into daily instruction by sizing up the present conditions, e.g., teachers' professional qualities, students' abilities, and existing teaching resources, and other teaching related factors, to teach creativity in concrete subject areas in primary and secondary schools.

1.3 The target level of creativity

To develop creativity, the teachers need to have a good knowledge of creativity. Creativity is a complex, multidimensional set of personal dispositions, involving cognition, motivation, attitudes, knowledge, and other attributes (Taylor, 1975; Barron & Harrington, 1981; Cheng, 2010). Although its two basic defining characteristics are recognized as originality and usefulness (Mayer, 1999; Sternberg & Lubart, 1999), creativity has no universally acknowledged definition because of its complex nature. It can be understood from different approaches, for instance, mystical, psychoanalytic, and pragmatic (Sternberg & Lubart, 1999).

Thus, the term "creativity" can vary within different contexts and across disciplines. For research purpose, it is necessary to distinguish different dispositions, levels, states, and life styles of creativity (Taylor, 1975; Lucas et al., 2012). In an overview of creativity, Taylor categorized creativity into five clusters—expressive, technical, inventive, innovative, and emergent creativity (Taylor, 1975; Liu & Schonwetter, 2004; Wilson, 2016).

- 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.

Each cluster involves different psychological processes and stands for a different level (Taylor, 1975). Consequently, to develop students' creativity through daily instruction, teachers must establish an appropriate target level of creativity, in line with realistic educational conditions.

In the primary and secondary schools, heavy teaching tasks, limited time, energy and competence, students' original thinking—learning habits, and other factors, decide that it is impractical to set the target level of creativity too high. In addition, creative application of learned knowledge is one important learning objective of primary and secondary schools. Consistent with the definition, technical creativity emphasizes both the originality of products and the creative application of learned knowledge. Therefore, developing technical creativity in primary and secondary schools can not only meet the requirements of the syllabus but also put creativity development into practice. What's more, applying existing knowledge to generate new ideas, products or processes happens to be the first level of creativity and innovation skills according to 21st century skills framework for 21st century learning (Dede, 2010). Therefore, for the primary and secondary school education, it is feasible to set the target level of creativity on technical creativity. In this study, technical creativity is defined as the ability to apply learned knowledge and skills to make personal products that are novel and appropriate (Sternberg & Lubart, 1999), at least for

students themselves.

1.4 Purpose and research questions

This study aims to explore the possibilities and limitations of integrating various creativity techniques into daily instruction to develop technical creativity in concrete subject areas in primary and secondary schools, and anticipates to contribute towards providing practical experience and exploring pedagogical content knowledge about integrating creativity development into the daily instruction for primary and secondary school teachers.

To that aim, investigations regarding two research questions have been conducted.

- *Research question 1*

Is it possible to utilize a teacher-centered instructional method to develop technical creativity in primary and secondary schools?

- *Research question 2*

Is a student-centered instructional method more effective in developing primary and secondary school students' technical creativity than a teacher-centered instructional method?

1.5 Approach

The approach of this thesis can be summarized into the following two points:

1. Practical instructions, including the identification of appropriate instructional methods based on the authentic instructional environment, the design of instruction, and the execution of the instruction in authentic classrooms.

2. Analysis, evaluation, and comparison of students' achievements in technical creativity.

Generally, it is assumed that modern instructional methods are more effective in stimulating thoughts and cultivating problem-solving, critical thinking, creative thinking, and other 21st century

skills than traditional instructional methods. However, this does not mean that traditional instructional methods, such as lecture and explicit teaching, cannot be used to develop 21st century skills. In some occasions, advantages of traditional instructional methods, such as clear explanations, large-class communication, and being widely known by teachers and students, can play a role in developing 21st century skills. Garside (1996) used a traditional teaching method—lecture—to develop critical thinking skills, and compared its effectiveness to one type of active learning—group discussion. Results showed that there were no significant difference between the two instructional methods in developing critical thinking skills, and both methods developed students' critical thinking. However, in creativity education, few practical research investigated whether traditional (teacher-centered) instructional methods could be used to develop creativity. In order to address Research Question 1, this research first presents the reasons to utilize explicit teaching to develop primary and secondary school students' technical creativity, and then proposes a framework of explicit technical creativity teaching, displays the instructional design of explicit technical creativity teaching, and finally compares its teaching effectiveness with a general teaching methods.

With more findings on creativity, people believe that creative thinking “is not so much an individual trait but rather a social phenomenon involving interactions among people within their specific group or cultural settings” (p. 174, DeHaan, 2009) and effective peer-peer interaction can enhance group creativity (Taggar, 2002). Therefore, the active interactions among students in modern instructional methods, such as collaborative learning, problem-based learning, inquiry-based learning, are supposed to help students build the relationship of separate knowledge, construct students' personal understanding and increase the creativity.

However, whether all these modern instructional methods are suitable to be applied in primary and secondary education that has the heavy curriculum and limited time, and whether these student-centered instructional methods are more effective in developing technical creativity than teacher-centered instructional methods are still questions unsolved. To answer Research Question 2, this research analyzes the advantages of utilizing peer instruction as a representative of student-centered instructional methods to develop technical creativity in primary and secondary education, and compares its' teaching effectiveness in developing technical creativity

with those of explicit technical creativity teaching.

1.6 The measurement of technical creativity

The measurement of creativity is a very complex and difficult task because of its complexity. Numerous instruments have been developed to measure creative talents. Hocevar (1981) reviewed the used measures of creativity and classified them into ten categories: tests of divergent thinking, attitude and interest inventories, personality inventories, biographical inventories, teacher nominations, peer nominations, supervisor ratings, judgment of products, eminence and self-reported creative activities and achievements. However, these categories are not out of two areas: creative potentiality and creative performance (Guilford, 1966). Creative potentiality is “what an individual brings to a possible creative performance because of his personality structure” (p. 186, Guilford, 1966). It is in the form of interests, attitudes, emotional dispositions, and various abilities. Creative performance is what an individual actually produces.

Linn and Gronlund (1995) proposed principles supporting effective assessments. One essential principle is to specify clearly what is to be measured. Actually, the instrument is less important than how well it aligns with specific learning objective. In this research, the learning objective is that students could design and create individual products by applying learned knowledge and skills. This objective emphasized the results of students’ creative application of learned knowledge. Therefore, in this research, I decided to rate students’ creative performance—products—to evaluate students’ technical creativity. The indicators of students’ technical creativity are designed based on learned knowledge. However, what have to be acknowledged is the narrow views of the simplex measure on students’ technical creativity.

1.7 Generalizability of the Research

This study, firstly, illustrated an example of defining creativity based on specific contexts to grant creativity specific meanings and criteria. It can help teachers and students remove the ambiguity about the creativity in their concrete subjects. Secondly, I tried integrating creativity development into authentic subject-dominated education without changing too much the original teaching

program. This helps to eliminate teachers' rejection of applying complex active learning methods to teach creativity in their classes. Additionally, this study provided valuable teaching experiences in adapting different (teacher-centered and student-centered) instructional methods into authentic classrooms to cultivate technical creativity. It is conducive to inspire teachers to adapt other methods in their subjects to teach creativity.

This research was implemented in typical teacher-centered classes in a large public senior middle school in China. The participants in the school were accustomed to receiving clear and direct instructions from their teachers, and they had little experience in active learning, not to mention the development of creative thinking. This means that our findings are free from the restriction of students' original thinking habits. Therefore, the findings of this research are supposed to be widely popularized in other similar teacher-centered schools.

1.8 Definition of terms

In an attempt to alleviate any confusion due to the use of different terminology, the definitions of relevant terms in this research are shown in this section.

1.8.1 Creativity

Creativity is a complex concept. Up to now, across the educational world, there is no widely used definition (Lucas et al, 2012). However, generally, creativity refers to the generation of novel and potentially useful ideas (Mayer, 1999; Sternberg & Lubart, 1999; Shalley et al., 2004). Its nature involves many distinct but related resources, including intellectual abilities, knowledge, styles of thinking, personality, and other intra-individual factors, and an external factor—the social environment (Amabile & Pillemer, 2012).

1.8.2 Technical creativity

Technical creativity is the ability to create products by applying existing skills, knowledge, and principles; through their application, however, expression of personal intention is restricted (Taylor, 1975; Liu & Schonwetter, 2004; Wilson, 2016).

1.8.3 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). Its core procedure includes: 1) clear and detailed interpretation of knowledge; 2) modeled practice to give students direct experience; and 3) mindfully independent application.

1.8.4 Explicit technical creativity teaching

Explicit technical creativity teaching is a method in which the teacher makes 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. (Wang & Murota, 2015)

1.8.5 Peer instruction

Peer instruction is “an interactive teaching technique that promotes classroom interaction to engage students and address difficult aspects of the material” (p. 39, Mazur & Watkins, 2010). Its commonly used mode is as follows: 1) first, the instructor conducts a brief presentation and poses a ConcepTest question to the students; 2) second, the students individually make a response after several minutes of thinking; 3) the students discuss their answers with their neighbors seated beside them; 4) they then answer the same ConcepTest question again or answer an isomorphic question (Smith et al., 2009; Zingaro & Porter, 2014); and 5) finally, the instructor explains the correct answer and may pose another isomorphic question or proceed to a different topic.

1.8.6 Big Five personality traits

Big Five personality traits is a widely-known model which describes five core categories of personality traits: openness to experience, conscientiousness, extraversion, agreeableness, and neuroticism (McCrae & Costa, 1987; Costa & McCrae, 1995).

1.8.7 Pedagogical content knowledge

Pedagogical content knowledge is proposed by Shulman to help to describe and evaluate teaching

expertise (Shulman, 1986). It is “a type of knowledge that is unique to teachers, and in fact is what teaching is about” (p.5, Cochran et al., 1991). The pedagogical content knowledge concerns the manner in which teachers relate their pedagogical knowledge (what they know about teaching) to their subject matter knowledge (what they know about what they teach). It is the integration or the synthesis of teachers' pedagogical knowledge and their subject matter knowledge that comprises pedagogical content knowledge. Therefore, it is the third major component of teaching expertise and teacher competence.

1.9 Thesis outline

The thesis is organized in 6 chapters (Figure1-1). In the next chapter, the ideas on creativity and creativity development are provided, describing the definitions of creativity, levels of creativity, theories and experience of creativity development, dilemmas of creativity development, and the orientation of creativity development in the subject-dominated education.

Chapter 3 introduces the effectiveness of a teacher-centered approach—explicit teaching—in increasing senior middle school students' technical creativity. Additionally, why explicit teaching was selected and how explicit teaching was adapted into the authentic classrooms are discussed. This chapter has been published as a journal paper (Wang & Murota, 2015).

Chapter 4 deals with the possibilities and limitations of a student-centered approach—peer instruction— in increasing senior middle school students' technical creativity. First, the reason to select peer instruction is explained. Next, the instructional designs of peer instruction and explicit technical creativity teaching are shown to demonstrate their differences. Finally, the teaching effectiveness of two methods are discussed to verify the possibilities and limitations of peer instruction in increasing high school students' technical creativity. This chapter was published as a journal paper (Wang & Murota, 2016b).

To answer RQ2 comprehensively, Chapter 5 investigates the influences of ETCT and PI on creative performances of students with different personalities. Parts of this chapter was presented at ICoME' 16 (Wang & Murota, 2016a).

Chapter 6 concludes the thesis by highlighting its contributions and discussing limitations and future research.

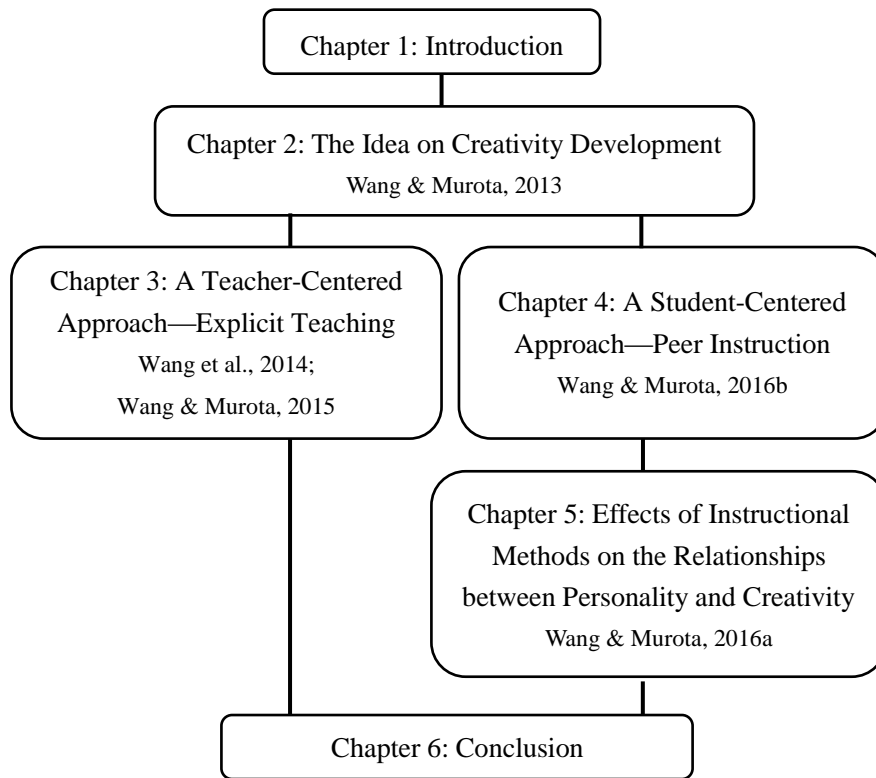


Fig. 1-1 Schematic representation of the structure of the thesis

Chapter 2 An Idea on Creativity Development

2.1 Creativity

Guilford called for greater attention to the study of creativity in 1950's address to the American Psychological Association (Sternberg & Lubart, 1999; Treffinger et al., 2002). Since then, researchers tried giving creativity a precise definition.

2.1.1 Definitions of creativity

However, creativity is a complex concept. It involves many distinct but interrelated resources. Therefore, various definitions made by different researchers reflect different perspectives on creativity. To illustrate the diversity of creativity definitions, several typical definitions are presented in the section.

J.P. Guilford concentrated on divergent thinking as the basis of creativity. He thought that creative thinking and problem solving were closely related because they both involved producing new responses to new situations. In addition, he specified the characteristics of creativity: sensitivity to problems, fluency, flexibility, novelty, reorganization, complexity, and evaluation (Guilford, 1950; Kurtzberg & Amabile, 2000-2001) and made the measurement of creativity possible.

E. Paul Torrance defined creativity as the process of becoming sensitive to problems, deficiencies, gaps in knowledge, missing elements, or disharmonies; identifying the difficulty; searching for solutions, making guesses, or formulating hypotheses about the deficiencies; testing and retesting these hypotheses and possibly modifying and retesting them; and finally communicating the results. This definition described a natural human process (Torrance, 1965).

Teresa M. Amabile firstly viewed creativity as an interaction of three components: domain-relevant skills, creativity-relevant skills, and task motivation. Domain-relevant skills include knowledge about the domain, teaching skills, and special domain-related talent. The creativity-relevant skills include a work style, a cognitive-perceptual style, and personality characteristics.

The task motivation includes two elements: the individual's baseline attitude toward the task and the individual perceptions of his or her reasons for undertaking the task in a given instance (Amabile, 1988). Afterwards, Amabile (2012) realized the importance of the social-environmental factor, and then proposed a componential theory of creativity that integrated conceptualizations of intrinsic motivation and the social environment with the cognitive and personality constructs. Based on the componential theory, factors that influence creativity include the three intra-individual factors, i.e., domain-relevant skills, creativity-relevant skills, and task motivation, and one external component—the social environment.

Robert J. Sternberg considered that “creativity is a topic of wide scope that is important at both the individual and societal levels for a wide range of task domains” (p.3, Sternberg & Lubart, 1999). Therefore, he and his co-workers proposed a confluence approach to understand creativity. They describe that creativity requires a confluence of six distinct but interrelated resources: intellectual abilities, knowledge, styles of thinking, personality, motivation, and environment. Additionally, Sternberg (2006) argued individual differences in creativity that although levels of these resources are sources of individual differences, often the decision to use a resource is a more important source of individual differences.

From the above definitions, I can learn that experts emphasized different elements or factors in creativity. For example, Guilford considered creativity as individual divergent thinking and Torrance defined creativity as a kind of creative problem-solving process. These two definitions thought of creativity as individual characteristics. However, in definitions of Amabile and Sternberg, the influence of an external factor—social-environmental factor—on creativity was emphasized.

In general, throughout several decades of research on creativity in psychology and education, the emphases of creativity center on three general areas: the cognitive processes underlying creative thought, the characteristics of creative individuals, and the confluence of different factors, such as cognitive domain, personality, and environmental contexts. In the area of cognitive process, creativity is regarded as “a kind of thinking, reasoning, association-making, or problem-solving” (p. 10, Treffinger et al., 2002). The mental processes may refer to retrieval, association, synthesis, transformation, analogical transfer, and categorization. Researchers in the area of creativity

characteristics explore the relationship between personal attributes and individual creativity. For example, Amabile (1983a) confirmed the importance of intrinsic motivation to creativity based on empirical evidence from a variety of domains. Additionally, after carefully weighing up the pros and cons of existing creative dispositions, Lucas et al. (2012) proposed five core dispositions of creative mind—inquisitive, persistent, imaginative, collaborative, and disciplined. However, with the deepening of understanding of creativity, people realized that creativity required a confluence of distinct resources. The confluence theory puts together multiple views on creativity and offers the possibility of interpreting diverse aspects of creativity. Moreover, it emphasizes not only the influence of individual factors but also the force of an external factor—environment. Amabile (1983b) presented a componential framework for conceptualizing creativity to describe the way in which cognitive abilities, personality characteristics, and social factors might contribute to stages of the creative process. Afterwards, Sternberg and Lubart (1999) described that the resources creativity required were a confluence of intellectual abilities, knowledge, styles of thinking, personality and environment.

The complex nature of creativity means that creativity denies a precise definition. However, through analyzing and summarizing numerous experts' definitions, two general defining characteristics of creativity are identified as originality and usefulness (Mayer, 1999; Sternberg & Lubart, 1999).

2.1.2 Levels of creativity

Because of the complex nature of creativity, the term “creativity” can vary within different contexts and across disciplines. For research purpose, it is necessary to distinguish different dispositions, levels, states, or life styles of creativity (Taylor, 1975; Lucas et al., 2012). In an overview of creativity, Taylor categorized creativity into five clusters—expressive, technical, inventive, innovative, and emergent creativity (Taylor, 1975; Liu & Schonwetter, 2004; Wilson, 2016.).

- Expressive creativity, incorporating intuitive expression, is the ability to generate unique ideas with no concern about the quality. Outcomes of this cluster can come from intuition, and need not a research or debugging process.

- Technical creativity, also known as productive creativity, involves the ability to create products by applying existing skills, knowledge, and principles. In this level, several ideas or solutions might be generated. However, the application of knowledge restricts the decision of possible ideas.
- Inventive creativity is the ability to explore different paths by revising present patterns or breaking particular rules or principles. In this level, ingenuity is displayed with materials, method, and techniques.
- Innovative creativity is the ability to modify something already in existence through alternative approaches, based on the understanding of foundational principles. In this level, there is improvement through modification involving conceptualizing skills.
- Emergent creativity is the most complex form, involving the most abstract ideational principles underlying a body of knowledge, which often emerges suddenly and is not necessarily predictable from prior knowledge. This cluster of creativity is characterized as genius. Its outcomes can be the most abstract scientific or artistic formulations.

The first level involves small elements and related elements are almost known by students. The higher the creativity level, the more involved and unknown elements. Correspondingly, the development becomes more complicated.

2.2 Creativity development

The study of creativity involves a wide scope of areas. Sternberg and Lubart (1999) summarized at least six approaches to studying creativity: mystical, psychoanalytic, pragmatic, psychometric, cognitive, and social-personality.

2.2.1 Theoretical perspectives

Because creativity is complex and multi-faceted in nature, developing students' creativity needs to comprehensively consider many interdependent factors. Many researchers have been trying to put forward various theories about the components of creativity to serve to its development.

As early as Guilford called for the attention to creativity in 1950, he argued that except intelligence, which was used to predict creative behavior at that time, some of the factors most crucial to creative performance must exist, but had not been discovered. Through over half a century of research on it, researchers discovered other related factors little by little. In the following, two famous theories will be introduced.

2.2.1.1 Teresa Amabile's componential theory of creativity

"The componential theory of creativity is a comprehensive model of the social and psychological components necessary for an individual to produce creative work" (Amabile, 2012). The theory was put forward based on a definition of creativity as the production of ideas, solutions, or outcomes that are both novel and appropriate. Specifically, the theory underlines two important assumptions. The first one is that creativity is a continuum from low, ordinary levels found in everyday life to the highest levels of creativity found in significant inventions. The second one is that individual creativity within different domains can be different.

The componential model of creativity is shown in Figure 2-1. Based on the theory, the influences on creativity include three intra-individual components—domain-relevant skills, creativity-relevant, and task motivation—and one external component—the social environment (Amabile, 2012; Amabile & Pillemer, 2012).

Domain-relevant skills: refer to knowledge, expertise, technical skills, intelligence, and talent in the particular domain where the problem-solver is working. These skills comprise the raw materials upon which the individual can draw throughout the creative process.

Creativity-relevant processes: (originally called creativity-relevant skills) include a cognitive style and personality characteristics that are conducive to independence, risk-taking, and taking new perspectives on problems, as well as a disciplined work style and skills in generating ideas.

Task motivation: emphasizes an important factor to affect creativity –the intrinsic task motivation. People are most creative when they feel motivated primarily by the interest, enjoyment, satisfaction, and challenge of the work itself. However, Amabile argued that extrinsic

motivation can sometimes affect the intrinsic motivation so as to undermine creative behavior (Amabile & Pillemer, 2012).

The social environment: An important reason that Amabile and Pillemer (2012) emphasized the function of the social environment is that “extrinsic motivators and extrinsic constraints in the social environment could alter motivational state from intrinsic to extrinsic and, thus undermine creative” (p. 7). Therefore, the social environment includes all of the extrinsic motivators that have been shown to undermine intrinsic motivation, and a number of other factors in the environment that can serve as obstacles (such as norms of criticizing new ideas; political problems within the organization; an emphasis on the status quo; a conservative, low-risk attitude among top management) or as stimulants (work teams that are collaborative, diversely skilled, and idea-focused; freedom in carrying out the work; supervisors who encourage the development of new ideas) to intrinsic motivation and creativity. Amabile and Pillemer (2012) considered that the social environment could influence each of the intra-individual factors, while its most immediate and prevalent influence was on the motivational component.

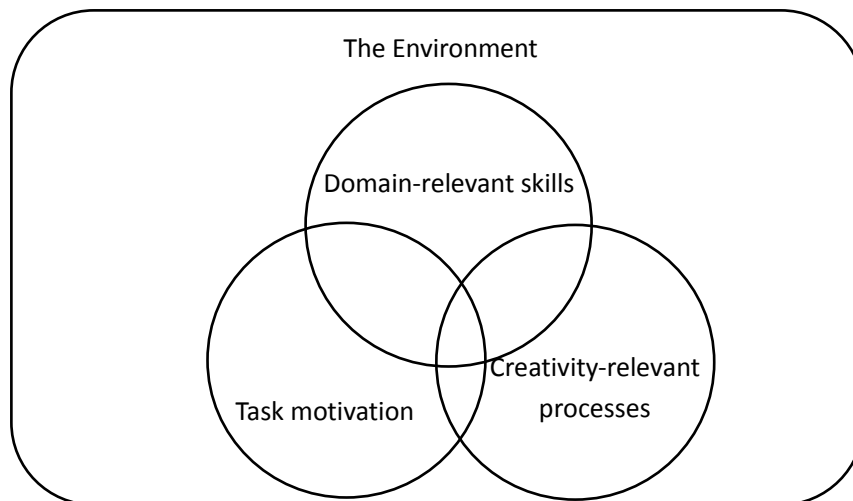


Fig. 2-1 Componential model of creativity

The componential model of creativity covers relatively comprehensive scope, ranging from intro-individual factors to the external social environment, and emphasizes the impact of the social environment on the motivational component. In addition, the theory is expanded to describe the process of organizational innovation. Therefore, the theory encompasses creativity in single

individuals, teams, and entire organizations.

2.2.1.2 Sternberg and Lubart's investment theory of creativity

The investment theory of creativity was proposed by Sternberg and Lubart on the basis of the economic theory (Sternberg & Lubart, 1992). According to the investment theory, creative people, like good investors in stocks, are ones “who are willing and able to metaphorically buy low and sell high in the realm of ideas” (p. 5, Sternberg, 2012). Buying low means pursuing ideas that are unknown or out of favor, but that have growth potential. Often, when these ideas are put forward, they encounter resistance. The creative individual persists in the face of this resistance, and eventually sell high, moving on to the next new, or unpopular, idea. When dealing with resistances, creative endeavors can be influenced by a confluence of resources—intelligence, knowledge, thinking styles, personality, motivation, and environment—although these resources are difficult to merge synergistically.

Intelligence

High intelligence is regarded as a necessary condition for creative achievement (Eysenck, 1993). Of course, due to the influences of other resources, it is not a sufficient condition for creativity achievement. Generally, to be creative, one must first decide to generate new ideas, analyze these ideas, and sell the ideas to others. Therefore, three intellectual skills are particularly important to creativity: (a) the synthetic ability to see things from new perspectives and to escape the bounds of conventional thinking; (b) the analytic ability to recognize the ideas that are worth pursuing and exploring; (c) the practical-contextual ability to persuade others to accept the new ideas (Sternberg, 2006).

Knowledge

One cannot move forward if he or she has no enough knowledge about the field. Therefore, to be creative, one needs to know enough knowledge about a field to move it forward. However, some research found that people's greatest contributions to a field come before they reached the peak of their knowledge about it (Sternberg, 2006). That is to say, knowledge about a field may

result in a closed perspective, resulting in not moving forward.

Thinking styles

Thinking styles are preferences for using abilities in certain ways. They are not abilities themselves, but the ways one likes to utilize abilities. The term *thinking style* is different from the use of the term *learning style*. Learning style refers to preferred ways to learn material, whereas thinking style is people's preferred ways to think about material. Sternberg summarized 13 types of thinking styles: legislative, executive, judicial, global, local, liberal, conservative, hierarchical, monarchic, oligarchic, anarchic, internal, and external (Sternberg & Zhang, 2005). Sternberg and Zhang (2005) argued that thinking style would be a good construct to account for individual differences in school performance. Some patterns of styles may lead to success in a course in discipline, and other patterns of styles may be successful in another course and other disciplines. For creativity, a legislative style (people has a predilection for tasks, projects, and situations that require creation, formulation, planning of ideas, strategies, etc.) is particularly important, and a global style (people treat tasks, projects, and situations with large, global, or abstract views) may also be helpful.

Personality

Personality is one's relatively enduring ways of thinking, feeling, and acting that characterize an individual (Costa & McCrae, 1995). Creative personality is a matter of those patterns of traits that are characteristic of creative person (Guilford, 1950). Throughout several decades of studies on creativity in psychology and education, people found that core characteristics of creative people included, but are not limited to: aesthetic sensitivity, broad interest, curiosity, fantasy and imagination, risk-taking, high energy, independence of judgment, tolerance of ambiguity, etc. (Barron & Harrington, 1981; Oldham & Cummings, 1996; Treffinger et al., 2002). Personality is considered as a resource that is closely related with creativity. The research on relationships between personality and creativity has attracted wide attention.

Motivation

Intrinsic motivation is also essential to creativity. Many empirical studies have proved that intrinsic motivation is conducive to creativity (Amabile & Pillemer, 2012). However, motivation is not something inherent in a person. One can decide to be motivated by one thing or another. Therefore, sometimes, it is difficult to control it to serve for creativity.

Environment

Environment is another recourse to affect creative ideas. Without the support of the environment, all of the internal resources that a person has might never be displayed. Different contexts support different creativity and different cultures may have different conceptions of what constitutes creativity. Therefore, it is important to take the environment into account when developing and assessing creativity. Eysenck (1995) once summarized environmental variables into political-religious factors, cultural factors, socioeconomic factors, and educational factors.

In all, creativity development involves various resources. To develop it in school education, it is essential to comprehensively consider as many related resources as possible.

2.2.2 Practical perspective

In recent years, to meet the talent demand of knowledge-based economy and to cope with constant changing environments, the pragmatic approach to the study of creativity has been “the takeover of the field” (p. 5, Sternberg & Lubart, 1999). That is, researchers are increasingly focusing on how to increase creativity.

2.2.2.1 In psychology

1) Explicit instruction

Earlier in 1950s and 60s, some psychologists found that participants tended to generate more creative outcomes when they were instructed to “be creative” (Niu & Liu, 2009). In psychological studies, the simple “be creative” instruction worked as a direction to describe the qualitative scoring criteria to participants and a goal to lead them to produce novel and worthwhile responses (Harrington, 1975). Initially, the effects of “be creative” was examined by the use of divergent

thinking tasks—the Alternate Uses Test. Results found that participants generated more creative outcomes when they were instructed to “be creative”(Niu & Liu, 2009). Subsequently, many researchers continued examining the facilitation effects. For example, Harrington (1975) compared outcomes of self-assessment for the performances of participants who received and did not receive the “be creative” instruction in divergent thinking tests. He found that the creativity instructions functioned better than the standard instructions (which said nothing about qualitative criteria—novel and worthwhile, or important). In addition, Chen et al. (2005) explored whether the effects of the “be creative” instruction varied across cultures and types of task. Finally, they found that the effects varied in different domains of the creativity tasks (greater for artistic and mathematical creativity than for verbal creativity), but not across cultural and ethnic groups.

Researchers used theories of goal setting to explain the positive effect of the “be creative” instruction. That is, people tend to do better when they know what the goal of the task is or when their attention is directed. This theory was proved by O’Hara and Sternberg (2000-2001). In their study, participants were divided into four groups randomly, and three of four groups were given a special emphasis on being creative, practical, or analytical. The fourth type of instruction included no particular emphasis or direction. The results showed that compared with the fourth type of instruction, the specific instructions resulted in better performances in other three groups.

However, individual differences in the facilitation effects cannot be disregarded. For example, Datta (1963, 1964) found that the explicit instruction— “be creative” only improved the performance of highly creative individuals. In addition, Harrington (1975) found that the creativity instruction depressed the performance of participants who lacked intellectual self-confidence and who were particularly susceptible to anxiety. He thought this was caused by an anxiety-arousing component in the creativity instructions. Moreover, Niu and Liu (2009) found that for Chinese high school students who are less creative, a few words instruction—“be creative” was not enough to facilitate their creativity. However, these students performed significantly better in creativity when they were given a detailed instruction on how to be creative than their schoolmates who didn’t receive a detailed instruction. What should also be mentioned is that, in another research, researchers (Niu & Sternberg, 2003) found that both a few words instruction—“be creative” and a detailed instruction on how to be creative helped Chinese students make more creative artworks.

In conclusion, no matter the “be creative” instruction or the explicit instruction on how to be creative needs to be designed by considering individual differences.

2) The function of rewards

The function of motivation in increasing creativity seems to be agreed by many people, especially the function of the intrinsic motivation. The pioneer of creativity research—Guilford, once stated that “whether or not the individual who has the requisite abilities will actually produce results of a creative nature will depend upon his motivational and temperamental traits” (p. 444, Guilford, 1950). Gradually, the effects of motivation were found in various experimental research. For example, Torrance found through his considerable studies that people who were doing what they loved were more creative in their pursuits (Torrance, 1965, 2004). In addition, Amabile (2012) articulated the Intrinsic Motivation Hypothesis of Creativity to emphasize the important function of motivation for creativity. This theory says that the intrinsically motivated state is conducive to creativity. Amabile (2012) regarded the theory as the cornerstone for the micro-level social psychology of creativity.

However, the problem is that in reality it is difficult to confirm how to increase the intrinsic motivation so as to increase creativity and whether the intrinsic motivation is increased or not after some treatments. Instead, people, especially teachers, tend to use external rewards, either material or verbal, in the hopes of increasing the intrinsic motivation so as to increase creative performance.

About whether the rewards could increase creative performance, researchers have different views. One camp of researchers argued that the extrinsically motivated state was detrimental to creativity (Collins & Amabile, 1999; Eisenberger & Shanock, 2003; Amabile, 2012), while the other camp of researchers found that novel performance was readily increased by reward through many behaviorist studies (Wiston & Baker, 1985; Eisenberger & Shanock, 2003). However, recently, some researchers who believed in the detrimental effects of rewards began to acknowledge the favorable effects of reward although the acknowledgement was done with some conditions. For example, in 1983, the Intrinsic Motivation Hypothesis of Creativity of Amabile figured that extrinsic motivation is detrimental to creativity. Afterwards, Collins and Amabile (1999) took a broader view

that reward could sometimes combine with intrinsic motivation to increase creativity. This trend of transformation certifies the function of rewards in increasing creativity to some degree. However, the point to make it work is how to utilize the reward. Through a meta-analysis, Eisenberger and Shanock (2003) concluded that rewards for novel performance increase intrinsic motivation and creativity, whereas rewards for conventional performance decrease intrinsic motivation and creativity.

In all, creative motivational orientation can strongly affect innovative performance. In creativity education, teachers can consider how to make orientations to increase students' creative motivation, including how to set rewards to stimulate students' intrinsic motivation.

2.2.2.2 In education

In education, various creativity techniques and active learning methods are widely used. The effects of creativity techniques or tools, such as brainstorming, mind mapping, six thinking hats, and synectics, in increasing divergent thinking have been proved by numerous empirical studies (Liu & Schonwetter, 2004; Zampetakis, et al., 2007; DeHaan, 2011). Additionally, active learning methods, e.g., problem-based learning, are vehemently regarded as effective in cultivating the ability of creative problem-solving. Belski (2009), for example, studied the effectiveness of teaching thinking and problem-solving through the Theory of Inventive Problem Solving (TRIZ), and found that students' creative problem solving ability were enhanced. In addition, Cheung (2011) confirmed that problem-based learning enhanced student designers' creative flexibility more effectively than lecture in advertising design. However, the effects of active learning methods in increasing creativity needs more empirical studies.

2.3 The measurement of creativity

Guilford (1966) summarized that the measurement of creativity involved two areas: creative potentiality and creative performance. Creative potentiality is "what an individual brings to a possible creative performance because of his personality structure" (p. 186, Guilford, 1966). It is in the form of interests, attitudes, emotional dispositions, and various abilities. Creative performance is what an individual actually produces, which is one important way to obtain people's information

about creativity.

Numerous instruments have been developed to measure creativity. Hocevar (1981) reviewed the used measures of creativity and classified them into ten categories: tests of divergent thinking, attitude and interest inventories, personality inventories, biographical inventories, teacher nominations, peer nominations, supervisor ratings, judgment of products, eminence and self-reported creative activities and achievements. However, the existing instruments are often criticized in terms of reliability, dimensionality, convergent validity, and discriminant validity. This implies that there is no one instrument could really measure creativity. Nevertheless, this does not prevent us from using them to judge the qualities of creativity I appreciate.

To support effective assessment, five general principles were proposed by Linn and Gronlund (1995): 1) Specify clearly what is to be assessed. 2) Select an assessment procedure that is relevant to the characteristics or performance you intend to measure. 3) Use a variety of procedures to attain a comprehensive assessment. 4) Be aware of the limitations of assessment resources. 5. Remember that assessment is a means to an end, not an end in itself. The most essential principle is to specify clearly what is to be measured. The factors or characteristics that are most important in one's understanding of creativity will influence the way to assess creativity and the selection of instruments. The instrument is less important than how well it aligns with specific learning objective. In addition, based on Treffinger, et al. (2002), assessment is a broader and more inclusive term than measurement. Assessment is "a process of 'taking stock' if an individual (or a group) by drawing together information from a number of sources and attempting to organize and synthesize those data in a meaningful way" (p. 23), while measurement refers to "the use of any instrument or testing procedure through which quantitative data can be obtained and thus can be treated statistically" (p. 23). Therefore, in modern times, to assess creativity comprehensively, researchers tend to use multiple sources of data. Treffinger et al. (2002) classified sources of data into four types: Behavior or performance data, self-reported data, rating scales, and tests.

2.4 Problems of creativity development in subject-dominated school education

By reviewing literatures, I can learn that although these techniques and methods are generally considered effective in increasing creativity, in the subject-dominated classrooms (commonly found in primary and secondary education), teachers seldom use them (Cheng, 2010; DeHaan, 2011; Wang & Murota, 2013) for some reasons. In this part, I will interpret the problems which hamper creativity reform.

Dilemmas teachers usually face in the subject-dominated education include:

- 1) The gap between the original teaching objective—knowledge learning—and the new teaching objective—creativity development. To realize the original teaching objective—knowledge learning, teachers have accustomed to the tight and heavy curriculum, rigid timetable, large class size, short lesson and small space. However, in order to give consideration to both creativity development and knowledge learning in the classrooms, different instructional strategies, different student learning and thinking styles, different supporting resources, different time-tabling and teaching schedule arrangements all need to be considered. This is not an easy work for teachers who has accustomed to conventional instructions. This problem is the origin of all other existing problems.
- 2) Time-consuming. On the one hand, it is difficult to arrange more time to execute these techniques and learning methods in the class under the heavy pressure of curriculum for teachers and schools. On the other hand, teachers who work in subject-dominated schools has no enough time and energy to do creativity reform. 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.
- 3) Teachers' professional qualities. Creativity takes place in the interaction among persons and their environments (Sternberg et al., 2001). Additionally, the "creativity" term has different meanings in different subjects and classrooms. It's unfortunate that there is no one instructional method that can be adapted in different classrooms, and no correct

templates provided for different subject teachers to follow. Therefore, when reforming pedagogical methods, teachers must balance the requirements of the syllabus with the new, extra teaching objective (in this case, creativity development). However, evidences show that teachers' concepts of creativity tend to be narrow (Newton, 2013; Pang & Plucker, 2013; Wang & Murota, 2013). For example, Wang and Murota (2013) found that teachers were not good at integrating higher-level creativity development into daily instruction, except expressive creativity, by investigating and analyzing the integrated situation of creativity development in high school ICT lesson plans of Shanghai, one of the best cities for education in China. Therefore, adapting various creativity techniques to develop different types of creativity is a challenge for most teachers. Furthermore, teachers also face the challenge of aligning creativity instructional strategies with educational realities: the limited instructional time, materials, devices, equipment as well as other factors.

- 4) Students. Students in the subject-dominated schools are accustomed to receiving clear and direct instructions from their teachers. They tend to lack creative consciousness and creative thinking ability. Whether they can understand teachers' instruction—giving creative and imaginative answers—is a problem. In addition, the utilization of creativity techniques and active learning methods need students' high degree of autonomy. However, the feature of students who are in the primary and secondary schools is lacking enough autonomy. What's more, some investigations showed that students had low motivation on creativity (Cheng, 2010). Finally, individual difference is a constant problem in education. These problems result in learners' undesirable performance in active learning. Thus, teachers face a challenge in moving creative lessons forward (Cheng, 2010).
- 5) Resources. Those creativity techniques and methods usually used in education require more professional facilitators, which might be impossible for the majority of primary and secondary schools. Additionally, an investigation on tensions and dilemmas teachers face in creativity reform showed that teachers thought they lacked time, convenient or flexible teaching materials, and space to do creativity education.

These problems are usually met by teachers in subject-dominated education. Therefore, generally, these complex techniques and methods are not suitable to be a fast start for teachers who have not mastered enough pedagogical content knowledge of creativity education to integrate creativity development into daily instructions. To develop creativity in subject-dominated schools, a series of theoretical and empirical studies are needed.

2.5 The idea on creativity development

Facing those problems mentioned above, teachers think that creativity education can't be realized unless these problems are solved. That can explain why in the classrooms, teachers often teach as if creativity is not important (DeHaan, 2011). However, thoroughly solving these problems has a long way to go. Before that, what teachers can do is to ceaselessly explore available approaches to changing the teaching and training students' creative thinking from a micro level.

The idea of creativity education in this study is to decide appropriate instructional methods and adapt them into the actual conditions by considering various resources and their interactions to develop different-level creativity. The prerequisite of the idea is that instruction is a process of making and implementing decisions. The concrete process includes:

- 1) Identify a level of creativity that is feasible to be developed in daily instruction of your subject, and define it as an observable teaching objective (Knowledge of creativity);
- 2) Investigate features of various instructional methods, including the functions, processes, and the principles and strategies of applying, organizing, and assessing them, the environments that go for various instructional methods, and other pedagogical knowledge of various instructional methods (Pedagogical knowledge of various instructional methods);
- 3) Figure out the actual conditions, covering levels of students, the original teaching objective of knowledge learning, the class size, the teaching schedule, and others factors (Content knowledge, Curriculum knowledge, and Knowledge of learner and characteristics);

- 4) Decide an available method and customize it based on the actual conditions (Pedagogical content knowledge);
- 5) Try the method and modify it to fit the class (Pedagogical content knowledge).

This process was proposed in concert with Shulman's theory of pedagogical content knowledge (Shulman, 1986). Based on Shulman (1986, 1987), the pedagogical content knowledge include the ways of representing and formulating the subject that make it comprehensible to others, and an understanding of what makes the learning easy or difficult. In short, teachers' pedagogical content knowledge are teachers' interpretations and transformations of knowledge of subject matter, pedagogy, context, curriculum, learner and characteristics, etc., when facilitating students' learning.

In creativity education, except these content and pedagogical knowledge, the knowledge of creativity is also essential. Therefore, the foremost two things of integrating creativity development into daily instruction for teachers are: 1) to define creativity clearly and observably; 2) to develop the pedagogical content knowledge of creativity education, that is, teachers need to adapt and tailor the instruction to all actual conditions. However, few experience are provided for them. In this study, I will present the experience in defining creativity and adapting two kinds of instructional methods to authentic classrooms to develop it.

In all, what should be encouraged is to explore the possibilities and limitations of integrating various creativity techniques into daily instruction to develop students' creativity, as well as teachers' pedagogical content knowledge of creativity education.

2.6 Summary

Creativity is a complex concept. Its development involves a confluence of distinct but interrelated recourses, such as intellectual abilities, knowledge, styles of thinking, personality, motivation, and environment (Sternberg, 2006). Therefore, in creativity education, teachers need to combine their content knowledge, pedagogical knowledge, and knowledge of creativity to define creativity and customize an optimal instructional method to teach it in authentic classrooms. This means teachers

need to develop their unique pedagogical content knowledge of creativity through numerous empirical studies. However, the limited time, energy, and professional qualities of teachers and other factors make it impossible for Chinese primary and secondary teachers to independently develop their unique pedagogical content knowledge of creativity. This study will demonstrate how to customize a viable instructional method by synthetically considering various knowledge and factors, i.e., content knowledge, pedagogical knowledge, and knowledge of creativity, levels and characteristics of learners, and the authentic instructional environment. This study will also discuss and compare the teaching effectiveness of customized instructional methods in increasing students' creativity.

Chapter 3 A Teacher-Centered Approach— Explicit Teaching

3.1 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).

3.2 Literature Review

3.2.1 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 3-1). Explicit teaching is derived from strategies for teaching concepts or skills in mathematics and reading (Flick, 1995).

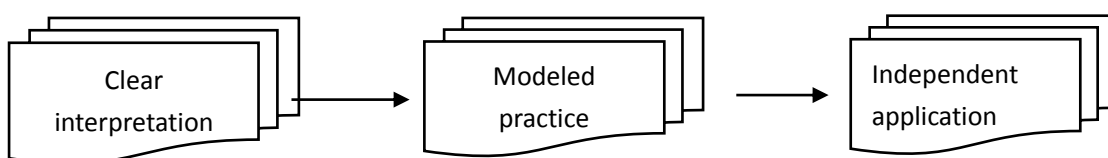


Fig. 3-1 Core procedures of explicit teaching

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".

3.2.2 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). I interpreted the five levels based on other researchers' explanations (Taylor, 1975; Liu & Schonwetter, 2004; Wilson, 2016).

- 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.

3.2.3 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, I 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.

3.3 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, I 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 3-2 displays the 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.

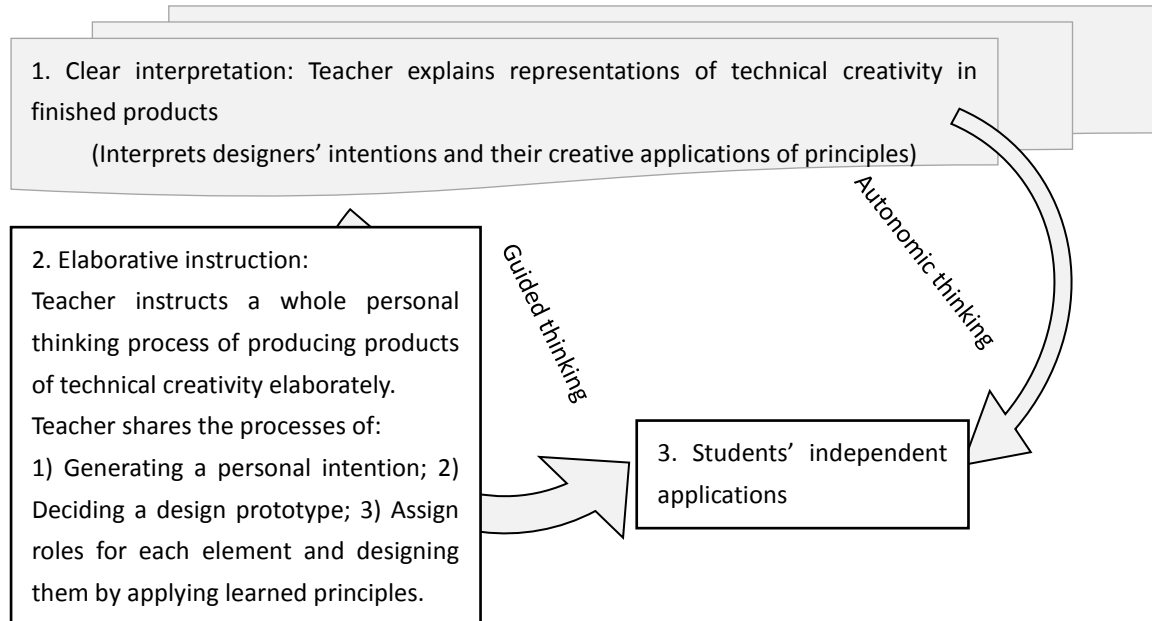


Fig. 3-2 A framework of explicit technical creativity teaching

3.4 Methods

3.4.1 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.

3.4.2 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 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, I focused on the third objective, designing and producing a Web site.

3.4.3 Templates of lesson plans

Explicit technical creativity teaching can be integrated naturally into daily instruction of high school SACs. In this study, I added it to general teaching to compare the two methods’ teaching effectiveness. Table 3-1 provides templates of two lesson plans.


Table 3-1. *Templates of Two Lesson Plans*

| Lessons | Technical Creativity Group | General Group |
|----------------|---|---------------|
| 1st (45min) | Knowledge Learning: (a local teacher) <ul style="list-style-type: none"> • 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): <ul style="list-style-type: none"> Color: <ul style="list-style-type: none"> #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: <ul style="list-style-type: none"> #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; <p>* After instructing principles, several typical applying examples will be shown to</p> | |

| | | |
|--|--|--|
| | students; | |
| 2 nd (45min) | Objectives: students could apply common tools of FrontPage to make a simple static website. | |
| | Students learn to use FrontPage software; (a Chinese who has a Chinese junior high school teacher's license on ICT) (Details are ignored.) | A local teacher demonstrates how to use FrontPage software; Students determine a theme & contents; then prepare materials; |
| 3 rd & 4 th (90min) | <p>Explicit Technical Creativity Teaching (a Chinese who has a Chinese junior high school teacher's license on ICT) (about 20min)</p> <ul style="list-style-type: none"> • Clear Interpretation: <ul style="list-style-type: none"> -A teacher selects finished works which implies the creative application of learned principles. (In this lesson, I 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. <p>A sample of an interpretation: <i>“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</i></p> | <p>Independent Application: (a local teacher)</p> <p>Task Presentation:</p> <p>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.</p> <p>Independent Making:</p> <p>Students make the website by applying learned knowledge and skills;</p> <p>Teachers work as facilitators.</p> |

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 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.

A 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

| | | |
|--|--|--|
| | <p><i>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)..... ”</i></p> | |
| | <p>Independent Application: Task & Objective Presentation: <i>Task:</i> design and make a “FrontPage-learning website” by applying learned FrontPage knowledge (source materials prepared by the teacher); <i>Objective:</i> 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.</p> | |

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.

3.4.4 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, I 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, I 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, I 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.

3.4.5 Rubric

I designed a rubric to rate students' products. Based on contents taught in the study, I 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 (Table 3-2).

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, I 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 (The details of the rubric refer to Appendix Table A-1).

Table 3-2. *Rubric of Three Technical Creativity Related Categories*

| Categories | Exemplary | Proficient | Basic | Novice | Failed |
|-------------------------|--|--|---|--|--|
| Layout-Originality | The layout is unique and attractive arrangement smart, skillful, or artful) compared with teachers'; | The arrangement of elements (the modified based on teacher's layout; | The layout is 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 | The space allocation of elements reasonable; | The spacing of elements is large, which seems that they | The position of navigation is out of the way; | |

| | | | | | |
|--------------|---|---|---|--|---|
| | on the characteristic of materials; | | are not associative; | | |
| Use of Color | 1.The added colors match with each other to express a certain feeling; 2.The student make the colors unique and attractive by using similar colors and contrasting colors; | 1.The background is clean and tidy; 2.The text color is bright to read; 3. The color matching of the website meets principles of color matching but doesn't serve for the expression of some feeling; | The student used various colors in the top page, and 1)Main color systems used in the top page are less than four categories generally; 2) It is difficult to discern the text color and background image color; | The student used various colors in the top page, but 1)Colors are optionally, so the web page looks messy; 2)Main color systems added in the top page are more than four; | The student did not add colors(excluding the content images) to the web page; |

3.4.6 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.

3.4.7 Hypotheses

Comparing two methods, I 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, I also expected no difference in knowledge application between the two methods.

3.5 Results

Since two raters rated all students' works separately, firstly, I examined the inter-rater reliability using Cohen's Kappa coefficient. The reliability coefficient was 0.589, 95% CI [0.522, 0.656], $p < 0.005$, which was considered moderate and acceptable according to Landis and Koch (1977). To do statistical analysis, I calculated the mean values of two raters' scores as the final scores of the students' products. Means and standard deviations of eight categories of two groups rated by each teacher are shown in Table 3-3.

Table 3-3. 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 | 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 | | |
| Creativity | 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 | 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 |
| Teaching | 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. I 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 3-3). The results are shown in Table 3-4. 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 3-4. 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 | | | |

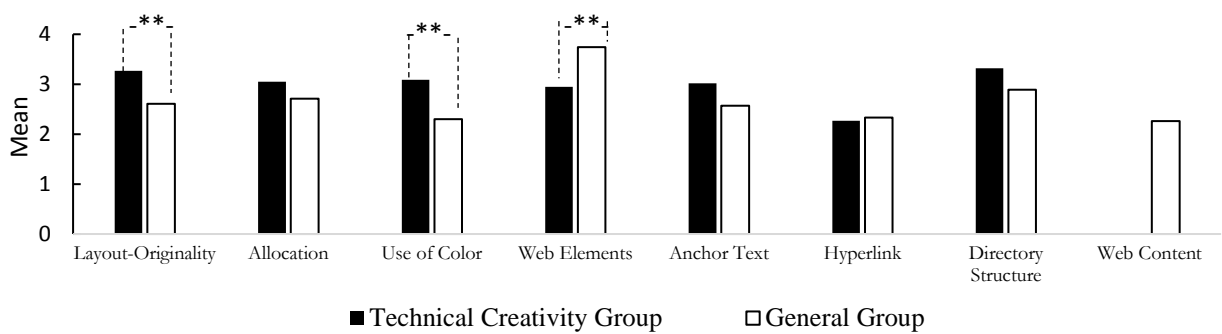


Fig. 3-3 Means of two teaching methods' products

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

3.6 Discussion

In this study, I 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, I 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, I 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, I 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, I 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, I 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, I 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, I 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, I 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 immersed in creative application under the guidance of 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.

3.7 Conclusion

In this study, I focused on customizing explicit teaching to develop lower-level students’ technical creativity and then examining this method’s effectiveness. To achieve this objective, I 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, I 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, I 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, I will clarify these relationships.

Chapter 4 A Student-Centered Approach—Peer Instruction

4.1 Introduction

Creativity is acknowledged as the most important competency of the 21st century learning. Correspondingly, creativity education has been launched in various subject areas (Liu & Schonwetter, 2004; Zampetakis et al., 2007; Cheng, 2010; Lin, 2011; DeHaan, 2011; Poon et al., 2014). However, the popularization of creativity education in primary and secondary schools faces too many dilemmas, such as the balance between the requirements of the syllabus and the extra teaching objective—creativity development, dilemmas in pedagogical arrangements, and lack of resources (Cheng, 2010). These issues present the need to perform practical research aimed at exploring the possibilities and limitations of integrating creativity techniques into daily instruction to teach creativity in concrete subject areas in primary and secondary schools.

To develop creativity through daily instruction, first, the teachers need to have a good knowledge of creativity. Creativity is a complex concept. Although its two basic defining characteristics are recognized as originality and usefulness (Mayer, 1999; Sternberg & Lubart, 1999), creativity has no universally acknowledged definition because of its complex nature. On the whole, the emphases of creativity center on three areas: the cognitive processes underlying creative thought (Treffinger et al., 2002), the characteristics of creative individuals (Amabile, 1983a; Lucas et al., 2012), and the confluence of different factors, such as cognitive domain, personality, and environmental contexts (Amabile, 1983b; Sternberg & Lubart, 1999; Amabile & Pillemer, 2012). In the area of cognitive process, creativity is regarded as “a kind of thinking, reasoning, association-making, or problem-solving” (p. 10, Treffinger et al., 2002). The mental processes may refer to retrieval, association, synthesis, transformation, analogical transfer, and categorization. Researchers in the area of creativity characteristics explore the relationship between personal attributes and individual creativity. For example, Amabile (1983a) confirmed the importance of intrinsic motivation to creativity based on empirical evidence from a variety of domains. Additionally, after carefully weighing up the pros and cons of existing creative dispositions, Lucas et al. (2012) proposed five core dispositions of creative mind—inquisitive, persistent, imaginative,

collaborative, and disciplined. However, with the deepening of understanding of creativity, people realized that creativity required a confluence of distinct resources. The confluence theory puts together multiple views on creativity and offers the possibility of interpreting diverse aspects of creativity. Moreover, it emphasizes the force of an external factor—environment. Amabile (1983b) presented a componential framework for conceptualizing creativity to describe the way in which cognitive abilities, personality characteristics, and social factors might contribute to stages of the creative process. Afterwards, Sternberg and Lubart (1999) described that the resources that creativity required were a confluence of intellectual abilities, knowledge, styles of thinking, personality and environment.

Thus, the term “creativity” can vary within different contexts and across disciplines. For research purpose, it is necessary to distinguish different dispositions, levels, states, and life styles of creativity (Taylor, 1975; Lucas et al., 2012). In an overview of creativity, Taylor categorized creativity into five clusters—expressive, technical, inventive, innovative, and emergent creativity (Taylor, 1975; Liu & Schonwetter, 2004; Wilson, 2016).

- Expressive creativity, incorporating intuitive expression, is the ability to generate unique ideas with no concern about the quality. Outcomes of this cluster can come from intuition, and need not a research or debugging process. An example is that students are asked to identify a unique design concept for their personal websites.

- Technical creativity, also known as productive creativity, involves the ability to create products by applying existing skills, knowledge, and principles. In this level, several ideas or solutions might be generated. However, the application of knowledge restricts the decision of possible ideas. In Web design, appropriately applying colors or other design principles to express an individual intention belongs to the technical creativity level.

- Inventive creativity is the ability to explore different paths by revising present patterns or breaking particular rules or principles. An example in Web design is that students match extraordinary colors by breaking regular color pattern matching.

- Innovative creativity is the ability to modify something already in existence through alternative approaches, based on the understanding of foundational principles. Modifying and combining features of dancing, calligraphy, sculpture, or other fields, to design a novel website can be regarded as the innovative creativity level.

- Emergent creativity is the most complex form, involving the most abstract ideational principles underlying a body of knowledge, which often emerges suddenly and is not necessarily predictable from prior knowledge. This cluster of creativity is characterized as genius. Its outcomes can be the most abstract scientific or artistic formulations.

The first level involves small elements and its related elements are almost known by students. The higher the creativity level, the more involved and unknown elements. Correspondingly, the development becomes more complicated.

However, several studies have noted that teachers' concepts of creativity tended to be narrow (Newton, 2013; Pang & Plucker, 2013). The creativity in their minds is equivalent to the most abstract scientific or artistic formulations. Therefore, to integrate creativity development into school education, it is necessary to define creativity according to the realistic circumstances of a subject. In the primary and secondary schools, heavy teaching tasks, limited time, energy and competence, students' original thinking and learning habits, and other factors decide that it is impractical to set the target level of creativity too high. Consistent with the definition, technical creativity emphasizes both the originality of products and the creative application of learned knowledge. The latter happens to be one important learning objective of primary and secondary schools. Therefore, developing technical creativity in primary and secondary school education can not only meet the requirements of the syllabus but also put creativity development into practice.

From the primary and secondary teachers' perspectives, creativity education requires developing a special environment, a task that demands much of their time and energy (Davies et al., 2013). They usually prefer teacher-centered teaching methods in their classes, although these methods are not helpful in developing creativity. In reaction to the phenomenon, Wang and Murota (2015) proposed to adapt a teacher-centered teaching method—explicit teaching to senior middle school teaching circumstances to explicitly teach students technical creativity. The adapted method was named explicit technical creativity teaching (ETCT). Specifically, teachers need to “make technical creativity explicit to students by interpreting the types of individual thinking that technical creativity involves and by elaborately displaying a whole individual thinking process for developing products through technical creativity” (p. 70, Wang & Murota, 2015). Their results verified ETCT's effectiveness in developing students' technical creativity. However, they also found

that students' performances depended too much on the teachers' instruction. The teacher-centered teaching method—ETCT contributed little to actively building the relationship of separate knowledge to construct their originalities.

Active peer-peer interaction is considered to be an effective way to generate new hypotheses or models and increase design solutions of architects and industrial designers (Paulus & Nijstad, 2003; DeHaan, 2011). However, the general group discussion is time-consuming. Because of the heavy curriculum and limited time, it is not cost-effective to apply group discussion in primary and secondary education. Additionally, to guarantee that active learning will work in schools, group work should avoid prolonged interactive discussion sessions (Felder & Brent, 2009). Therefore, another interactive learning method—peer instruction (PI), which is easily adapted to various pedagogies, is more feasible for primary and secondary education.

Although peer instruction is intended to help develop creativity, there is a paucity of empirical research regarding how to adapt PI to primary and secondary education to increase creativity. In this study, the primary purpose was to assess the possibilities and limitations of PI in teaching technical creativity through empirical teachings in authentic classrooms.

In China, the dilemmas of creativity education senior middle schools face are grimmer than those of primary schools and junior middle schools because of the National Higher Education Entrance Examination. To investigate the accessibility of PI, I conducted the study in a Chinese senior middle school ICT course. The majority of Chinese teachers and students have little experience in PI, which provides us an opportunity to explore PI's sphere of application. The reason why I selected the ICT course was that the teaching objectives of several software application classes within the ICT course coincided with technical creativity. This situation provided an ideal trial site for our study.

4.2 Literature Review

4.2.1 Creativity development

Creativity attracted attention since Guilford's 1950 address to the American Psychological

Association (Sternberg & Lubart, 1999; Treffinger et al., 2002). The study of creativity involves a wide scope of areas. Sternberg and Lubart (1999) summarized at least six approaches to studying creativity: mystical, psychoanalytic, pragmatic, psychometric, cognitive, and social-personality. In recent years, to meet the talent demand of knowledge-based economy and to cope with constant changing environments, the pragmatic approach to the study of creativity has been “the takeover of the field” (p. 5, Sternberg & Lubart, 1999). That is, researchers are increasingly focusing on how to increase creativity.

In psychology, earlier in 1950s and 60s, some psychologists found that participants tended to generate more creative outcomes when they were instructed to “be creative” (Niu & Liu, 2009). Subsequently, many researchers continued examining the facilitation effects. For example, Harrington (1975) compared performances of participants who received and did not receive the “be creative” instruction. Chen et al. (2005) explored whether the effects of the “be creative” instruction varied across cultures and types of tasks. They found that the effects varied in different domains of the creativity tasks (greater for artistic and mathematical creativity than for verbal creativity), but not across cultural and ethnic groups. However, individual differences in the facilitation effects cannot be disregarded (Datta, 1963, 1964; Chen et al., 2005, Niu & Liu, 2009). For people who are less creative, a detailed instruction on being creative was more effective in increasing their creativity (Niu & Sternberg, 2003; Niu & Liu, 2009).

This finding coincided with several studies on applying a detailed instruction— explicit teaching to teach higher-order thinking strategies (Fogarty & Tighe, 1993), meta-strategic knowledge (MSK) in the context of control of variables (Zohar & Peled, 2007; Zohar & David, 2008), and individual thinking process of technical creativity (Wang et al., 2014; Wang & Murota, 2015). The effectiveness of explicit teaching in enhancing high-achieving and low-achieving students’ meta-strategic knowledge (MSK) in the context of control of variables were examined in a laboratory environment (Zohar & Peled, 2007) and in the authentic classroom (Zohar & David, 2008). The results of both studies showed that explicit teaching was effective for students, especially for low-achieving students. Additionally, Wang and Murota (2015) used explicit teaching to teach senior middle school students technical creativity in authentic classrooms, and compared its effectiveness with that of “be creative” instruction. The results showed that explicit technical

creativity teaching was more effective in developing students' technical creativity although the application of detailed knowledge might be affected by the intense concentration on creativity.

In education, various creativity techniques and active learning methods are widely used. The effects of creativity techniques or tools, such as brainstorming, mind mapping, six thinking hats, and synectics, on generating new ideas or solutions have been proven by numerous empirical studies. Additionally, active learning methods, e.g., problem-based learning, are vehemently regarded as effective in cultivating creativity. Belski (2009), for example, studied the effectiveness of teaching thinking and problem solving through the Theory of Inventive Problem Solving (TRIZ), and found that students' creative problem solving ability were enhanced. Cheung (2011) confirmed that problem-based learning enhanced student designers' creative flexibility more effectively than lecture in advertising design. However, these techniques and methods require more professional facilitators and take more class time, which result in the few implementation in general subject-dominated classrooms. For teachers, who wish to change their teachings from lecture-centered to more student-centered, Kalman et al. (2010) preferred to recommend PI rather than recommend collaborative groups as a fast start although the latter was more effective in promoting conceptual understanding.

In all, there is no almighty teaching technique or method applicable everywhere because of the complexity of creativity and variety of educational contexts. Therefore, more studies on creativity development are needed to provide experiences for various specific domains.

4.2.2 Peer instruction

PI is "an interactive teaching technique that promotes classroom interaction to engage students and address difficult aspects of the material" (p. 39, Mazur & Watkins, 2010). It was originally developed by Mazur Group to modify the traditional lecture format to engage non-physics students and uncover difficulties with the material to promote a deeper understanding in the 1990s (Mazur & Watkins, 2010; Gok, 2011). PI can be easily adapted to various pedagogies to engage students in their own learning. Its commonly used mode is as follows: 1) first, the instructor conducts a brief presentation and poses a ConcepTest question to the students; 2) second, the students individually make a response after several minutes of thinking; 3) the students discuss their answers with their

neighbors seated beside them; 4) they then answer the same ConcepTest question again or answer an isomorphic question (Smith et al., 2009; Zingaro & Porter, 2014); and 5) finally, the instructor explains the correct answer and may pose another isomorphic question or proceed to a different topic (Figure 4-1).

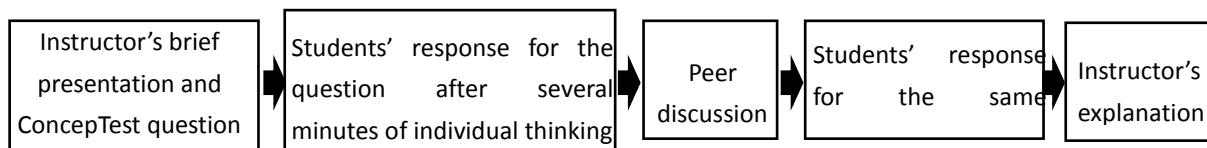


Fig. 4-1 General procedure for peer instruction

According to 10 years data of PI in calculus- and algebra-based introductory physics courses for nonmajors, PI was more effective in increasing student mastery of conceptual understanding and quantitative problem solving than traditional instruction (Crouch & Mazur, 2001). In addition to physics, the impact of PI has been studied in other disciplines. For example, McConnell et al. (2006) developed over 300 ConcepTest questions for geosciences, and used them in different classroom settings of various institutions. The results of pre- and post-class Geoscience Concept Inventory revealed quantifiable gains of PI in understanding concepts. Moreover, students' attendance and engagement were apparently improved (McConnell et al., 2006). Similarly, Simon et al. (2010) reported their experience of using PI in introductory computing course. They analyzed and compared students' initial responses to ConcepTest questions and the responses after peer discussion. The results demonstrated that the average correctness increased after peer discussion.

However, there was concern that the increase between pre- and post- tests might be caused by simple copy in peer discussion. To verify this doubt, Smith et al. (2009) followed students' individual response to an isomorphic question after peer discussion in an undergraduate genetics course. The results indicated that students indeed learned from peer discussion. In 2011, Porter et al. replicated this study in upper-division computing courses. In the study, Porter et al. defined a new metric—Weighted Learning Gain, which could better reflect the learning value of discussion, to illuminate student learning. Finally, they reported similar findings. Moreover, several research confirmed the effectiveness of PI on metacognition in introductory entomology (Jones et al., 2012), and on the ability of knowledge transfer in exercise physiology classes (Cortright et al. 2005) and in introductory entomology (Jones et al., 2012) by using multiple choice questions that involved novel situations.

Additionally, some instructors believed that their explanations of ConcepTest questions would be “clearer, more efficient, and more informative” (p. 56, Smith et al., 2011) than what students could learn from peers. Therefore, they skipped peer discussion when they used PI. To clarify the question, Smith et al. (2011) compared three different approaches—peer discussion only, an instructor explanation only, and peer discussion followed by an instructor explanation, in genetics courses. The results showed that for both nonmajors and majors, all ability groups of students (weak, medium, and strong) gained from the combination approach. Subsequently, Zingaro & Porter (2014) also examined the impact of peer discussion alone versus peer discussion and instructor intervention in computing. They found that the instructor-led classwide discussion was more valuable for all groups of students (weak, average, and strong), particularly for weak students, than peer discussion alone.

However, few research has explored the possibilities and limitations of PI in increasing creativity through open-ended questions, although there has been increasing acknowledgment of the importance of peer interaction in developing creativity.

4.2.3 Group creativity

The emphasis on group creativity can be traced back to Alex Osborn’s brainstorming. In the 1940s, Alex Osborn began to promote group brainstorming to enhance group creativity. In recent years, more scholars have acknowledged the importance of social, cultural, and contextual factors in creativity (Paulus & Nijstad, 2003; Leung & Chiu, 2008). With more findings on the psychology of creativity (Kurtzberg & Amabile, 2000-2001; Sternberg & Lubart, 1999), they believed that creative thinking “is not so much an individual trait but rather a social phenomenon involving interactions among people within their specific group or cultural settings” (p. 174, DeHaan, 2009) and effective peer-peer interaction can enhance group creativity (Taggar, 2002).

The peer discussion provides students more opportunities to communicate. Therefore, I have reasons to expect that through peer discussion, students may achieve a deeper understanding of the relationship between an individual design intention and creative application to make creative products. However, group interaction does not always enhance group creativity. For example, the impact of group interaction will be limited unless one can persuade others to adopt his or her idea

(Paulus & Nijstad, 2003). Generally, common ideas are easily adopted in group work. There is a likelihood that the information shared among group members is common but unique (Stasser, 1999). Additionally, if groups are too large or are not well organized, group creativity will be stifled (Taggar, 2002). These problems manifest that when students pursue identification, approval, and consensus in group interactions, they might be hesitant to be creative.

However, PI pays attention to helping students construct individual understanding through the social interaction (peer discussion), but not forcing students to reach consensus. This can eliminate students' hesitation of being creative in groups. Based on Craft's model, creativity can be viewed from as an individualized phenomenon to as a collective endeavor (Lucas et al., 2012). Technical creativity focuses on the range of Craft's individualized phenomenon. Therefore, adapting PI, a method that focuses on the individual traits of students (individual votes/responses), to increase individual technical creativity may avoid those problems of group creativity.

4.2.4 Adaption of PI in creativity education

To make PI more effective, I adapted its procedure. The adapted procedure of PI is similar to its general mode, except the time that the students engaged in peer discussion and additional guidance for peer discussion (Figure 4-2).

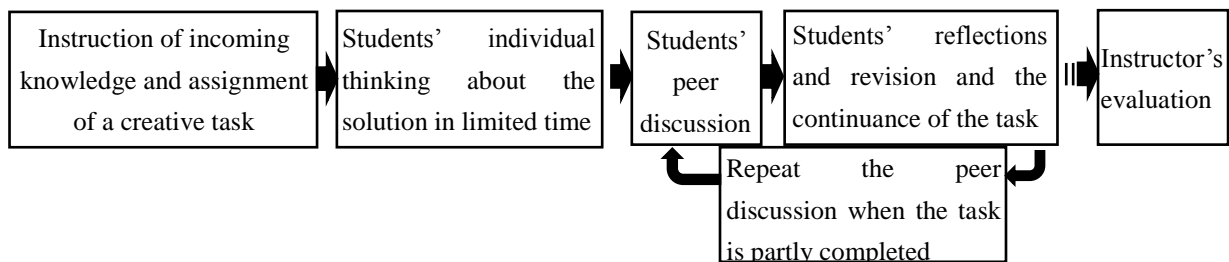


Fig. 4-2 Procedure of PI adapted to creativity education.

After all of the required incoming knowledge of a creative task is taught, an instructor poses a higher-order creative task to students. Then, the instructor gives the students a certain period of time to do individual thinking preparing for the subsequent active discussion. In this step, to motivate lower-level students to become engaged, guidance materials, e.g., a detailed worksheet, must be prepared.

Creativity is a multicomponent process. Finke indicated that a creative process involved two

phases: a generative phase and an explorative or evaluative phase (DeHaan, 2009). During the generative phase, a set of novel potential solutions are explored. In the explorative phase, a particular solution is identified for additional work, such as transformation, expansion and combination (Leung & Chiu, 2008; Taggar, 2002). In this procedure, the students' individual thinking is the commencement of the generative phase. Considering the importance of group communication in enhancing creativity (Kurtzberg & Amabile, 2000-2001; Paulus & Nijstad, 2003; Leung & Chiu, 2008; DeHaan, 2009; Taggar, 2002), it is necessary to follow a peer discussion after the students' individual thinking. This procedure aims to facilitate the completion of the creative process, which is the generation of more novel ideas and the identification of a particular one, by expanding students' thinking and increasing cognitive conflict. To avoid the common remarks or feedback in peer discussion, it is advisable to define the evaluation criteria for students. After the discussion, the students are allotted more time to reflect and revise their ideas based on feedback to identify a particular one as their original idea.

In addition to the creative process, technical creativity involves the other important process—a reflection-improvement process. That is, the students need to reflect whether the applications of related design principles serve to express their original ideas to make improvements after they complete their elementary ideas. In this period, peer discussion can also play an important role. Therefore, the peer discussion step and the students' reflection and revision step need to be duplicated until the majority of the students have expressed their novel ideas. Finally, the teacher evaluates the students' products.

In the creative process, the peer discussion aims at engaging students in the generation of new ideas and the active construction of in-depth understanding. However, compared to ETCT (Wang et al., 2014; Wang & Murota, 2015), whether it is more effective in increasing different-level students' creativity needs to be discussed. Additionally, considering the teaching effectiveness of peer discussion, the hypothesis that in the reflection-improvement phase, all-level (higher-, medium-, and lower-level) students would gain more through peer instruction than through a self-reflection must be confirmed.

In this study, I aimed to explore the possibilities and limitations of PI in teaching technical

creativity by comparing its teaching effectiveness with that of a teacher-centered instructional method—ETCT, which has been proven by Wang and Murota (2015).

4.3 Methods

4.3.1 Participants

This study was conducted in a software application class with ICT subject of an ordinary senior middle school in China (spring semester of 2015). Approximately 200 Chinese 10th graders attended the classes. However because ICT is a minor subject in Chinese high schools, the students were told to submit their products voluntarily. Finally, 127 Chinese 10th graders (n=54 males, 73 females; mean age=16.2 years) participated in the study. A total of 68 students (n=31 males, 37 females; mean age=16.3 years) participated in the peer instruction, and 59 students (n=23 males, 36 females; mean age=16.2 years) were taught by ETCT. These participants belonged to four classes.

4.3.2 Instructional design

The teaching contents of this study were Web design and website making, usually taught during the second term of 10th grade (March–July). In this course, the students need to learn basic knowledge about web design, learn to use Microsoft FrontPage 2003 (a discontinued WYS/WYG HTML editor and web site administration tool from Microsoft), and then design and produce an individual website by applying the learned knowledge (design principles and software skills).

The course was planned to be completed in five lessons (one lesson per week). In the first two lessons, the following knowledge were instructed: the required basic knowledge of web design and website making, how to match colors to express certain feelings, how to design a layout to express the design intention, and how to use Microsoft FrontPage 2003 to make a static website. In the third lesson, two groups began to execute respective lesson plans. The concrete contents of five lessons are shown in Table 4-1.

Table 4-1. Lesson plans of Web Design and Website Making

| Lessons 40 min/lesson | Explicit Technical Creativity Teaching (ETCT Group) | Peer Instruction (PI Group) |
|-----------------------------|---|---|
| 1st (40 min) | <p>Knowledge Learning</p> <ol style="list-style-type: none"> 1) Basic knowledge about web design: basic elements of a webpage, general process of web design, website making software, etc. 2) Knowledge about color <ul style="list-style-type: none"> Different feelings delivered by colors How to make color patterns Principles of color matching 3) Knowledge about layout <ul style="list-style-type: none"> Basic structure of the layout Different functions of different layout designs Expressiveness of irregular layouts (e.g., supplementary role of lines or shapes in layouts) | |
| 2nd (40 min) | <ol style="list-style-type: none"> 1. Instruction of Microsoft FrontPage 2003 The teacher demonstrates how to use Microsoft FrontPage 2003 software to construct a website and make static web pages 2. Interpretation of design intention The teacher explains the following: <ol style="list-style-type: none"> 1) What the design intention of a website is; 2) What factors can help to identify the design intention of a website and how to read a design intention from its color matching and layout through interpreting good designs. | |
| 3rd (40 min) | <p>1. Elaborative instruction</p> <p>The teacher models a practice to instruct the relationship between an individual intention and the application of related design principles by interpreting the entire process of creating an original webpage.</p> <p>The concrete contents include the following: The teacher interprets, during the creative phase, how to</p> <ol style="list-style-type: none"> 1) generate several design concepts through divergent thinking or associative thinking; 2) identify the particular design | <p>1. Teacher assigns a higher-order creative task</p> <p>The task: design and make a novel “FrontPage-learning website” by applying the learned knowledge and using the source materials prepared by the teacher. (approximately 2-3 min)</p> <p>2. Students’ individual thinking</p> <p>Students complete a design by filling out a task sheet (the steps of the task sheet are identical to the steps of the</p> |

| | | |
|--------------------------------|--|--|
| | <p>intention/concept based on personal experience;</p> <p>3) use three or four keywords to refine the intention;</p> <p>4) express these keywords by designing the layout and selecting images;</p> <p>5) express these keywords by matching colors (images, background, text, etc.); and then demonstrate what the students should do in the reflection-improvement phase by</p> <p>6) showing to others and interpreting the website designed in the creative phase;</p> <p>7) reflecting whether the design intention (key words) is explicitly expressed and whether the principles of colors and layout are correctly applied, and then interpreting the modification plans;</p> <p>8) showing the revised final product. (approximately 16-18 min)</p> <p>2. Teacher assigns a task</p> <p>The task: design and make a novel “FrontPage-learning website” by applying the learned knowledge and using the source materials prepared by the teacher. (approximately 2-3 min)</p> <p>3. Students’ independent application</p> <ul style="list-style-type: none"> • Design a website by completing a task sheet (the steps of the task sheet are identical to the steps of elaborative instruction) • Make a website on their computers based on their designs (approximately 20 min) | <p>ETCT group’s elaborative instruction). (approximately 14-15 min)</p> <p>3. Peer discussion</p> <ul style="list-style-type: none"> • Students share their individual intention and explain how to design their project with neighbors seated next to them. • Peers provide feedback based on a set of evaluation criteria. (approximately 6 min) <p>4. Students’ independent creation</p> <ul style="list-style-type: none"> • Improve their intentions and conceive designs based on feedback • Start the making on their computers based on their designs (approximately 18 min) |
| <p>4th (40 min)</p> | <p>Self-improvement and independent creation</p> <p>Students reflect on their designs based on the evaluation criteria as they continue making their websites on their computers.</p> | <p>1. Peer discussion</p> <ul style="list-style-type: none"> • Students share their individual intention and explain how the current designs expressed their |

| | | |
|--------------------------|--|--|
| | | <p>intention or how the principles were applied to transfer the intention with neighbors seated next to them.</p> <ul style="list-style-type: none"> • Peers provide feedback based on a set of evaluation criteria. <p>(approximately 6 min)</p> <p>2. Students' independent creation</p> <ul style="list-style-type: none"> • Complete their intentions and conceive designs based on feedback • Continue making the website on their computers |
| First submission | <p>After this lesson, the majority of students are supposed to complete the first version of their products. This means that the creative phase is finished. To examine students' achievements in the phase, the students in both groups need to voluntarily submit their current products, at the end of this lesson.</p> | |
| 5th (40 min) | <p>Self-improvement and independent creation</p> <p>Students reflect on their designs based on the evaluation criteria as they continue making their websites on their computers.</p> | <p>1. Peer discussion</p> <ul style="list-style-type: none"> • Students share their individual intention and explain how the current designs expressed their intention or how the principles were applied to transfer the intention with neighbors seated next to them. • Peers provide feedback based on a set of evaluation criteria. <p>(approximately 6 min)</p> <p>2. Students' independent creation</p> <ul style="list-style-type: none"> • Revise their designs based on the feedback • Continue completing the website on their computers |
| Second submission | <p>In the 5th lesson, students focus on reflecting and improving their products. This phase is regarded as the reflection-improvement phase. To assess students' improvements in the phase, at the end of this lesson, the students in both groups need to voluntarily submit their final products.</p> | |

In the third lesson, the instructor modeled the process of creating an original webpage step by

step to instruct the students in the ETCT group how to make a novel webpage. This process, in fact, is intended to lead students to generate an original design intention and consider how to apply the learned principles to realize their intention. Therefore, after the instructor's explicit instructions, the students were asked to design their webpages by completing a step-by-step task sheet that could guide students' creative thinking. However, explicit teaching was teacher-centered, which contributed little to actively building the relationship of separate knowledge to construct their originalities. As a comparison, PI was conducted in the other group. To examine the effects of peer interactions on technical creativity, in the PI group, the instructor just distributed the task sheet, explained how to complete the task, and then worked as a facilitator. In this lesson, the students in the PI group needed to 1) independently create their own work using the task sheet as guidance; 2) share their original conceptions with their peers and receive feedback; and 3) sketch their designs according to the feedback and ideas generated during the peer discussion.

In the following two lessons, the students in the ETCT group refined their designs through self-reflection according to the evaluation criteria, whereas the students in the PI group engaged in a 6-minute peer discussion to make improvements at the beginning of each lesson. At the end of the fourth lesson, the majority of the students had completed the first version of their products, which meant that their creative process was nearly finished. Therefore, the students were asked to submit their products to compare the effectiveness of the two methods in the creative process. In the fifth lesson, the students' discussion focused on the creative application. That is, the students evaluated and reflected on the relationship between the design intention and the applications of the learned design principles to improve their products. To check the effectiveness of the two methods in this phase, I asked the students to resubmit their products at the end of the lesson.

Because the independent creation is a long process, it is impossible to gather students' products to test achievements of ETCT immediately. Therefore, the submissions of two groups couldn't simply reflect the achievements of ETCT and PI. In this study, the two submissions of ETCT group reflected the achievements of ETCT instructional activity, independent creations, and two self-reflections; the two submissions of PI group reflected the achievements of independent thinking, independent creations, and peer discussion; the term "ETCT" means the ETCT method

which contains ETCT instructional activity, independent creations, and self-reflections, and the term “PI” means the PI method which contains independent thinking, repeated peer discussions, and independent creations.

During the teaching, to avoid the influences of the different instructors, I worked as the sole instructor of all five classes. A local teacher worked as a facilitator.

4.3.3 Data analysis

109 products (56 were from the PI group and 53 were from the ETCT group) were collected at the first submission, and 104 products (63 were from the PI group and 41 were from the ETCT group) were collected at the second submission. An irregular event of our cooperative school affected the submissions of the ETCT group in the fifth lesson, thereby resulting in fewer submissions. In the PI group, 51 students submitted their products for both times, whereas the number of submissions in the ETCT group was 35.

Students who have different levels of academic achievements might hold different learning attitudes, and have different levels of knowledge comprehension and acquisition. Therefore, there might be differences in creative achievements between students from different achievement levels who study technical creativity with the traditional ETCT method and those who study with the student-centered PI method.

Therefore, in this study, to analyze different-level students’ creative performances, the participants were divided into higher, medium and lower three levels based on their average academic achievements of comprehensive subjects (from the mid-term and final examinations) in the first semester of the 10th grade. The students whose average academic achievements were ranked in the top 30% of the grade were considered as higher-level students. Students who were ranked between 31% and 70% were regarded as medium-level students, and the remaining students belonged to the lower-level. The numbers of students’ submissions in the two groups in different phases are shown in Table 4-2.

Table 4-2. *Numbers of Different-Level Students' Submissions in Two Groups in Different Phases*

| Numbers Levels | 1st Submission | | 2nd Submission | | Submissions for Both Times | |
|-------------------|----------------|------------|----------------|------------|----------------------------|------------|
| | PI Group | ETCT Group | PI Group | ETCT Group | PI Group | ETCT Group |
| Higher | 16 | 18 | 19 | 15 | 15 | 13 |
| Medium | 31 | 16 | 30 | 14 | 28 | 11 |
| Lower | 9 | 19 | 14 | 12 | 8 | 11 |

According to Guilford (1966), there are two important areas to measure creativity: one is the area of “creative potential” and the other is the area of “creative performance”. This study focused on measuring students’ performance to assess the increase of technical creativity. To rate the students’ products, I designed a rubric. Because technical creativity involves two essential aspects, i.e., originality and the application of knowledge, I identified 4 categories: Layout-Originality; Design Intention; Use of Color; and Intention of Colors according to the teaching contents of this study. The Layout-Originality category assessed the students’ originality of the layout design. Design Intention rated the original intention implied in the design of the website. The two categories were used to reflect students’ originality. Use of Color was designed to rate the appropriateness of applying the principles of colors, and Intention of Colors were designed to assess whether the colors matched to transfer a particular intention. These two categories aimed to assess the application of knowledge. Each category had the following five levels: failed; novice; basic; proficient; and exemplary. The corresponding points of these levels ranged from 0 to 4. The interval between two points was 1.

To design a good descriptive rubric, I synthetically considered the observable teaching objectives, opinions of a local ICT teacher with 5 years of experience, and expert advice on web design from a university professor. After the design, I pretested the validity of the rubric by several products with different qualities and revised the statements according to the test. During the coding, all of the products were mixed together and were, respectively, rated by two teachers. An explanation of how to use the rubric was written in a file. Before rating the products, the raters were informed of the need to read the explanations carefully, and if they had any questions, they could ask for help from the researchers. Table 4-3 shows the rubric of Design Intention category (The details of the rubric refer to Appendix Table A-2).

Table 4-3. Rubric of Design Intention

| | | | | | |
|------------------|---|--|---|--|---|
| Design Intention | Can you interpret an intention (style/ feeling) from the whole design (The answer is not limited to one)? | | | | |
| | If Yes , please use several key words to describe it and write them down. Key words: Please rate the degree of your certainty according to your experience. | | If No , please rate the design based on the description of following three levels. | | |
| | Exemplary(4) | Proficient(3) | Basic(2) | Novice(1) | Zero(0) |
| | The webpage's layout, images, and colors are designed in distinctive ways, and they work in concert with each other. It's easy to clearly interpret a distinctive intention. | The layout may be unique, or colors may be distinctive. However, they do not work in concert with each other, so the design intention is not clear for all visitors. | The design of the webpage are basically completed. However, visitors hardly interpret a distinctive intention from its featureless layout and colors. | The design of the webpage is partly completed. However, the completed part is not complete enough to express a design intention. | The design was just started, so it is impossible to interpret the design intention. |

Because the majority of the 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 expected 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.

To check the effectiveness of self-reflection and peer discussion in improving creative performance more comprehensively, I divided students into higher-performance, medium-performance, and lower-performance three groups based on their creative performance in the first submissions to examine their improvements. Students, whose total points of four categories (the full points of each category was 4) were between 12 and 16, including 12, were divided into the higher-performance group (PI group: n=15; ETCT group: n=12). Those students, whose total points were between 9 (including 9) and 12, were divided into the medium-performance group (PI group: n=28; ETCT group: n=17). The left students were divided into the lower-performance group (PI group: n=8; ETCT group: n=6).

4.4 Results

Because two raters rated all of the students' products separately, first, I examined the inter-rater reliability using Cohen's Kappa coefficient. The reliability coefficient was 0.457, 95% CI [0.402, 0.512], $p < 0.005$ which was considered moderate and acceptable according to Landis and Koch (1977). To do statistical analysis, I calculated the mean values of two raters' scores as the final scores of the students' products.

4.4.1 Overall performances

Overall, no significant differences between the two groups were found after the creative phase ($F(1,107)=0.68$, $MSe=0.63$, $p > 0.1$, $\eta^2=0.0063$ for Layout-Originality; $F(1,107)=0.39$, $MSe=0.70$, $p > 0.1$, $\eta^2=0.0036$ for Design Intention; $F(1,107)=0.00$, $MSe=1.04$, $p > 0.1$, $\eta^2=0.00005$ for Use of Color; $F(1,107)=0.32$, $MSe=1.04$, $p > 0.1$, $\eta^2=0.003$ for Intention of colors) and after the reflection-improvement phase ($F(1,102)=0.62$, $MSe=0.48$, $p > 0.1$, $\eta^2=0.0061$ for Layout-Originality; $F(1,102)=0.15$, $MSe=0.39$, $p > 0.1$, $\eta^2=0.0015$ for Design Intention; $F(1,102)=0.04$, $MSe=0.37$, $p > 0.1$, $\eta^2=0.00004$ for Use of Color; $F(1,102)=0.24$, $MSe=0.39$, $p > 0.1$, $\eta^2=0.0023$ for Intention of colors). To check whether the non-significant results were due to a lack of statistical power or not, post hoc power analysis was conducted using GPower (Faul et al., 2007) with power($1-\beta$) set at 0.80 and $\alpha=0.05$. The results showed that in order for the effects of those sizes of each category, sample sizes of four categories would have to respectively increase up to $N=1246$, 2152, 166992, and 2638 in the creative phase, and $N=1292$, 5228, 17834, and 3408 in the reflection-improvement phase. Therefore, it's unlikely that the negative findings can be attributed to a limited sample size. The mean and standard deviation values of the two groups in two phases are shown in Table 4-4.

Table 4-4. Mean and Standard Deviations Values of the Two Groups of Two Phases

| Categories | 1st submission | | | | 2nd submission | | | |
|---------------------|----------------|------|----------|------|----------------|------|----------|------|
| | ETCT Group | | PI Group | | ETCT Group | | PI Group | |
| | M | SD | M | SD | M | SD | M | SD |
| Layout-Originality | 2.74 | 0.86 | 2.55 | 0.82 | 3.13 | 0.63 | 3.10 | 0.68 |
| Design Intention | 2.73 | 0.74 | 2.59 | 0.93 | 3.24 | 0.63 | 3.29 | 0.57 |
| Use of Color | 2.71 | 0.90 | 2.59 | 1.00 | 3.27 | 0.68 | 3.33 | 0.57 |
| Intention of Colors | 2.81 | 0.92 | 2.63 | 0.99 | 3.27 | 0.69 | 3.43 | 0.52 |

I extracted the students who submitted their products in both phases, which had no significant differences, and used a two-way mixed ANOVA to examine the effects of self-reflection and peer

discussion in improving students' creative performance. The results showed that there were no statistically significant interaction between two ways of improvement (self-reflection and peer discussion) and students' creative performance at different time points. The main effect of time showed a statistically significant difference in mean creative performance in four categories before and after self-reflection and peer discussion, ($F(1, 84) = 31.96$, $MSe = 0.28$, $p < 0.01$, partial $\eta^2 = 0.28$, $f = 0.62$, power=1.00 for Layout-Originality; $F(1, 84) = 43.75$, $MSe = 0.35$, $p < 0.01$, partial $\eta^2 = 0.34$, $f = 0.72$, power=1.00 for Design Intention; $F(1, 84) = 34.35$, $MSe = 0.51$, $p < 0.01$, partial $\eta^2 = 0.29$, $f = 0.64$, power=1.00 for Use of Color; $F(1, 84) = 31.97$, $MSe = 0.52$, $p < 0.01$, partial $\eta^2 = 0.28$, $f = 0.62$, power=1.00 for Intention of Colors). The size of self-reflection and peer discussion effect on student creative performance were large (Faul et al., 2007), and the powers of differences were all higher than 0.9. These results indicated that self-reflection and peer discussion have strong effects on student creative performance in four categories (Smeets et al., 2009).

4.4.2 Different-level students' performances

To investigate the effects of the two methods on the students who have different learning abilities and learning attitudes, I statistically compared the creative performances of higher-, medium-, and lower-level students. The mean and standard deviation values of the three level students of two groups in different phases are shown in Table 4-5.

Table 4-5. Mean and Standard Deviations Values of the Three Level Students of Two Groups

| Categories | Levels | 1st Submission | | | | 2nd Submission | | | |
|---------------------|--------|----------------|------|------------|------|----------------|------|------------|------|
| | | PI Group | | ETCT Group | | PI Group | | ETCT Group | |
| | | M | SD | M | SD | M | SD | M | SD |
| Layout-Originality | Higher | 2.59 | 0.62 | 2.53 | 0.95 | 2.92 | 0.52 | 3.17 | 0.81 |
| | Medium | 2.71 | 0.77 | 3.06 | 0.46 | 3.25 | 0.72 | 3.11 | 0.57 |
| | Lower | 1.94 | 0.86 | 2.47 | 0.66 | 2.46 | 0.58 | 2.96 | 0.48 |
| Design Intention | Higher | 2.72 | 0.73 | 2.72 | 0.67 | 3.16 | 0.49 | 3.43 | 0.54 |
| | Medium | 2.77 | 0.87 | 2.91 | 0.67 | 3.40 | 0.56 | 3.14 | 0.52 |
| | Lower | 1.72 | 1.03 | 2.50 | 0.71 | 2.75 | 0.59 | 3.08 | 0.79 |
| Use of Color | Higher | 2.75 | 0.85 | 2.44 | 0.86 | 3.29 | 0.47 | 3.43 | 0.54 |
| | Medium | 2.81 | 0.90 | 2.81 | 0.97 | 3.38 | 0.54 | 3.21 | 0.41 |
| | Lower | 1.67 | 1.33 | 2.50 | 1.05 | 2.82 | 0.62 | 3.08 | 0.86 |
| Intention of Colors | Higher | 2.78 | 0.81 | 2.78 | 0.90 | 3.32 | 0.44 | 3.40 | 0.52 |
| | Medium | 2.87 | 0.89 | 2.91 | 0.91 | 3.55 | 0.49 | 3.36 | 0.58 |
| | Lower | 1.50 | 1.20 | 2.53 | 1.07 | 2.93 | 0.68 | 3.04 | 0.85 |

1. Performances in the creative phase

Students' products of two groups during the creative phase were analyzed with a 2 (instructional methods: ETCT vs PI) x 3 (levels of academic achievements) two-way between-subjects ANOVA (Table 4-6). The main effects of levels of academic achievements on the creative performance were significant in all four categories. The results of a post-hoc test—Tukey HSD Test showed that in the Design Intention and Intention of Colors two categories, the means of the higher- and medium-level students were significantly higher than those of lower-level students (Design Intention: $MSe=0.64$, $p<0.05$; Intention of Colors: $MSe=0.95$, $p<0.05$), and in the Layout-Originality and Use of Color two categories, the means of medium-level students were significantly higher than those of lower-level students (Layout-Originality: $MSe = 0.57$, $p<0.05$; Use of Color: $MSe=0.99$, $p<0.05$). In Use of Color and Intention of Colors two categories, there was a trend of interaction between instructional methods and different-level students. The simple main effect of instructional methods on mean creative performance for the lower-level students was statistically significant ($F(1,103)=5.6$, $Mse=0.99$, $p<0.01$, Partial $\eta^2=0.052$, $f=0.23$, $power=0.67$ for Use of Color; $F(1,103)=8.87$, $Mse=0.95$, $p<0.01$, Partial $\eta^2= 0.08$, $f=0.29$, $power=0.86$ for Intention of Colors). The scores of lower-level students in the PI group in Use of Color and Intention of Colors two categories were significantly lower than the lower-level students in the ETCT group. The simple main effect of student levels on mean creative performance of PI group was statistically significant ($F(2,103)=6.66$, $Mse=0.99$, $p<0.01$, Partial $\eta^2 =0.11$, $f=0.35$, $power=0.91$ for Use of Color; $F(2,103)= 9.91$, $Mse=0.95$, $p<0.01$, Partial $\eta^2 =0.16$, $f=0.44$, $power=0.99$ for Intention of Colors). The results of a post-hoc test—Tukey HSD Test showed that in PI group, higher- (Use of Color: $M=2.75$, $p<0.05$; Intention of Colors: $M=2.78$, $p<0.05$) and Medium-level (Use of Color: $M=2.81$, $p<0.05$; Intention of Colors: $M=2.87$, $p<0.05$) students performed significantly better than lower-level students (Use of Color: $M=1.67$; Intention of Colors: $M=1.5$), while in ETCT group, no significant differences were found. From these results, we can see that generally, the magnitude of differences between two instructional methods, or among different-level students found in the analysis are medium (Faul et al., 2007). In addition, except in Use of Color category, the powers of differences in other three categories were higher than 0.9. These results indicated that the possibilities of making Type I and Type II Error in this analysis were very low.

Table 4-6. *Two-way ANOVA: Effects of Two Methods on Different-Level Students in the Creative Phase*

| Categories | Source | SS | df | MS | F | p | Partial η^2 | Effect size(f) | Power |
|---------------------|---------------------------------|--------|-----|------|------|------|------------------|----------------|-------------|
| Layout-Originality | Instructional methods | 1.77 | 1 | 1.77 | 3.08 | <.1 | 0.029 | 0.17 | 0.43 |
| | Levels of academic achievements | 7.31 | 2 | 3.65 | 6.36 | <.01 | 0.11 | 0.35 | 0.91 |
| | Interaction | 1.49 | 2 | 0.74 | 1.30 | >.1 | 0.025 | 0.16 | 0.28 |
| | Error | 59.13 | 103 | 0.57 | - | - | - | - | - |
| | Total | 69.69 | 108 | - | - | - | - | - | - |
| Design Intention | Instructional methods | 2.22 | 1 | 2.22 | 3.45 | <.1 | 0.032 | 0.18 | 0.4 |
| | Levels of academic achievements | 9.74 | 2 | 4.87 | 7.58 | <.01 | 0.128 | 0.36 | 0.93 |
| | Interaction | 2.74 | 2 | 1.37 | 2.13 | >.1 | 0.04 | 0.19 | 0.40 |
| | Error | 66.18 | 103 | 0.64 | - | - | - | - | - |
| | Total | 80.88 | 108 | - | - | - | - | - | - |
| Use of Color | Instructional methods | 0.76 | 1 | 0.76 | 0.77 | >.1 | 0.007 | 0.09 | 0.15 |
| | Levels of academic achievements | 8.88 | 2 | 4.44 | 4.50 | <.05 | 0.08 | 0.28 | 0.75 |
| | Interaction | 5.52 | 2 | 2.76 | 2.79 | <.1 | 0.05 | 0.22 | 0.50 |
| | Error | 101.72 | 103 | 0.99 | - | - | - | - | - |
| | Total | 116.88 | 108 | - | - | - | - | - | - |
| Intention of Colors | Instructional methods | 2.97 | 1 | 2.97 | 3.14 | <.1 | 0.03 | 0.17 | 0.44 |
| | Levels of academic achievements | 14.51 | 2 | 7.25 | 7.67 | <.01 | 0.13 | 0.36 | 0.93 |
| | Interaction | 5.43 | 2 | 2.71 | 2.87 | <.1 | 0.053 | 0.22 | 0.51 |
| | Error | 97.43 | 103 | 0.95 | - | - | - | - | - |
| | Total | 120.33 | 108 | - | - | - | - | - | - |

2. Performances after the reflection-improvement phase

After the reflection-improvement phase, students' products were analyzed with a 2(instructional methods: ETCT vs PI) x 3(levels of academic achievements) between-subjects ANOVA (Table 4-7). The interaction effect was not statistically significant. However, the main effects of student levels on the creative performance were significant in all four categories. The results of a post-hoc test—Tukey HSD Test showed that in the Design Intention and Intention of Colors two categories, the means of the higher- and medium-level students were significantly higher than those of lower-level students (Design Intention: $MSe=0.35$, $p<0.05$; Intention of Colors: $MSe=0.35$, $p<0.05$), in Layout-Originality, the mean of the medium-level students were significantly higher than those of lower-level students (Layout-Originality: $MSe = 0.43$, $p<0.05$), and in Use of Color category, the

means of higher-level students were significantly higher than those of lower-level students (Use of Color: $MSe=0.35$, $p<0.05$). In all, lower-level students had lower creative performance.

Table 4-7 Two-way ANOVA: Effects of the Two Methods after the Reflective-Improvement Phase

| Categories | Source | SS | df | MS | F | p | Partial η^2 | Effect size(f) | Power |
|---------------------|---------------------------------|-------|-----|------|------|------|------------------|----------------|-------|
| Layout-Originality | Instructional methods | 0.94 | 1 | 0.94 | 2.17 | >.1 | 0.022 | 0.15 | 0.32 |
| | Levels of academic achievements | 3.66 | 2 | 1.83 | 4.24 | <.05 | 0.079 | 0.28 | 0.73 |
| | Interaction | 1.63 | 2 | 0.82 | 1.89 | >.1 | 0.037 | .20 | 0.41 |
| | Error | 42.39 | 98 | 0.43 | - | - | - | - | - |
| | Total | 48.63 | 103 | - | - | - | - | - | - |
| Design Intention | Instructional methods | 0.33 | 1 | 0.33 | 0.92 | >.1 | 0.009 | 0.10 | 0.17 |
| | Levels of academic achievements | 2.85 | 2 | 1.43 | 4.03 | <.05 | 0.076 | 0.27 | 0.68 |
| | Interaction | 1.68 | 2 | 0.84 | 2.37 | >.1 | 0.046 | 0.23 | 0.53 |
| | Error | 34.67 | 98 | 0.35 | - | - | - | - | - |
| | Total | 39.52 | 103 | - | - | - | - | - | - |
| Use of Color | Instructional methods | 0.15 | 1 | 0.15 | 0.43 | >.1 | 0.004 | 0.07 | 0.10 |
| | Levels of academic achievements | 3.08 | 2 | 1.54 | 4.43 | <.05 | 0.083 | 0.28 | 0.73 |
| | Interaction | 0.79 | 2 | 0.39 | 1.13 | >.1 | 0.023 | 0.16 | 0.27 |
| | Error | 34.01 | 98 | 0.35 | - | - | - | - | - |
| | Total | 38.02 | 103 | - | - | - | - | - | - |
| Intention of Colors | Instructional methods | 0.00 | 1 | 0.00 | 0.00 | >.1 | 0.00 | 0.00 | 0.05 |
| | Levels of academic achievements | 3.88 | 2 | 1.94 | 5.47 | <.05 | 0.1 | 0.32 | 0.83 |
| | Interaction | 0.45 | 2 | 0.23 | 0.64 | >.1 | 0.013 | 0.12 | 0.17 |
| | Error | 34.75 | 98 | 0.35 | - | - | - | - | - |
| | Total | 39.09 | 103 | - | - | - | - | - | - |

3. Different-level students' improvements through self-reflection and peer discussion

3.1 students who have different-level academic achievements

To check the effectiveness of peer discussion and self-reflection in improving creative performances of students who have different level of learning attitudes and knowledge comprehension, I selected the students who submitted their products for both times and compared their improvements. The students in the two groups had no statistically significant differences in academic achievements of comprehensive subjects. A three-way mixed ANOVA was conducted to understand the effects of "ways of improvement (self-reflection vs peer discussion)", "levels of academic achievements (higher-, medium-, and lower-level students)" and time (1st

submissions vs 2nd submissions) on students' creative performance. There was homogeneity of variances for both the scores of the 1st submissions ($p = 0.076$ for Layout-Originality; $p = 0.129$ for Design Intention; $p = 0.05$ for Intention of Colors) and scores of the 2nd submissions ($p = 0.085$ for Layout-Originality; $p = 0.347$ for Design Intention; $p = 0.148$ for Intention of Colors), as assessed by Levene's test for equality of variances. In Intention of Colors category, there was a statistically significant three-way interaction among "ways of improvement", "levels of academic achievements" and time, $F(2,80) = 4.63$, $Mse = 0.49$, $p < 0.05$, partial $\eta^2 = 0.104$, $f = 0.34$, power = 0.98. There was statistically significant two-way interactions between "ways of improvement" and "levels of academic achievements", $F(2, 80) = 4.18$, $Mse = 0.49$, $p < 0.05$, partial $\eta^2 = 0.123$, $f = 0.37$, power = 0.99, between "ways of improvement" and time, $F(2, 80) = 4.61$, $Mse = 0.49$, $p < 0.05$, partial $\eta^2 = 0.055$, $f = 0.24$, power = 0.88. There was a statistically significant simple two-way interaction of "ways of improvement" and time for lower-level students, $F(1, 17) = 6.35$, $Mse = 0.49$, $p < 0.05$, partial $\eta^2 = 0.272$, $f = 0.61$, power = 1.00, but not for medium-level students, $F(1,37) = 0.74$, $p > 0.05$, partial $\eta^2 = 0.02$, $f = 0.14$, power = 0.46, and higher-level students, $F(1,26) = 0.24$, $p > 0.05$, partial $\eta^2 = 0.009$, $f = 0.10$, power = 0.24. There was a statistically significant simple main effect of "ways of improvements" on improvements of all three level students (higher-level students: $F(1, 14) = 6.17$, $p < 0.05$, partial $\eta^2 = 0.303$, $f = 0.66$, power = 1.00, medium-level students: $F(1, 27) = 28.46$, $p < 0.001$, partial $\eta^2 = 0.515$, $f = 1.03$, power = 1.00, and lower-level students: $F(1, 7) = 6.63$, $p < 0.05$, partial $\eta^2 = 0.485$, $f = 0.97$, power = 1.00; and there was a statistically significant simple main effect of "levels of academic achievements" on creative performance in both the 1st submissions of PI group ($F(2, 48) = 8.86$, $p < 0.001$, partial $\eta^2 = 0.27$, $f = 0.61$, power = 1.00) and the 2nd submissions of PI group ($F(2, 48) = 6.95$, $p < 0.01$, partial $\eta^2 = 0.226$, $f = 0.54$, power = 1.00). All pairwise comparisons were performed for statistically significant simple main effects. Results show that through peer discussion, all three level students significantly improved their creative performance (Figure 4-3), while three level students didn't significantly improved their creative performance through self-reflection (Figure 4-4). However, although lower-level students significantly improved their creative performance through peer discussion, their scores were still lower than their peers—medium-level students. The magnitude of differences between "two ways of improvements", i.e., self-reflection vs peer discussion, and differences among three level students found in the study are large (Faul et al., 2007). The powers of differences were higher

than 0.9. These results indicated that the possibilities of making Type I and Type II Error in this analysis were low.

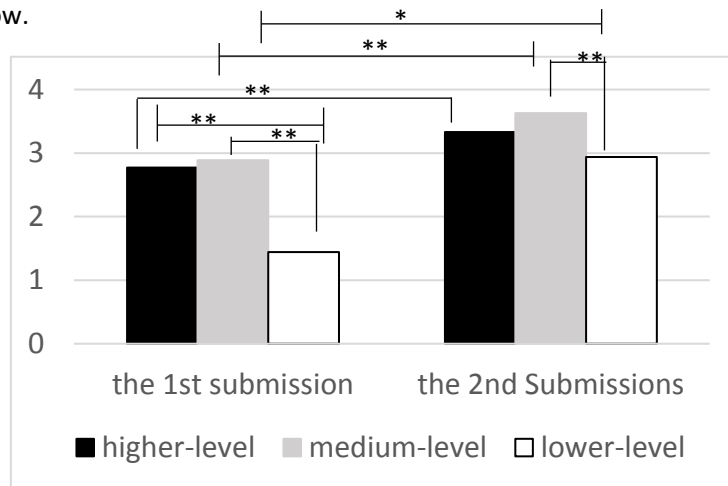


Fig. 4-3 3 level student creative performance of PI group in Intention of Colors in two submissions

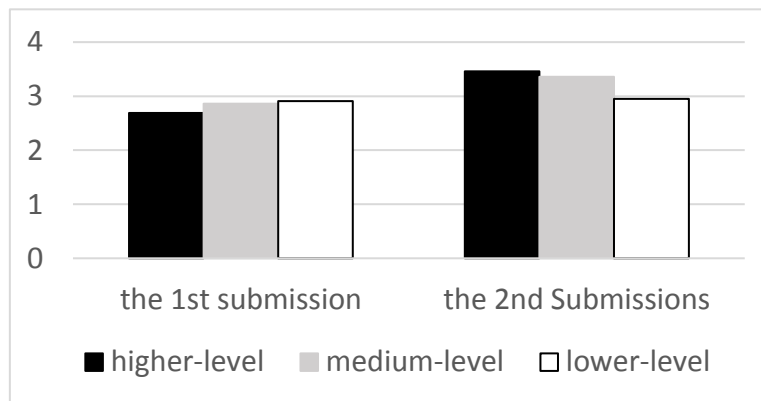


Fig. 4-4 3 level student creative performance of ETCT group in Intention of Colors in two submissions

*p<0.05, ** p<0.01

Table 4-8. Three-way ANOVA: Effects of Self-Reflection and Peer Discussion on Improvements of Different-Level Students

| Categories | Source | SS | df | MS | F | p | Partial η^2 | Effect size(f) | Power |
|---------------------|---------------------------------|-------|----|-------|-------|-------|------------------|----------------|-------|
| Intention of Colors | Ways of improvement | 1.61 | 1 | 1.61 | 2.45 | >0.1 | 0.04 | 0.20 | 0.76 |
| | Levels of academic achievements | 10.89 | 2 | 5.44 | 8.28 | <0.01 | 0.217 | 0.53 | 1.00 |
| | Ways* Levels | 5.50 | 2 | 2.78 | 4.18 | <0.05 | 0.123 | 0.37 | 0.99 |
| | Time | 17.40 | 1 | 17.40 | 35.38 | <0.01 | 0.307 | 0.67 | 1.00 |
| | Levels*Time | 0.16 | 2 | 0.079 | 0.16 | >0.1 | 0.004 | 0.06 | 0.10 |
| | Way*Time | 2.27 | 1 | 2.27 | 4.61 | <0.05 | 0.055 | 0.24 | 0.88 |
| | Ways* Levels*Time | 4.56 | 2 | 2.28 | 4.63 | <0.05 | 0.104 | 0.34 | 0.98 |
| | Error | 39.35 | 80 | 0.49 | - | - | - | - | - |
| Total | 134.30 | 171 | - | - | - | - | - | - | |

3.2 students who have different-level creative performance in the first submissions

To examine whether the effectiveness of self-reflection and peer discussion were influenced by the level of previous creative performance (higher-performance, medium-performance, and lower-performance), a two-way ANOVA was conducted to the effects of “ways of improvement (self-reflection vs peer discussion)” on improvements (the 1st submissions vs the 2nd submissions) of students who had different creative performance in the 1st submissions. The mean and standard deviation values of three level performance of two groups in two phases are shown in Table 4-9.

Table 4-9. Mean and Standard Deviations Values of the Different-Level of Creative Performance in the 1st Submissions

| Categories | Groups | 1st Submission | | | | 2nd Submission | | | |
|---------------------|--------|----------------|------|------------|------|----------------|------|------------|------|
| | | PI Group | | ETCT Group | | PI Group | | ETCT Group | |
| | | M | SD | M | SD | M | SD | M | SD |
| Layout-Originality | Higher | 3.43 | 0.57 | 3.54 | 0.52 | 3.63 | 0.50 | 3.54 | 0.52 |
| | Medium | 2.29 | 0.43 | 2.44 | 0.54 | 2.91 | 0.66 | 2.88 | 0.63 |
| | Lower | 1.81 | 0.86 | 2.00 | 0.96 | 2.75 | 0.43 | 3.00 | 0.29 |
| Design Intention | Higher | 3.47 | 0.43 | 3.46 | 0.38 | 3.67 | 0.39 | 3.63 | 0.36 |
| | Medium | 2.59 | 0.46 | 2.53 | 0.44 | 3.16 | 0.54 | 3.00 | 0.67 |
| | Lower | 0.94 | 0.53 | 1.83 | 0.62 | 3.06 | 0.63 | 3.17 | 0.62 |
| Use of Color | Higher | 3.43 | 0.44 | 3.42 | 0.45 | 3.73 | 0.44 | 3.46 | 0.43 |
| | Medium | 2.68 | 0.36 | 2.68 | 0.38 | 3.18 | 0.50 | 3.09 | 0.81 |
| | Lower | 0.69 | 0.75 | 1.42 | 1.13 | 3.13 | 0.60 | 3.42 | 0.53 |
| Intention of Colors | Higher | 3.47 | 0.39 | 3.58 | 0.34 | 3.73 | 0.31 | 3.63 | 0.41 |
| | Medium | 2.70 | 0.43 | 2.79 | 0.25 | 3.30 | 0.54 | 3.00 | 0.77 |
| | Lower | 0.81 | 0.86 | 1.33 | 1.07 | 3.31 | 0.56 | 3.33 | 0.55 |

Table 4-10. Two-way ANOVA: Effects of Self-Reflection and Peer Discussion on Improvements of Students Who Had Different Performance in the 1st Submissions

| Groups | Categories | Main effects of Time | Interaction |
|--------------------|---------------------|---------------------------------|---------------------|
| Higher-performance | Layout-Originality | F(1,25)=1.96, Mse=0.07, p>0.1 | F(1,25)=1.96, p>0.1 |
| | Design Intention | F(1,25)=8.73, Mse=0.05, p<0.01 | F(1,25)=0.07, p>0.1 |
| | Use of Color | F(1,25)=4.2, Mse=0.09, p<0.1 | F(1,25)=2.4, p>0.1 |
| | Intention of Colors | F(1,25)=5.95, Mse=0.05, p<0.01 | F(1,25)=3.17, p<0.1 |
| Medium-performance | Layout-Originality | F(1,43)=22.23, Mse=0.27, p<0.01 | F(1,43)=0.27, p>0.1 |
| | Design Intention | F(1,43)=20.08, Mse=0.29, p<0.01 | F(1,43)=0.19, p>0.1 |
| | Use of Color | F(1,43)=14.48, Mse=0.30, p<0.01 | F(1,43)=0.14, p>0.1 |
| | Intention of Colors | F(1,43)=12.68, Mse=0.28, p<0.01 | F(1,43)=0.71, p<0.1 |
| Lower-performance | Layout-Originality | F(1,12)=11.26, Mse=0.57, p<0.01 | F(1,12)=0.01, p>0.1 |
| | Design Intention | F(1,12)=79.26, Mse=0.26, p<0.01 | F(1,12)=4.15, p<0.1 |

| | | |
|---------------------|---------------------------------|---------------------|
| Use of Color | F(1,12)=69.13, Mse=0.49, p<0.01 | F(1,12)=0.67, p>0.1 |
| Intention of Colors | F(1,12)=57.56, Mse=0.6, p<0.01 | F(1,12)=0.71, p>0.1 |

Results showed that in the Design intention category of lower-performance group, there was a trend of statistically significant interaction between the intervention and time on creative performance, $F(1, 12) = 4.15$, $MSe=0.26$, $p < 0.1$, partial $\eta^2 = 0.257$, $f=0.59$, $power=0.83$. Lower-performance students significantly improved their creative performance through both peer discussion ($F(1, 12) = 59.85$, $MSe=0.26$, $p < 0.01$, partial $\eta^2 = 0.83$, $f=2.21$, $power=1.00$) and self-reflection ($F(1, 12) = 23.56$, $MSe=0.26$, $p < 0.01$, partial $\eta^2 = 0.66$, $f=1.39$, $power=1.00$), and the lower-performance students after ETCT had a significantly higher score than the lower-performance students after PI in the Design Intention category ($F(1,12)=7.25$, $MSe=0.26$, $p<0.05$, partial $\eta^2 = 0.47$, $f=0.94$, $power=1.00$). In the Intention of Colors category of medium-performance group, there was a trend of statistically significant interaction between the intervention and time on creative performance, $F(1,43) = 3.09$, $MSe=0.28$, $p < 0.1$, partial $\eta^2 = 0.067$, $f=0.27$, $power=0.71$. Medium-performance students significantly improved their creative performance through peer discussion ($F(1, 43) = 14.14$, $MSe=0.28$, $p < 0.01$, partial $\eta^2 = 0.248$, $f=0.57$, $power=1.00$), but not through self-reflection ($F(1, 43) = 1.63$, $MSe=0.28$, $p > 0.1$, partial $\eta^2 = 0.037$, $f=0.20$, $power=0.45$). In the Intention of Colors category of higher-performance group, there was a trend of statistically significant interaction between the intervention and time on creative performance, $F(1,25) = 3.17$, $MSe=0.05$, $p < 0.1$, partial $\eta^2 = 0.11$, $f=0.35$, $power=0.71$. Higher-performance students significantly improved their creative performance through peer discussion ($F(1,25) = 8.9$, $MSe=0.05$, $p < 0.01$, partial $\eta^2 = 0.26$, $f=0.59$, $power=0.99$), but not through self-reflection ($F(1,25) = 0.22$, $MSe=0.05$, $p > 0.1$, partial $\eta^2 = 0.007$, $f=0.08$, $power=0.09$). The main effect of time showed a statistically significant difference in mean creative performance before and after self-reflection and peer discussion. The sizes of self-reflection and peer discussion effects on the creative performance of different-performance students found in the study were large, and their powers were generally higher than 0.9. Therefore, it is highly unlikely to make Type I and Type II Error in this analysis.

4.5 Discussion

This study aimed to assess the possibilities and limitations of PT in increasing technical creativity.

To confirm the teaching effectiveness of ETCT and PI in the creative phase and the reflection-improvement phase, I asked students to submit their products after each phase. Using a measure of two groups' final products, I found that in general, the effectiveness of the two methods had no significant differences. Wang and Murota (2015) had proven that ETCT was effective in increasing students' technical creativity. Therefore, PI was found to be as effective as ETCT in increasing the students' technical creativity. Especially, the ETCT used in this study modified the shortage in the previous study and it focused on the relationship between separate knowledge.

However, because different-level students might hold different learning attitudes, and have different levels of knowledge comprehension and acquisition, a teacher-centered instructional method—explicit teaching—and a student-centered instructional method—peer discussion— may have different modes of producing effects on the different-level students in different phases, which warrant additional discussion.

Effectiveness of the two methods in the creative phase

Examining the effects of two methods and three levels of academic achievements on student creative performance through a two-way ANOVA, I found that in the creative phase, only the lower-level students had significant differences between the two groups in Use of Color and Intention of Colors. That is, creative performances (originality and creative application) of the lower-level students in the PI group were not as good as those of the lower-level students in the ETCT group. Additionally, in the PI group, the creative performances of lower-level students were significantly worse than those of higher- and medium-level students, whereas in the ETCT group, there were no significant differences among them.

From these results, I indicated that compared with ETCT, PI was less effective in increasing lower-level students' originality in the creative phase, although I had made clear criteria for them, which were considered to be effective in improving creativity (Bielaczyc & Collins, 2006; Sawyer, 2008). That is to say, the peer communication in the creative phase could not fully meet the learning needs of the lower-level students. By observing the classrooms, I found that the peer discussion in the creative phase was not animated. They hesitated to open the dialogue and closed the dialogue early. This might be caused by two reasons. One was that students lacked the psychological safety (Roger, 1954). Thus, they could not immediately engage in discussion. The

other reason might lie in the focus of the creative phase. The creative phase is a process of producing individual designs and creating individual websites from nothing. In this phase, the students focused primarily on their own products. In addition, some research documented that before discussing individual ideas with peers, the majority of students preferred answering the question individually (Nicol & Boyle, 2003). This implied that once students (or they thought they) failed in organizing or generating individual ideas, the communication would be limited. The limited peer communication was not enough to help the lower-level students, whom formerly had no idea how to generate and identify novel ideas and how to express an idea by applying learned knowledge, complete their designs. In contrast, in the ETCT group, students were explicitly instructed how to be creative through applying learned knowledge. This was proven effective in increasing creativity of students, especially that of lower-level students (Niu & Sternberg, 2003; Niu & Liu, 2009; Wang et al., 2014; Wang & Murota, 2015). Therefore, lower-level students in the ETCT group performed better than those in the PI group and performed similarly with their peers—the medium- and higher-levels students in the ETCT group. The finding concerning the lower-level students in the creative phase can also be revealed by the findings in computing science (Zingaro & Porter, 2014) and biology (Smith et al., 2011). In their research, the authors found that compared with peer discussion alone, the instructor intervention after the peer discussion was more valuable for all groups of students (weak, average, and strong), particularly for the weak students. The similar findings mean that the explicit explanation is essential for the lower-level students, even in creativity education. Therefore, comparatively speaking, an instructor's in-depth instruction on the technical creativity in ECTC was more effective in motivating students, especially lower-level students, to be creative in the creative phase.

Effectiveness of self-reflection and peer discussion

Additionally, I examined the improvements of the different-level students of two groups in the reflection-improvement phase through a three-way ANOVA by analyzing the products of those students who submitted their works both times to discuss the effects of self-reflection and peer discussion. From the results, I found that all three levels of students in the PI group significantly improved their creative performances in Intention of Colors category, whereas in the ETCT group, three level students didn't statistically significantly improve their creative performances. The

differences in the effectiveness of self-reflection and peer discussion can be reflected by the rate of products with improved scores during the reflection-improvement phase. The rate in the PI group was 71%, whereas the rate in the ETCT group was 46%.

From these results, I learned that the third peer discussion of this study was actually effective in improving all levels of the students' creative performances in the reflection-improvement phase. However, the effects of the evaluation criteria-based self-reflection were limited.

In addition, to check the effectiveness of self-reflection and peer discussion in improving creative performance more comprehensively, I divided students into higher-performance, medium-performance, and lower-performance three groups based on their creative performance in the first submissions and compared the three group students' improvements separately through a two-way ANOVA.

Results showed that 1) lower-performance students, whom were thought had lower-level technical creativity abilities, significantly improved their creative performance through both self-reflection and peer discussion. 2) medium-performance and higher-performance students in the PI group, whom were thought had relatively medium-level or a higher-level technical creativity abilities, significantly improved their creative performance through peer discussion, while medium-performance and higher-performance students in the ETCT group, whose creative performance were influenced by explicit instruction, didn't significantly improve their creative performance through self-reflection. In addition, results showed that after ETCT and PI, lower-performance students in the ETCT group performed significantly better than lower-performance students in the PI group in the 1st submissions.

These results indicated that the third peer discussion of this study was effective for students who had different-level technical creativity abilities. However, the significant improvements of lower-performance in the third peer discussion reflected that some students need time to make psychological and ideational preparations for the genuine peer instruction. However, in the ETCT group, only lower-performance students significantly improved their creative performance between 1st submissions and 2nd submissions. It's difficult to attribute the significant improvements to the simple effect of self-reflection. Therefore, the effect of self-reflection in improving student

creative performance might be limited. In addition, the differences between lower-performance of two groups reflected the effects of ETCT in helping student generate new ideas, again.

This study confirmed the effects of peer discussion in improving the different student creativity. Similar finding was reported by Smith et al. (2009). The results of their study revealed that “peer discussion can be effective for understanding difficult concepts even when no one in the group initially knows the correct answer.”(p. 124, Smith et al., 2009).

However, from the different performances in the two different phases, I can infer that the effects were qualified. During the study, students in the PI group did peer discussion for three times (twice in the creative phase, and once in the reflection-improvement phase). However, from students’ creative performance in these two phases, I found that peer discussion had effects in the reflection-improvement phase but not in the creative phase. The reason might be that the majority of students had done enough preparation in both psychological aspects and individual ideas or works in the reflection-improvement phase. The preparation in psychological aspects can be reflected from students’ better performances in the peer discussion in the reflection-improvement phase. The majority of students immediately engaged in the discussion and constantly focused on products. This might be because that the peer discussion during the creative phase helped students know each other and know more about the criteria. Therefore, they felt safe to provide feedback by using assessment criteria. Additionally, through the creative phase, the majority of students had formed individual ideas or works. This situation turned student focus to evaluate and refine their products, which provided a foundation for the following discussion. Therefore, students would be proactive in providing valuable feedback to each other, which would motivate them to reinforce group creativity. This explanation is consistent with findings regarding the appropriate time to engage students in peer discussion. Several empirical studies in science indicated that to ensure learning gains, it is better to engage students in peer discussion when the percentage of correct answers on the individual vote falls between 35% and 70% (Crouch & Mazur, 2001; Smith et al., 2009; Gok, 2014, 2015; Vickrey et al., 2015). Of course, in a different environment, the percentage may be different. However, the emphasis on the percentage is to ensure that a proportion of the students have a correct understanding to instruct their peers, which is the precondition of peer discussion. In creativity education where there is no correct answer, the precondition of peer

discussion should be that the students have individual ideas to share.

Effectiveness of the two methods in the reflection-improvement phase

After the reflection-improvement phase, I also compared the performances of different-level students in two groups. The results showed that no significant differences between student of two groups, and lower-level students of two groups had lower creative performance. These results illustrated that although all students improved their products through peer discussion, creative performance of lower-level students are still lower. Therefore, generally, when teachers use peer instruction to develop students' creativity, they need to consider how to facilitate lower-level students to ensure their good creative performance. In addition, after ETCT, to develop lower-level student creative performance, just using self-reflection might be not enough. What's more, because peer discussion was effective in improving student creative performance, it is difficult to attribute the worse performance of lower-level students to teacher's limited experience in peer instruction.

In conclusion, PI was effective in developing student technical creativity and improving students' creative ideas, but it needs give students time to make psychological and ideational preparations for the genuine peer instruction. ETCT was more effective in facilitating the lower-level students to generate their own ideas and understand the relationships among disparate facts than PI. As a result, with respect to the practice of developing technical creativity, it is advisable to combine them. That is, at the commencement of the peer instruction, explicit instructions are provided, and then PI begins when the instructor proposes a task to the students. Providing detailed instructions ensures that the majority of the lower-level students know how to be creative and generate novel ideas, which might be novel just for themselves.

This hybrid-type PI—the combination of PI and ETCT—is supposed to be widely popularized because the participants in this study had little PI and other active learning experience before they participated in the study. However, PI succeeded in increasing the higher- and medium-level senior middle school students' technical creativity. Therefore, I believe that the hybrid-type PI can be adopted by other Chinese high schools or even by other countries and regions.

What should be mentioned is that although the instructional design of this study did not emphasize collaboration, students were suggested to collaborate with each other when the teacher assigned the task. This implied that if students selected the collaborative method, there were no enough measures to ensure all collaborators could not loaf on the task. However, the result was that only four students selected to collaborate with another classmate. The reason why the majority of students avoided collaboration might be that students were not good at using it. Under this kind of circumstances, it is difficult to adopt some completed collaborative learning methods, such as problem-based learning and enquiry-based learning, without extensive practice. In addition to the collaborative ability, problem-based learning and enquiry-based learning require students to have good self-directed learning ability and require teachers to have a strong professional ability to facilitate students. These requirements prevent primary and secondary school teachers from applying complete collaborative learning methods in classrooms without deliberation. The local teacher also reflected that:

Students' performance were out of my imagination. In the future, I should provide them with more opportunities to let them express themselves. However, there are over 60 students in one class. It is difficult for me to use those completed teaching methods in such a situation.

In all, how to clearly define creativity in specific subject areas and how to adapt various teaching and learning methods to increase the creativity by considering environment, characteristics of students, styles of creativity, and other factors, need more thought and attention.

4.6 Conclusion

This study, firstly, illustrated an example of defining creativity based on specific contexts to grant creativity specific meanings and criteria. It can help teachers and students remove the ambiguity about the creativity in their concrete subject. Secondly, I tried integrating creativity development into real senior middle school classrooms without changing too much the original teaching program. This helps to eliminate teachers' rejection of applying completed creative teaching methods to teach creativity in their classes. Additionally, this study provided valuable teaching

experiences in using open-ended questions in PI to cultivate creativity. It is conducive to inspire teachers to adapt other methods in their subjects to teach creativity.

Specifically, I examined the possibilities and limitations of integrating PI into technical creativity education through comparing the teaching effectiveness of PI and ETCT in authentic classrooms. I found that peer discussion was effective in improving all (higher-, medium-, lower-level academic achievements and technical creativity abilities) students' creative performances when they had already had their own ideas and their discussion could focus on evaluating and improving these ideas (the genuine peer instruction). However, for the lower-level students, it was not easy to obtain instructions from their peers to help them generate novel ideas from nothing, especially when their peers were busy with their own work. An instructor's detailed instruction on technical creativity before the independent work can remedy this shortcoming, by essentially motivating the students, especially the lower-level students, to generate and identify their novel ideas. Therefore, to apply the functions of these two methods, I suggest combining them.

4.7 Limitations & Future work

The limitations of the study lie in: 1) The reliability and validity of the rubric. In this study, I focused on rating student products by utilizing a rubric to measure their achievements in creativity. When designing the rubric, I crosschecked the observable teaching objectives, views of a local ICT teacher with 5 years of teaching experience, and expert advice on web design from a university professor. After the design, I pretested its validity through several products with different qualities and made revisions according to the test results. Despite this, the reliability and validity of the rubric are still problems must be acknowledged in this study. 2) The instructional design. One limitation is that I should have repeated ETCT at the beginning of fourth and fifth lesson to ensure compare the effects of ETCT and PI, fairly. However, when I designed the instruction, I saw the three lessons of independent creations as different stages of a whole creative process, so I didn't repeat ETCT. This caused that I couldn't compare the effects of ETCT and PI, precisely and fairly. To maximize the ecological validity, I did not purposefully pair students during peer discussion. Consequently, in this study, I could not examine the qualities of peer discussion among different-level students. It might provide us with a direction for the further study.

In addition, to check the effectiveness of two methods in improving creative performances in technical creativity comprehensively, it is necessary to examine the improvement of student technical creativity. This means that I need to test students' technical creativity before the study. However, there is no a credible test developed to measure students' technical creativity, and in the authentic instruction, it is impossible to spend at least 3 weeks in making a website before the experiment to test students' original technical creativity. Therefore, it is impossible to measure students' original technical creativity. However, as what I have mentioned above, most Chinese high school students lack creative thinking (Niu & Liu, 2009), which can also be reflected from students' performance of the conventional group in the study of Chapter 3. Therefore, in this study, I assumed that all participants had a lower-level technical creativity, and then did a quasi-experiment design to maximize the ecological validity of authentic instruction. Despite of this, this is a profound limitation to analyze the effects of ETCT and PI, including the effects of self-reflection and peer discussion, in developing student technical creativity.

In the future, the effects of ETCT, PI, and the hybrid-type PI must be compared by the experimental research design. Additionally, in developing the students' technical creativity, their thinking styles and personalities might play an important role. Therefore, it is necessary to assess whether these three teaching methods have different effects on students who have different thinking styles and personalities.

Chapter 5 Effects of Instructional Methods on the Relationships between Personality and Creativity

5.1 Introduction

Personality is one important component of creativity. Therefore, exploring the relationship between personality and creativity is valuable for creativity development. Many studies have been done to investigate the relationship between personality and creativity. Some relationships are relatively clear, for example, people who are reflective, curious for everything, and like to take a risk usually have more creative performance. However, in many situations, personality failed in predicting creative performance. This might be because the situation restricts the manifestation of different personalities' creative potential. Therefore, it is necessary to investigate how the environment interacts with personality to affect the creative behavior. In the previous research, I have investigated the effects of ETCT and PI on different-level students' technical creativity. However, what effects can the situation of ETCT and PI make on the relationship between personality and creativity? Or, do they have any effects on different-personality students' technical creativity? In the chapter, I would investigate the answers of these questions.

5.1.1 Personality

Personality is defined as one's relatively enduring ways of thinking, feeling, and acting that characterize an individual (Costa & McCrae, 1995). Creative personality is a matter of those patterns of traits that are characteristic of creative person (Guilford, 1950). Throughout several decades of studies on creativity in psychology and education, core characteristics of creative people have been basically identified (Barron & Harrington, 1981; Oldham & Cummings, 1996; Treffinger et al., 2002). Gough's Adjective Check List and Composite Creative Personality scale were developed to test a set of core creative characteristics (Barron & Harrington, 1981).

Early in 1932, William McDougall conjectured that "personality may to advantage be broadly analyzed into five distinguishable but separable factors, namely, intellect, character, temperament, disposition, and temper....." (p. 418, Digman, 1990). Since then, many researchers devoted themselves to the taxonomy for personality attributes. Although views varied in labeling some

dimensions of personality, in principle, five factors are regarded as openness to experience, conscientiousness, extraversion, agreeableness, and neuroticism (McCrae & Costa, 1987; Costa & McCrae, 1995). They constitute the well-known Big Five personality traits.

5.1.2 Personality and creativity

Considerable studies have been done to investigate the relationships between five personality traits and creativity. The relationships between certain personality traits and creativity are relatively clear, while some relationships are still debatable and need more studies to prove it.

1) Openness to experience

Openness to experience describes the extent to which individuals are imaginative, curious, original, broad-minded, flexible, reflective, intelligent and artistically sensitive. People who are high on openness to experience tend to broadly absorb knowledge and ideas from others. Individuals with low openness to experience are usually conventional, narrow in interests, rigid, and unanalytical (Feist, 1998; Zhao & Seibert, 2006). High openness to experience can lead to creative expression and exploration. Therefore, researchers believe that it should be one of trait factors which can predict one's creative achievement.

Various studies have demonstrated that openness to experience was positively related to different types of creativity scaled by different creativity measures. For example, Furnham and Bachtiar (2008) gathered 176 participants (mean age: 18.6) to investigate the relationship between personality and creativity. They measured the creativity through Divergent Thinking, Biographical Inventory of Creative Behaviors, Self-Rating Creativity, and Barron-Welsh Art Scale. The results showed that openness to experience was significantly correlated to Divergent Thinking. King et al. (1996) examined the relations among personality, creative ability, and creative accomplishments. In the study, openness to experience was the only trait factor that was significantly positively correlated with creative ability and creative accomplishments. In addition, the outcome of a meta-analysis (Feist, 1998) showed that regardless of which measure or taxonomy was used to assess personality, creative people tend to be opened to experience.

2) Conscientiousness

Conscientiousness refers to individual differences in impulse control, conformity, persistence, hard work, organization, and motivation in the pursuit of goal accomplishment (George & Zhou, 2001; Zhao & Seibert, 2006). People who are high on conscientiousness have a strong sense of purpose and will; obey rules and conform to norms; are reliable and self-controlled. The low end of conscientiousness tend to directly express individual needs and be psychopathic deviant. Conscientiousness showed the strongest and most consistent relationship with job performance (George & Zhou, 2001; Sung & Choi, 2009). However, traits of conscientiousness—conforming, following rules, and striving to achieve predetermined goals—may result in individuals to carry out a given task in an efficient and organized way rather than complete it by coming up with new ideas (George & Zhou, 2001). Therefore, high conscientiousness is considered to be less creative. Based on the results of a meta-analysis (Feist, 1998), artists, compared to nonartists, were less cautious, conscientious, controlled, orderly, and reliable.

3) Extraversion

Extraversion reflects individual's tendency to be assertive, dominant, energetic, active, talkative, and enthusiastic, gregarious, and sociable (Feist, 1998; Zhao & Seibert, 2006). Individuals who are high on extraversion tend to seek excitement and stimulation, whereas those who are low on extraversion prefer to spend more time alone and reserved, quite, and independent (Zhao & Seibert, 2006). Generally, extraversion involves two dimensions. Hogan named them as Ambition and Sociability (Barrick & Mount, 1991). In California psychological inventory, they were called as Sociability and Dominance (Costa & McCrae, 1995). In all, extroverts tend to be active and passionate, and have high desires for material gain, status, recognition, and power (King et al., 1996). King et al. (1996) found that except openness to experience, extraversion was the other trait factor positively correlated with creative ability. In addition, Feist (1998) reported in his meta-analysis of personality that extraversion was positively related to creativity.

4) Agreeableness

Agreeableness assesses individuals' interpersonal orientation. People with high agreeableness are trusting, forgiving, caring, altruistic, and gullible (Zhao & Seibert, 2006). High agreeableness has cooperative value and a preference for positive interpersonal relationships.

People with low agreeableness tend to be hostile, aggressive, argumentative, self-centered, and suspicious. However, because agreeable people appear to care about others' feeling and try to avoid conflict, when cooperating with others, they may hesitate to express different ideas but conform to others' common ideas. Therefore, agreeableness is supposed to have a negative relationship with creativity. This conjecture was indirectly confirmed by the findings of Feist (1998) that warmth (one factor of 16 personality factors) was negatively related to creative achievements. In addition, Feist (1998) found that both in science and art, creative people were ambitious, dominant, hostile, and impulsive.

5) Neuroticism

Neuroticism represents individual differences in adjustment and emotional stability. Individuals who score high on neuroticism tend to be neurotic, emotional, shrewd, nervous, high-strung, insecure; low scorers tend to be calm, stable, adjusted, ego-strength, well-being. The relationship between neuroticism and creativity is debatable. Some researchers consider that emotional instability of high neuroticism seems make them lack the energy to perform their tasks. Therefore, neuroticism should have had a negative relationship with creativity (Sung & Choi, 2009). However, high level of anxiety and emotional sensitivity appear to be common among creative people Feist (1998). Artists "are distinguished more by their emotional instability, coldness, and their rejecting group norms" (p. 300, Feist, 1998).

With more findings on the psychology of creativity, psychologists believe that creative thinking is not so much an individual trait but rather a social phenomenon involving interactions among people within their specific group or cultural settings. Therefore, some researchers began to focus on the effects of interactions between personality and social-environmental factor on creative behavior.

5.1.3 Social-environmental factor, personality, and creativity

There is considerable evidence to support the correlation between personality and creative behavior (Barron & Harrington, 1981; Aguilar-Alonso, 1996). However, although the relationships between personality traits and creativity have been repeatedly examined and consensus about these relationships have been basically formed, in many situations, these personality factors failed

in predicting creative performance. This might be because the situational factor restricts the manifestation of different personality's creative potential. Therefore, understanding the effects of the interaction between environment and personality on creative performance is important.

Some researchers investigated how personality interacted with the social-environmental factor to affect the creative behavior in the workplace. For example, Oldham and Cummings (1996) examined the joint contributions of employees' creativity-relevant personal characteristics and three organizational contexts—job complexity, supportive supervision and controlling supervision—to three indicators of employees' creative performance: patent disclosures written, contributions to an organization suggestion program, and supervisory ratings of creativity. The results showed that employees produced the most creative work when they had appropriate creativity relevant characteristics, worked on complex, challenging jobs, and were supervised in a supportive, non-controlling way. In addition, George and Zhou (2001) adopted an international approach to investigating how openness to experience and conscientiousness were related to employees' creative behavior. Their results showed that creative behavior was highest when individuals who were high on openness to experience received positive feedback and had unclear ends on their jobs; and creative behavior could be inhibited when employees with high conscientiousness were in the situation encouraged their conformist and controlled tendencies.

However, few research investigated the interactional effects of instructional methods and personality on students' creative performance. I have investigated the effects of ETCT and PI on the different-level students in different phases. In this section, I aimed to investigate whether personality traits interacted with two instructional methods—ETCT and PI—to affect students' creative performance in a Chinese senior middle school.

5.2 Methods

5.2.1 Subjects

127 Chinese 10th graders (n=54 males, 73 females; mean age=16.2 years) participated in the study. A total of 68 students (n=31 males, 37 females; mean age=16.3 years) participated in the PI, and 59 students (n=23 males, 36 females; mean age=16.2 years) attended in ETCT. These participants belonged to four classes.

5.2.2 Learning contexts

The instructional contents of this study were Web design and website making. The instructional procedures are shown in Table 5-1.

Table 5-1. *Instructional procedures of ETCT and peer instruction*

| Lessons 40 min/lesson | Explicit technical creativity teaching (ETCT Group) | Peer Instruction (PI Group) |
|----------------------------------|---|---|
| 1st | Learning of basic knowledge | |
| 2nd | <ol style="list-style-type: none"> 1. Instruction of Microsoft FrontPage 2003 2. Interpretation of design intention | |
| 3rd | <p>1. Elaborate instruction The teacher models a practice to instruct the entire process of creating an original webpage. (approximately 16-18 min)</p> <p>2. Assignment of a task Students design and make a novel “FrontPage-learning website” by applying the learned knowledge and using the source materials prepared by the teacher. (approximately 2-3 min)</p> <p>3. Students’ independent creation Students design an individual website by following the teacher’s instruction. (approximately 20 min)</p> | <p>1. Assignment of a higher-order creative task The same with the task of ETCT (approximately 2-3 min)</p> <p>2. Students’ individual thinking Students complete a design by filling out a task sheet. (approximately 14-15 min)</p> <p>3. Peer discussion Students share individual intention with peers and explain the design; and peers provide feedback based on evaluation criteria. (approximately 6 min)</p> <p>4. Students’ independent creation Students reflect and improve their intentions and conceive designs based on feedback, and then start the making (approximately 18 min)</p> |
| 4th | <p>Self-improvement and independent creation Students reflect on their designs based on the evaluation criteria and continue making their websites.</p> | <p>1. Peer discussion Students share individual intention with peers and explain how the design expressed the intention; and peers provide feedback based on evaluation criteria. (approximately 6 min)</p> <p>2. Independent creation Students reflect and improve intentions and conceive designs based on feedback and complete the making.</p> |
| 1st submission | At the end of this lesson, students need to voluntarily submit their products in the creative phase. | |
| 5th | <p>Self-improvement and independent creation Students reflect on their designs</p> | <p>1. Peer discussion 2. Independent creation These two learning activities are similar with</p> |

| | | |
|----------------------------------|--|-----------------------------|
| | based on the evaluation criteria and make a revision. | those of the fourth lesson. |
| 2nd submission | At the end of this lesson, students need to voluntarily submit their products in the reflection-improvement phase. | |

The first two classes were used to teach the required basic knowledge of web design and website making. In the 3rd and 4th lessons of ETCT, the instructor modeled the process of creating an original webpage step by step to instruct the students how to make a novel webpage. Then, the students were asked to design their webpages by completing a step-by-step task sheet that could guide students' creative thinking. In the 3rd and 4th lessons of PI, the instructor just distributed the task sheet, explained how to complete the task, and then worked as a facilitator. The students needed to 1) independently create their own work using the task sheet as guidance; 2) share their original conceptions with their peers and receive feedback; and 3) sketch their designs according to the feedback and ideas generated during the peer discussion. Students focused on revising and improving their products in the 5th lesson.

At the end of the fourth lesson, the majority of the students had completed the first version of their products, which meant that their creative process was nearly finished. Therefore, the students were asked to submit their products to demonstrate their achievements in the creative process. In the fifth lesson, the students' discussion focused on the creative application. That is, the students evaluated and reflected on the relationship between the design intention and the applications of the learned design principles to improve their products. To check the achievements in this phase, I asked the students to resubmit their products at the end of the lesson.

5.2.3 Measures

Creative achievements: Students' creative achievements were reflected by scores of their products rated based on a rubric designed by Wang and Murota (2016b). According to the teaching contents, I identified 4 categories: Layout-Originality; Design Intention; Use of Color; and Intention of Colors. The Layout-Originality category assessed the students' originality of the layout design. Design Intention rated the original intention implied in the design of the website. Use of Color was designed to rate the appropriateness of applying the principles of colors, and Intention of Colors were designed to assess whether the colors matched to transfer a particular intention. Each category had the following five levels: failed; novice; basic; proficient; and exemplary. The

corresponding points of these levels ranged from 0 to 4. The interval between two points was 1.

Big five personality traits: I measured big five personality traits with the big five project personality test developed by Jeff Potter. This scale contains 46 items. Respondents indicate the strength of their agreement with each statement, utilizing a scale ranging from 1 (strongly disagree) to 5 (strongly agree).

In the creative phase, the student numbers who submitted both products and the big five project personality test in the PI group and the ETCT group were separately 50 and 52. In the reflection-improvement phase, the student numbers in the PI group and the ETCT group were respectively 55 and 41.

5.2.4 Data analysis

Because about 9 items were used to measure one personality factor, the original scores of each factor ranged from 0 to 100. Except conscientiousness, other four personality factors have five levels. Generally, those original scores were less than 20 belong to “level 1”, those original scores were between 20 and 39 belong to “level 2”, those original scores were between 40 and 59 belong to “level 3”, those original scores were between 60 and 79 belong to “4”, and those original scores were more than 79 belong to “level 5”. As for conscientiousness, students whose original scores were less than 20 belong to “level 1”, those original scores were between 20 and 39 belong to “level 2”, those original scores were between 40 and 59 belong to “level 3”, those original scores were more than 59 belong to “4”,

The concrete interpretations of each level of five factors are shown in Table 5-2.

Table 5-2. *Interpretations of each level of Big Five Personality Factors*

| Personality factor | Level(original score) | Interpretation |
|------------------------|-----------------------|---|
| Openness to experience | 1 (0-19) | You prefer traditional and familiar experience. |
| | 2 (20-39) | You are somewhat conventional. |
| | 3 (40-59) | You typically don't seek out new experience. |
| | 4 (60-79) | You are relatively open to new experience. |
| | 5 (80-100) | You enjoy having novel experience and see things in |

| | | |
|-------------------|------------|--|
| | | new ways. |
| Neuroticism | 1 (0-19) | You probably remain calm, even in tense situations. |
| | 2 (20-39) | You are generally relaxed. |
| | 3 (40-59) | You aren't particularly nervous nor calm. |
| | 4 (60-79) | You tend to become anxious or nervous. |
| | 5 (80-100) | You are a generally anxious person and tend to worry about things. |
| Conscientiousness | 1 (0-19) | You probably have a messy desk. |
| | 2 (20-39) | You tend to do things somewhat haphazardly. |
| | 3 (40-59) | You are neither organized nor disorganized. |
| | 4 (60-100) | You are very well-organized, and can be relied on. |
| Extraversion | 1 (0-19) | You probably enjoy spending quiet time alone. |
| | 2 (20-39) | You tend to shy away from social situations. |
| | 3 (40-59) | You are neither particularly social nor reserved. |
| | 4 (60-79) | You are relatively social and enjoy the company of others. |
| | 5 (80-100) | You are extremely outgoing, social and energetic. |
| Agreeableness | 1 (0-19) | You find it easy to criticize others. |
| | 2 (20-39) | You find it easy to express irritation with others. |
| | 3 (40-59) | You are neither extremely forgiving nor irritable. |
| | 4 (60-79) | You tend to consider the feelings of others. |
| | 5 (80-100) | You are good-natured, courteous, and supportive. |

5.3 Results

I did analysis of correlation among the study variables for the achievements of two groups in two phases. Results showed that in the creative phase, openness to experience ($r=.32, p<.5$) and conscientiousness ($r=.28, p<.5$) in the ETCT group positively correlated with creative achievements in intention of colors (Table 5-3), and conscientiousness of PI group in the reflection-improvement phase negatively correlated with creative achievements in both design intention category ($r=-.29,$

p<.5) and intention of colors category (r=-.28, p<.5)(Table 5-4).

Table 5-3. Means, Standard Deviation, and Correlations among Study Variables of ETCT Group in the Creative Phase

| Variable | M(SD) | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|------------------------|------------|---|-------|-------|--------|--------|--------|--------|--------|--------|
| Personality: | | | | | | | | | | |
| 1.Open | 2.62(1.23) | - | .36** | .10ns | .40** | -.27+ | .20 ns | .27+ | .25+ | .32* |
| 2.Cons | 2.37(1.02) | | - | .30* | .47** | -.45** | .02 ns | .18 ns | .16ns | .28* |
| 3. Extra | 3.06(1.01) | | | - | .19 ns | -.56** | .06 ns | -.08ns | .01 ns | -.02ns |
| 4.Agree | 3.27(1.00) | | | | - | -.33* | .08 ns | -.06ns | .01 ns | .11ns |
| 5.Neuro | 2.56(1.15) | | | | | - | -.08ns | .23+ | .09ns | .10ns |
| Creative achievements: | | | | | | | | | | |
| 6. L-O | 2.66(0.78) | | | | | | - | .42** | .29* | .45** |
| 7.DI | 2.69(0.71) | | | | | | | - | .77** | .84** |
| 8.UoC | 2.57(0.99) | | | | | | | | - | .85** |
| 9.loC | 2.72(0.99) | | | | | | | | | - |

Open = Openness to experience; Cons= Conscientiousness; Extra= Extraversion; Agree=Agreeableness; Neuro=Neuroticism; L-O= Layout-Originality; DI= Design Intention; UoC= Use of Color; loC=Intention of colors.

*p < .05. **p < .01. ns p > .05.

Table 5-4. Means, Standard Deviation, and Correlations among Study Variables of PI Group in the Reflection-improvement Phase

| Variable | M(SD) | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|------------------------|------------|---|-------|-------|-------|--------|--------|--------|--------|--------|
| Personality: | | | | | | | | | | |
| 1.Open | 2.33(1.19) | - | .13ns | .57** | .14ns | -.03ns | -.11ns | -.01ns | -.04ns | -.02ns |
| 2.Cons | 2.47(.89) | | - | .23+ | .34* | -.26+ | -.21ns | -.29* | -.19ns | -.28* |
| 3. Extra | 3.07(1.14) | | | - | .27* | -.32* | -.15ns | -.04ns | -.01ns | -.01ns |
| 4.Agree | 3.07(1.09) | | | | - | -.39** | -.04ns | -.05ns | .03ns | -.03ns |
| 5.Neuro | 2.46(1.09) | | | | | - | .19ns | .16ns | .14ns | .21ns |
| Creative achievements: | | | | | | | | | | |
| 6.O-L | 2.99(.69) | | | | | | - | .65** | .68** | .65** |
| 7.DI | 3.22(.58) | | | | | | | - | .81** | .83** |
| 8.UoC | 3.26(.56) | | | | | | | | - | .76** |
| 9.loC | 3.36(.54) | | | | | | | | | - |

Open = Openness to experience; Cons= Conscientiousness; Extra= Extraversion; Agree=Agreeableness; Neuro=Neuroticism; L-O= Layout-Originality; DI= Design Intention; UoC= Use of Color; loC=Intention of colors.

*p < .05. **p < .01. ns p > .05.

The results of analysis of variance showed that there were no significant differences between ETCT and PI in all four categories. To discuss different effects of ETCT and PI on different personality factors, I grouped students who belonged to the top two levels of each personality into the high

level group, and grouped left students into the low level group to compare their creative performance in the phases that correlations appeared. The means and standard deviations of each group of openness to experience and conscientiousness in the creative phase are separately shown in Table 5-5 and 5-6. The means and standard deviations of conscientiousness in the reflection-improvement phase are shown in Table 5-7.

Table 5-5. Means and standard deviations of openness to experience in the creative phase

| Openness (student number) | Layout-Originality | | | | Design Intention | | | | Use of Color | | | | Intention of Colors | | | |
|---------------------------------|--------------------|-----|------|------|------------------|-----|------|------|--------------|------|------|------|---------------------|------|------|------|
| | ETCT | | PI | | ETCT | | PI | | ETCT | | PI | | ETCT | | PI | |
| | M | SD | M | SD | M | SD | M | SD | M | SD | M | SD | M | SD | M | SD |
| Low(41/40) | 2.60 | .80 | 2.48 | 0.81 | 2.60 | .69 | 2.64 | .86 | 2.44 | 1.02 | 2.64 | .99 | 2.60 | 1.04 | 2.64 | .96 |
| High(11/10) | 2.91 | .63 | 2.65 | 0.71 | 3.05 | .66 | 2.45 | 1.08 | 3.05 | .66 | 2.60 | 1.14 | 3.18 | .53 | 2.50 | 1.16 |

Table 5-6. Means and standard deviations of conscientiousness in the creative phase

| Conscientio sness (student number) | Layout-Originality | | | | Design Intention | | | | Use of Color | | | | Intention of Colors | | | |
|---|--------------------|-----|------|-----|------------------|-----|------|-----|--------------|------|------|------|---------------------|------|------|-----|
| | ETCT | | PI | | ETCT | | PI | | ETCT | | PI | | ETCT | | PI | |
| | M | SD | M | SD | M | SD | M | SD | M | SD | M | SD | M | SD | M | SD |
| Low (36/38) | 2.74 | .79 | 2.46 | .82 | 2.68 | .78 | 2.57 | .92 | 2.53 | 1.13 | 2.62 | 1.03 | 2.63 | 1.15 | 2.62 | 1.0 |
| High(16/12) | 2.50 | .71 | 2.67 | .66 | 2.72 | .50 | 2.71 | .88 | 2.66 | .52 | 2.67 | 1.01 | 2.94 | .34 | 2.58 | 1.0 |

Table 5-7. Means and standard deviations of conscientiousness in the reflection-improvement phase

| Conscientio sness (student number) | Layout-Originality | | | | Design Intention | | | | Use of Color | | | | Intention of Colors | | | |
|---|--------------------|-----|------|-----|------------------|-----|------|-----|--------------|-----|------|-----|---------------------|-----|------|-----|
| | ETCT | | PI | | ETCT | | PI | | ETCT | | PI | | ETCT | | PI | |
| | M | SD | M | SD | M | SD | M | SD | M | SD | M | SD | M | SD | M | SD |
| Low (29/39) | 3.10 | .71 | 3.14 | .63 | 3.19 | .71 | 3.35 | .51 | 3.22 | .68 | 3.33 | .51 | 3.24 | .74 | 3.5 | .42 |
| High(12/16) | 3.04 | .48 | 2.62 | .70 | 3.33 | .37 | 2.91 | .62 | 3.33 | .51 | 3.06 | .61 | 3.38 | .46 | 3.03 | .65 |

To check whether the creative performance of high and low level groups in two methods are different or not, I used two-way ANOVA. The results showed that in the creative phase where correlations were found, there were no significant differences among high and low level groups of two methods in openness to experience and conscientiousness two personality factors. In the reflection-improvement phase, I found that in the design intention, $F(1, 92)=5.31$, $MSe=0.35$, $p<0.05$, partial $\eta^2=0.055$, $f=0.24$, $power=0.64$, and intentions of colors, $F(1, 92)=6.11$, $MSe=0.35$, $p<0.05$, partial $\eta^2=0.06$, $f=0.25$, $power=0.68$, two categories, low conscientiousness of PI

performed significantly better than high conscientiousness; and in the design intention category, the high conscientiousness of ETCT performed significantly better than high conscientiousness of PI ($F(1, 92)=5.00$, $MSe=0.35$, $p<0.05$, partial $\eta^2=0.052$, $f=0.23$, $power=0.62$).

5.4 Discussion

This study examined the effects of ETCT and PI on the relationships between students' personality and creative achievements. The results showed that the two instructional methods served to affect the creative performance of openness to experience and conscientiousness.

In order to make the relationships clear, I conclude them in a table (Table 5-8).

Table 5-8. *The summary of relationships between personality and creative performance appeared in the research*

| Personality | Explicit technical creativity teaching | | | | Peer instruction | | | |
|------------------------|--|---------------------|----------------------------|---------------------|----------------------------|---------------------|----------------------------|---------------------|
| | 1 st submission | | 2 nd submission | | 1 st submission | | 2 nd submission | |
| | Design Intention | Intention of colors | Design Intention | Intention of colors | Design Intention | Intention of colors | Design Intention | Intention of colors |
| Openness to experience | --- | Positive | --- | --- | --- | --- | --- | --- |
| Conscientiousness | --- | Positive | --- | --- | --- | --- | Negative | Negative |

a. Effects on the relationship between openness to experience and creative performance

The characteristics of openness to experience, such as curious, open-minded, flexible, drive people to absorb and apply the information or instructions from others to come up with their own ideas. Therefore, generally, it has a positive relationship with creativity (King et al., 1996; Feist, 1998; George & Zhou, 2001; Batey et al., 2010). In this study, the results suggested that openness to experience had a positive relationship with creative performance in the creative phase of ETCT, while had no relationships with students' creative performance in the reflection-improvement phase of ETCT and in the whole PI.

In the creative phase of ETCT, students received an elaborate instruction on the entire process of creating an original webpage from a teacher. During this phase, the traits of openness to experience—curious, open-minded, flexible, and reflective—drove them to absorb and apply the information or instructions to come up with their own ideas. Therefore, high openness to experience in the ETCT group had higher creative performance. However, for low openness, even

elaborative instruction was provided, they were not as sensitive as high openness to the instructions to increase their creative performance. As a result, the creative phase of ETCT was conducive to the demonstration of a positive relationship between openness to experience and students' creative performance.

Similarly, in the PI, students received comments or feedback from peers. Therefore, it was reasonable to expect that openness to experience in the PI group would also positively correlate with creative performance. However, the results showed that openness to experience and students' creative performance didn't demonstrate a linear relationship in the PI group. Meanwhile, the results of two-way ANOVA showed that there were no significant differences between creative performances of high and low openness of two groups in the creative phase. That is to say, statistically, students with the similar degree of openness to experience performed similarly under the instruction of ETCT and PI. The reason why a positive relationship appeared in the creative phase of ETCT but didn't appear in the whole process of PI might be the huge differences of students' creative performance in PI. Unlike the concentrated creative performance of students in ETCT, students' creative performance in PI were relatively scattered. This might be caused by the quality of instructions from peers. If the feedback or comments received from their peers were not valuable enough, they couldn't stimulate even high openness's creative thinking, not to mention the low openness's. In the PI of this study, peers were formed randomly. This could not ensure that the majority of students could receive high quality of comments from peers. Moreover, without a detailed instruction, like the elaborative instruction of ETCT, some students had no sufficient knowledge about technical creativity to provide valuable comments for peers. Therefore, there is no guarantee that high openness in the PI received valuable feedback or comments from their peers as the high openness in the ETCT did. In addition, George and Zhou (2001) found that in organizations, positive feedback and performing heuristic tasks were particularly important for fostering creative behavior of individuals who were high on openness to experience. Therefore, the valence of feedback from peers might also have affected the creative performance of individuals with high openness to experience.

In all, for high openness, to stimulate their creative performance, qualified instructions (no matter from teachers or from peers) are needed. Therefore, when a teacher uses peer instruction to develop students' creativity, how to ensure the quality of instruction of peers is a topic. Based

on this study, adding an elaborative instruction in the PI is one solution.

b. Effects on the relationship between conscientiousness and creative performance

Individuals who are high on conscientiousness tend to be controlled, conformist (George & Zhou, 2001), scrupulous, dutiful, work-hardy, and well-organized. These traits imply the purposefulness and adherence to plans, schedule (McCrae & Costa, 1987). Low conscientiousness, who are psychopathic deviant, tends to break the rules and violate the norms to explore new ways to be creative. Therefore, conscientiousness is generally negatively related with creative performance.

The results of this study showed that in the creative phase of ETCT, high conscientiousness had a positive relationship with the creative performance in Intention of colors. This reflected the function of the elaborative instruction in helping high conscientiousness arrange their plans to some degree. For students who are inexperienced in being creative, an imaginable goal and step-by-step instructions on how to be creative in the creative phase show them a clear way to be creative. High conscientiousness would conform to the goal and instructions and work hard to be creative. Therefore, high conscientiousness performed higher creativity in the creative phase. The results of two-way ANOVA that high conscientiousness of ETCT performed better than high conscientiousness of PI in the design intention category in the reflection-improvement phase, reflected that 1) the guiding function of an elaborative instruction lasted to the reflection-improvement phase; 2) without an elaborative instruction, the feature of high conscientiousness—controlled, conformist (George & Zhou, 2001), scrupulous, dutiful, work-hardy, and well-organized—might make them lose the direction of being creative so as to inhibit their creative performance.

In the reflection-improvement phase of ETCT, low conscientiousness found their ways to be creative after a period of exploration (the creative phase). As a result, the linear positive relationship between conscientiousness and creativity in the reflection-improvement phase disappeared. In addition, the results of two-way ANOVA that low conscientiousness of PI performed similarly with high conscientiousness of ETCT in the creative phase, but performed significantly better than high conscientiousness of PI in the reflection-improvement phase could also reflect that low conscientiousness needs time to be creative.

Therefore, for high conscientiousness who are inexperienced in being creative and are controlled, conformist, scrupulous, dutiful, work-hardy, and well-organized, the situation which does not provide enough instructions might inhibit their creative performance, and the situation which provides clear instructions might help them display creative performance. For low conscientiousness, they were barely affected by different instructional environment, but they need a period of time to explore their own ways to be creative.

5.5 Conclusion

In this study, I was concerned with identifying effects of different instructional methods on the relationship between personality and creative performance. In the ETCT and PI instructional methods, two types of personality—openness to experience and conscientiousness—displayed some relationships with the creative performance. These results imply that: 1) when using PI to increase the technical creativity of high openness, the instructional design should focus on increasing the quality and availability of feedback from peers. 2) Generally, low conscientiousness need a period of time to explore their originality no matter in ETCT or PI. 3) A clear way to be creative could help increase the technical creativity of high conscientiousness, especially for students who had few experience in being creative. Therefore, no matter using ETCT or PI to increase students' creativity, it's better to provide high conscientiousness with an elaborative instruction on how to be creative.

These findings imply that when developing creativity, if teacher could provide appropriate materials or interventions for students with different personality, it might be more helpful to increase creativity of different types of students.

However, this research didn't track the deep reasons that affect creative performance of different types of students. It is just a beginning. In the future, more research are needed to serve to creativity development of all students.

Chapter 6 Conclusion

Why are teacher-centered instructional methods needed in creativity education? How to decide a suitable instructional method according to various actual conditions and integrate it into daily instruction? What are possibilities and limitations of ETCT and PI in developing technical creativity? These questions have been elaborately discussed in previous chapters. However, as far as RQ2 is concerned, I think I cannot give a simple 'Yes' or 'No' answer. In this chapter, I will synthesize these discussion and try to answer RQ2 as comprehensive as possible.

6.1 RQ1: The value of teacher-centered instructional methods in creativity development

In chapter 2, I have listed problems and dilemmas that hinder teachers from reforming their curriculums to teach creativity. Facing with these problems, adapting teacher-centered instructional methods to develop creativity seems to be a feasible start for teachers who teach in subjected-dominated schools to reform their teaching. However, correspondingly, many teachers may continue to face with such questions: how to adapt a teacher-centered instructional method to creativity education? What are the points? As a case study, I tried to summarize experience based on our empirical research.

6.1.1 The case of explicit technical creativity teaching

Explicit teaching is derived from strategies for teaching concepts or skills in mathematics and reading (Flick, 1995). In mathematics and language learning, the clear interpretation focuses on explicitly interpreting a theorem or a concept by naming it, modeling its use, describing it, and explaining its function. When it was used to develop higher-order thinking skills, the interpretation focuses on the objective explanation of strategies, or rather, the summary of experience from experts), such as naming the thinking strategy, and explaining rules about when, why and how such a thinking strategy should be used. However, I have said that creativity is a complex concept. Seemingly, it arises spontaneously from an individual's free mind. In fact, the individual creativity is the interaction of personal dispositions, such as cognition, motivation, attitudes, knowledge,

personalities, and other attributes, and an external factor—social environment. These reflect the low explainability and unpredictability of creativity. Therefore, just explaining doctrines of creativity to students is difficult to make them understand how to do creative thinking in actual environment.

In fact, if giving students an observable objective of creativity in authentic environments, the explainability would become higher. In this research, I defined technical creativity in high school SACs as an ability to apply learned knowledge and software-related skills to make personal products that are novel and appropriate, at least for students themselves, to make students understand what the products of technical creativity is and what the goal of the learning is. And, then, I proposed a framework of ETCT to instruct students on the firsthand experience of being creative to help them understand how to reach the goal of being creative. In ETCT, teachers modeled how to realize technical creativity through interpreting the kinds of individual thinking that technical creativity involved and elaborately displaying a whole individual thinking process for developing products through technical creativity to make technical creativity clear to students. The results of our empirical research have proved the effectiveness of ETCT in developing students' technical creativity.

6.1.2 Points to adapt teacher-centered instructional methods to creativity education

The problem that teachers face in adapting teacher-centered instructional methods to creativity education may be how to explicitly transfer the target level of creativity to students. Based on the experience, two points are helpful.

6.1.2.1 A clear and observable definition of creativity

The target level of creativity should be clear and observable not only for a teacher but also for students. An observable definition works like a performance objective, which aims to communicate the purposes of instruction and provide a foundation for the development of instructional activities and assessment of learning (Gagné et al., 2005). Similarly, the purpose of clearly and observably defining creativity is to help teachers identify what the end of the creativity instruction would be and how to reach the end in a specific class and then communicate to students what they should do after the instruction.

6.1.2.2 Individual experience

The feature of teacher-centered instructional methods is knowledge transfer. Knowledge transfer seeks to organize, create, capture or distribute knowledge and to ensure its availability for future users. This process implies teachers' comprehension and creation of knowledge. With regard to creativity, without firsthand experience, it is difficult to comprehend the nature and process of creativity. Consequently, the transferred knowledge would not be effective. In addition, knowledge transfer is complex because much knowledge is difficult to articulate. Due to the low explainability of creativity, teachers are suggested to do the instruction based on individual experience so as to transfer it clearly. Only a teacher experiences the creative process in advance, can he or she master the whole thinking process, hampers that are usually met, scaffoldings that can help to solve hampers, and other essential points of being creative. The spiral creating process would be primary sources for teachers' teaching to demonstrate students how to explore a distinctive solution when they meet other problems.

6.2 RQ2: Comparison of a teacher-centered and a student-centered method in creativity development

When I investigated the effects of ETCT in developing technical creativity, I found that students' performances depended too much on the teachers' instruction. The concrete performance is that students performed badly when teachers did not clearly point out some relationships between two interdependent knowledge. This suggests that the teacher-centered teaching method—ETCT contributed little to actively building the relationship of separate knowledge to construct their originalities. Therefore, I supposed that student-centered instructional methods could solve the problem.

Comprehensively considering various realistic conditions, such as teaching circumstances, the general level of learners, the feature of different student-centered methods, and other factors, I decided to investigate the possibilities and limitations of PI in developing technical creativity, and compare them with those of ETCT.

The results of comparison showed that in general, the effectiveness of the two teaching methods had no significant differences. The ETCT used in the comparing research modified the

shortage in the previous study. That is, it emphasized the relationship between separate knowledge. Therefore, PI was as effective as ETCT in increasing the students' technical creativity.

6.2.1 The influences on creative performances of different-level students

However, two methods' modes of producing effects on the different-level students in different phases were different. By comparing the performances of higher-, medium-, and lower-level students in the two (ETCT & PI) groups, I found that 1) in the creative phase, in which students focused on producing individual designs and creating individual websites from nothing, the explicit explanation of ETCT was more essential for the lower-level students than PI; 2) in the reflection-improvement phase, where the majority of students had done enough preparation in both psychological aspects and individual ideas or works, PI was more effective in improving the existing creative ideas of students who had different level of academic achievements and different level of creative performance than ETCT. In conclusion, PI was effective in improving the different students' existing creative ideas, while ETCT was more effective in facilitating the students who had lower-level academic achievements and lower-level creative performance to generate their own ideas and understand the relationships among disparate facts. As a result, to exploit the advantages of two methods in developing technical creativity, it is advisable to combine them together. That is, at the commencement of the peer instruction, it's better to add an instructional event—ETCT. Providing detailed instructions can make sure that the majority of the lower-level students know how to be creative and generate novel ideas, which might be novel just for themselves.

6.2.2 The influences on creative performances of students with different personalities

By analyzing and comparing creative performances of different-personality students, I found that ETCT and PI had influences in openness to experience and conscientiousness two personality factors. Specifically, the features of high openness to experience drove them to absorb information from teachers or peers. Based on the creative performance of high openness in ETCT and PI, I could infer that the elaborative instruction of ETCT provided more qualified instruction than PI because the quality of the instructions from peers was difficult to be guaranteed. In addition, if giving low conscientiousness enough time to explore their own ways, they seemed to perform well in both ETCT and PI. However, for high conscientiousness who tend to carry out a given task in efficient

and organized way rather than complete it by coming up with new ideas (George & Zhou, 2001), unstable instructions from peer instruction couldn't provide them with an organized plan or a direct decision. Therefore, when applying PI to develop their creativity, teachers could consider provide high conscientiousness with a clear way to conform. Based on findings of this research, the combination of ETCT and PI might be a good choice.

In conclusion, ETCT and PI have their own merits. ETCT provides clear instructions for students to help them (including lower-level students) generate their own ideas in a short period of time, while PI is conducive to improve creativity of all students when they have already had original ideas. With regard to different personality, both ETCT and PI could encourage the creative performance of high openness. What should be noticed is that to guarantee the creative performance of high openness in PI, teachers should consider how to match students to make sure that high openness could receive valuable feedback and comments. As for high conscientiousness who are inexperienced in being creative, PI without an elaborative instruction might inhibit their creative performance.

6.3 Summary

This research provided interesting answers for two research questions of technical creativity development. Generally, teacher-centered instructional methods are not regarded as effective methods to develop the higher-order thinking skill—creativity. However, the research revealed that explicitly teaching the individual whole thinking process of creating an original products by applying learned knowledge to students—ETCT—was effective in developing technical creativity in daily instruction. In addition, the research also verified that various instructional methods had their pros and cons in developing technical creativity. The comparison of the teaching effectiveness of ETCT and PI revealed that generally, ETCT and PI had similar effectiveness in developing student technical creativity. However, they had different effects on different types of students. The teacher-centered instructional method—ETCT—was more conducive to instruct lower-level students to generate new ideas from nothing and encourage the manifestation of creative performance of high openness to experience and high conscientiousness than the student-centered instruction method—PI. In addition, although the self-reflection after ETCT also could improve student

creative performance, the peer discussion in which students could realize the genuine peer instruction was more effective in helping students improve their creative performance than it.

6.4 Suggestions

Therefore, in practice, to exert their effects, it's better to combine them together. That is, at the beginning of instruction, teachers do an elaborative instruction to explicitly teach how to be creative, and then use peer instruction to improve student original creative performance. I name the combination of ETCT and PI as a hybrid-type PI.

The general procedures of a hybrid-type PI include:

1. The learning of fundamental knowledge

The fundamental knowledge include all requisite descriptive knowledge and procedural knowledge.

2. An elaborative instruction of technical creativity

In the elaborative instruction, a teacher need to instruct a whole personal thinking process of producing products of technical creativity as elaborately as possible. What should be noticed is that the instruction should focus on interpreting the origin of personal concept and the turning points which are essential to refine a new idea. In other words, a teacher needs to demonstrate his or her personal thinking process to lead students to creatively think their own ideas based on their prior knowledge or experience.

3. The explanation of a creative task

The task should be related to students' thinking in the elaborative instruction.

4. Students' individual thinking

To ensure the learning gains, it is better to engage students in peer discussion when 35% to 70% of them have their own ideas (Crouch & Mazur, 2001; Smith et al., 2009; Gok, 2014, 2015; Vickrey et al., 2015). Therefore, after assigning a task, a teacher needs to give students a period of time to individually think about the task. The length of time is different according to the difficulty of a task and features of students. However, for general middle school and high school students who have no enough the power of self-control, giving students too much time may disrupt the learning achievements and waste time.

5. Peer discussion

After the individual thinking, students need to share individual ideas with peers and mutually provide feedback. What should be noticed is that the focus of a discussion should be different with the change of the purpose. In addition, matching different types of students, e.g., learning ability or personality, will also affect the effectiveness of peer discussion.

6. Students' reflections and revision and the continuance of the task

After the peer discussion, students need to reflect and refine the individual thinking and continue the task.

7. Repetition of peer discussion and reflection

A process of creativity is arduous. Therefore, students need to repeat peer discussion and reflection until the task is complete

8. Teacher's explanation and evaluation

Finally, a teacher needs to make some supplements and assess students' products to help students make improvements. The methods of evaluation should be effective and comprehensive.

6.5 Limitations of the research

6.5.1 The instructional design

First, because the study was conducted in authentic classes, where the syllabus and schedule were fixed in advance, the experiment lasted for five weeks (45 min or 40 min per week), and the instructional activities involved technical creativity were carried out for only three weeks. This implies that students' products reflected the short-term achievements of two instructional methods. This study did not provide long-term achievements of two methods to prove the effects of two methods.

Second, when designing the instruction of ETCT and PI, I didn't repeat ETCT at the beginning of fourth and fifth lesson. This caused that I couldn't compare the effects of ETCT and PI, precisely and fairly. In addition, to examine the development of creativity, it's better to measure the improvements of creativity itself. In this study, because of many realistic limitations, I failed in evaluating students' original technical creativity. This resulted in that I couldn't exactly compare

the effects of ETCT and PI in developing technical creativity. This is another profound limitation of this research.

Third, this research focused on integrating technical creativity development into daily instruction. Therefore, to maximize the ecological validity of authentic classrooms, during the instructional design, I did not purposefully match students with different personality or learning ability in peer discussion. Consequently, in this research, I could not precisely examine the qualities of peer discussion among students with different characteristic.

6.5.2 The evaluation method

The definition of creativity provides a basis for identifying suitable instruments and specifying indicators to assess creativity. The learning objective of this research was that students could design and create individual products by applying learned knowledge and skills. This objective emphasized the results of students' creative application of learned knowledge. Therefore, I decided to rate students' creative performance—products to evaluate students' technical creativity. Although the indicators of students' technical creativity were designed based on learned knowledge, which could reflect students' achievements of technical creativity to a great extent, what I have to acknowledge is the narrow views of the simplex measure on students' technical creativity. This research failed in using multiple approaches to measure students' achievements of technical creativity comprehensively.

Additionally, another limitation of this research is the reliability and validity of the rubric. In this study, I focused on rating student products by utilizing a rubric design by ourselves to measure their achievements in technical creativity. When I designed the rubric, I crosschecked the observable teaching objectives, views of a local ICT teacher with 5 years of teaching experience, and expert advice on web design from a university professor. After the design, I also pretested its validity through several products with different qualities and made revisions according to the test results. Despite this, I still acknowledge that the reliability and validity of the rubric might be a limitation of this research.

6.6 Future work

Having introduced the limitations of the research, this section offers some possible directions for future research.

6.6.1 The effects of hybrid-type PI

The effects of ETCT and PI have been discussed in the previous sections. Based on the findings about two instructional methods, I suggest that in the daily instruction, teachers should combine them as a hybrid-type PI to remedy the shortcomings of two methods. However, the effects of the hybrid-type PI have not been measured in authentic classrooms. Therefore, in the future, it is necessary to compare its teaching effectiveness with those of ETCT and PI under similar conditions.

6.6.2 Data-gathering

As mentioned, the research just involved the technical creativity development in Chinese high school ICT classes. However, to explore pedagogical content knowledge of integrating creativity development into daily instruction, more practical research on developing technical creativity in various subjects and grades are needed, including research on exploring the functions of modern information technologies in developing creativity. I have discussed that the definition of technical creativity in different subjects or classes is different. Therefore, defining technical creativity in other subjects and verifying the effects of ETCT and PI in developing it will be a meaningful way to improve the applicability of creativity development. In addition to replicate the development of technical creativity in other subjects, future work can focus on developing other levels of creativity, e.g., inventive creativity and innovative creativity, in individual classes.

6.6.3 Quality of peer discussion among students with different characteristics

According to a perspective of Vygotskian (1978), learning is constructed during the social interaction. Constructing different levels of knowledge needs different types of interaction (King, 2002). In a general method of peer tutor, tutors may work as motivators, informers, and knowledge constructors to support tutees (Set et al. 2008). The communication places emphasis on the instruction flowed from a tutor (higher-level) to a tutee (lower-level). However, peer discussion focuses on reciprocal communication among peers. For all this, matching students with different learning abilities or personality must affect the roles of peers and effects of peer discussion. In this way, several related research questions can be proposed:

- 1) Do ETCT, PI and Hybrid-type PI have different effects on the creative performance of students who have different thinking styles or personalities in certain subjects?
- 2) When a teacher uses PI or Hybrid-type PI to develop (technical) creativity, what are the effects of peer discussions if peers are matched by different characteristics, e.g., thinking styles, personalities, or learning abilities, on students' creative performance?
- 3) What are the roles of peers during peer discussion in different phases of generating new ideas or products?
- 4) How to structure peer interaction to help students with different characteristics generate new ideas?

Finally, new research questions should be assessed by multiple effective and comprehensive evaluation methods.

Acknowledgements

This thesis could not be completed without the help of many people. Foremost, I would like to acknowledge my supervisor, Professor Masao Murota, for his supervision, encouragement, and guidance. Professor Murota always patiently leads me to discover questions, seek answers, and finally, identify the research interests and direction. Besides the patient guidance in the research, he also gives me unconditional supports in life. Thanks to the five and half years in Murota laboratory, which makes my experience rewarding. I will follow him to be a comprehensive teacher and a great scholar.

Secondly, I would like to thank all my examiners: Professor Meyekawa, Professor Nakayama, Professor Hayashi, Assoc. Professor Yamagishi, and earnest Assoc. Professor Matsuda for their valuable suggestions on my research and their patient guidance.

I am also grateful to Xin Du for her continuous support for my research, without which the practical implementation of the research would not have been possible. My gratitude also goes to Kae Nakaya, Hisashi Hatakeyama, Dai Sakuma, Shaoyu Ye, Hodošček Bor, and all members of Murota Lab. Thank you for all your kindness, supports, suggestions, and encouragements. I am so proud to be in such a warm team.

Behind the scenes, my best friend Jin Li has provided invaluable support. I can't thank her enough for the daily support she provides. Whenever I need her, she is always there to listen to my complaint and to give me confidence to keep going. I would also like to thank Ye Fan, Huizhu Gao, and Tao Yu, who are always be with me in the past five years.

Most importantly, I appreciate the lifelong efforts of my family, including my father, mother, sister Hua, and sister Qiao. No matter what decision I make, they always trust me and try their best to support me. This provided me with a strong foundation to grow in my life and achieve my professional goal. I am so blessed to have them as integral parts of my life.

Shijuan Wang

February 4th, 2017

Tokyo

Appendix

Table A-1. Rubric used to assess the products of ETCT and a general teaching in Chapter 3

| Categories | Exemplary | Proficient | Basic | Novice | Zero |
|--|---|--|---|--|---|
| layout (analyzing object: index page/ top page/ page) | <p>Learning objective: students distribute and organize the website elements- content images(not background images), navigation, header(image, title)and footer to make an unique layout;</p> <p>Standards:</p> <p>Webpage elements: navigation, header(title, images), content images and footer;</p> <p>Arrangement of elements: the settings of elements should be associative; header & title should not be too small;</p> <p>Originality of the layout : the layout implies students’ creativity;</p> <p>The layout here is defined as the composition of different web page elements (images, header, navigation and footer). The background and colors are not included in the layout. Please assess the layout of each website referring to teachers’ examples.</p> | | | | |
| Web elements | There are three elements- header(title) and navigation and footer at least in the top page; | There are two elements- header(title) and navigation at least in the top page; | There are two elements- navigation and one of other three elements at least arranged in the top page; | The element included in the top page is only the navigation; | There is no the most important element- navigation in the top page; |
| Layout-Originality | The layout is unique and attractive (the arrangement is smart, skillful, oron artful) compared with teachers’; | The arrangement of elements is modified based on teacher’s layout; | The layout is limited 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 category aims to evaluate the original layout.) | 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; | The layout and navigation was copied from teacher’s examples. |
| Web Contents (for general group) | <p>Learning objective: students need to prepare a website theme and contents independently to make a website;</p> <p>Standards:</p> <p>Students determine the theme and contents of a website;</p> <p>Students search source materials(text, images) based on the theme and contents;</p> | | | | |
| | All materials of this website, including | The student prepared own | The student used sources | The student used source materials | The student didn’t make a |

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| | the title, texts, images etc., were all prepared by the student totally; | source materials partly, such as anchor images, and additional text , and used them in the website; | materials prepared by the teacher flexibly; Basis for judgment: The layout, contents and images of the website is not the same; | prepared by the teacher mechanically; Basis for judgment: the student copied the teacher's example totally, including images, and the sequence of navigation; | top page successfully by using teachers' source materials; |
| Navigation | <p>Learning objective: students create anchors based on contents of the website, and build hyperlinks among anchors and contents subpages; Notice: hyperlink is one important factor of navigation. And because of this, we want to assess hyperlink separately. Therefore, in this item, we won't involve it. Standards: There are enough contents listed in the top page- content list of anchor texts; Anchor texts describe contents of the website correctly-accuracy of anchor texts; The anchor texts are created by students- originality of anchor texts;</p> | | | | |
| | 1.The student created the anchor texts independently; or the student added more anchor texts to the navigation although hyperlinks have not been added to them; 2.Anchor texts describe contents of the website correctly and completely; 3. The hyperlinks have been added to anchor texts. | 1. The anchor texts are revised by students based on the website's contents, that they are different with teachers'; 2.Anchor texts describe contents of the website correctly and completely; 3. The hyperlinks have been added to anchor texts. | 1. The anchor texts of the navigation are the same with the teachers';(Wang group: 网页布局、网页样式、超链接 ;Du group: 绍兴东湖, 嘉兴南湖, 杭州西湖; 北京故宫简介, 太和殿, 乾清宫, 金水桥, 文物宝库) 2. The hyperlinks have been added to anchor texts. | 1.There are enough anchor texts to interpret the contents of the website; 2.The hyperlinks have not been added to anchor texts yet; | The navigation has not been completed, so that visitors can't know the contents of the website from it; |
| Hyperlink | <p>Learning objective: students use hyperlinks to link web pages; Standards: There are no lost links (all web pages existed in the website file are linked with</p> | | | | |

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|---|--|---|--|---|--|---|
| | <p>corresponding anchor texts); All existed anchors are linked correctly; There are enough hyperlinks to ensure that visitors could access any contents of the website easily; Various types of hyperlinks(images, text, email, and http) are used;</p> | | | | | |
| | <table border="1"> <tr> <td data-bbox="368 398 587 857"> <p>1. There are enough hyperlinks to ensure that visitors could access any contents of the website easily; 2. Various types of hyperlinks(images, text, email, and http) are used;</p> </td> <td data-bbox="587 398 767 857"> <p>1. There are no lost hyperlinks; 2. All hyperlinks link correctly; 3. There is an anchor(s) in the subpages and the anchor(s) link with the top page, or other subpages;</p> </td> <td data-bbox="767 398 963 857"> <p>A. If there are more than three hyperlinks in the website, over 70% link correctly; B. If the number is less than 3, the hyperlinks must be linked correctly;</p> </td> <td data-bbox="963 398 1160 857"> <p>A. There are lost hyperlinks; B. Most existed hyperlinks are incorrect;</p> </td> <td data-bbox="1160 398 1355 857"> <p>There is no hyperlink in the website;</p> </td> </tr> </table> | <p>1. There are enough hyperlinks to ensure that visitors could access any contents of the website easily; 2. Various types of hyperlinks(images, text, email, and http) are used;</p> | <p>1. There are no lost hyperlinks; 2. All hyperlinks link correctly; 3. There is an anchor(s) in the subpages and the anchor(s) link with the top page, or other subpages;</p> | <p>A. If there are more than three hyperlinks in the website, over 70% link correctly; B. If the number is less than 3, the hyperlinks must be linked correctly;</p> | <p>A. There are lost hyperlinks; B. Most existed hyperlinks are incorrect;</p> | <p>There is no hyperlink in the website;</p> |
| <p>1. There are enough hyperlinks to ensure that visitors could access any contents of the website easily; 2. Various types of hyperlinks(images, text, email, and http) are used;</p> | <p>1. There are no lost hyperlinks; 2. All hyperlinks link correctly; 3. There is an anchor(s) in the subpages and the anchor(s) link with the top page, or other subpages;</p> | <p>A. If there are more than three hyperlinks in the website, over 70% link correctly; B. If the number is less than 3, the hyperlinks must be linked correctly;</p> | <p>A. There are lost hyperlinks; B. Most existed hyperlinks are incorrect;</p> | <p>There is no hyperlink in the website;</p> | | |
| <p>Use of Color (assess the index page mainly, subpages are subsidiary)</p> | <p>Learning objective: students use rules and techniques of colors to create unique colors for his/her website; Standards: The application of rules & techniques: 1) the background is clean and tidy; 2) the text color is vivid; 3) students construct the website style by using similar colors and contrasting colors; 4) main color systems used in the top page should be less than four categories, only if the colors have special meanings; Novelty of color matching: different colors are corresponding; the color matching is unique and attractive;</p> <table border="1"> <tr> <td data-bbox="368 1234 587 2018"> <p>1. The added colors match with each other; they are vivid and attractive; 2. The student make the colors unique and attractive by using similar colors and contrasting colors;</p> </td> <td data-bbox="587 1234 767 2018"> <p>1. The background is clean and tidy; 2. The text color is bright; 3. The colors matching of the website meets principles of color matching;</p> </td> <td data-bbox="767 1234 963 2018"> <p>A. The student used various colors in the top page, and 1) Main color systems used in the top page are less than four categories generally; 2) It is difficult to discern the text color and background image color; B. The student did nothing but added border-color and</p> </td> <td data-bbox="963 1234 1160 2018"> <p>A. The student used various colors in the top page, but 1) colors are added optionally, so the web page looks messy; 2) main color systems added in the top page are more than four; B. Only border-color is added in the top page;</p> </td> <td data-bbox="1160 1234 1355 2018"> <p>The student did not add the content (excluding images) and other settings to the web page;</p> </td> </tr> </table> | <p>1. The added colors match with each other; they are vivid and attractive; 2. The student make the colors unique and attractive by using similar colors and contrasting colors;</p> | <p>1. The background is clean and tidy; 2. The text color is bright; 3. The colors matching of the website meets principles of color matching;</p> | <p>A. The student used various colors in the top page, and 1) Main color systems used in the top page are less than four categories generally; 2) It is difficult to discern the text color and background image color; B. The student did nothing but added border-color and</p> | <p>A. The student used various colors in the top page, but 1) colors are added optionally, so the web page looks messy; 2) main color systems added in the top page are more than four; B. Only border-color is added in the top page;</p> | <p>The student did not add the content (excluding images) and other settings to the web page;</p> |
| <p>1. The added colors match with each other; they are vivid and attractive; 2. The student make the colors unique and attractive by using similar colors and contrasting colors;</p> | <p>1. The background is clean and tidy; 2. The text color is bright; 3. The colors matching of the website meets principles of color matching;</p> | <p>A. The student used various colors in the top page, and 1) Main color systems used in the top page are less than four categories generally; 2) It is difficult to discern the text color and background image color; B. The student did nothing but added border-color and</p> | <p>A. The student used various colors in the top page, but 1) colors are added optionally, so the web page looks messy; 2) main color systems added in the top page are more than four; B. Only border-color is added in the top page;</p> | <p>The student did not add the content (excluding images) and other settings to the web page;</p> | | |

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| | | | changed text-color; | | |
| The directory structure of website | <p>Learning objective: students use a general directory structure to make a website;</p> <p>Standards:</p> <p>There must be an index page and subpages in the site file;</p> <p>File names of subpages should be consistent with anchor texts;</p> | | | | |
| | There are an index and all subpages in the website file, and names of subpages are consistent with the anchor texts. | There are an index and all subpages in the website file, but names of subpages are not consistent with the anchor texts. | 1. There are an index and subpage(s) in the website file; 2. The number of subpages is less than the anchor number of anchor text in the index; 3. Existed subpages' names are consistent with the anchor texts. | 1. There are an index and subpages in the website file; 2. File names of subpages are not consistent with the anchor texts. | All web pages of the website are not in the same directory file. |

Table A-2. Rubric used to assess the products of ETCT and PI in Chapter 4

| Category | Exemplary | Proficient | Basic | Novice | Zero |
|--|---|--|--|--|--|
| layout (analyzing object: index page/ top page) | <p>Objective: students arrange the website elements- content images(not background images), navigation, header(image, title)and footer to create an unique layout;</p> <p>Explanation:</p> <p>1) Basic elements of a webpage include: navigation, header (title, images), content (text & images) and footer; however, an index page without content (text & images) is allowed because its special function.</p> <p>2) Originality of a layout means that a layout comes from students' originality, but a teacher's examples;</p> <p>The layout is defined as the composition of different web page elements (images, header, navigation and footer). The background and colors are not included in the layout. Please assess the layout of each website referring to teachers' examples.</p> | | | | |
| Web elements | The top page contains at least three elements header (title), navigation and footer. | The top page contains at least two elements- header (title) and navigation, but no a footer. | The top page contains the most important element — navigation, but has no a title. | The top page may contain a title and other elements, but doesn't contain a navigation. | There is no essential elements — navigation and title, in the top page. |
| Layout-Originality | The student use some individual strategies/ideas, for instance, arranging elements according to features of images, to make a unique or interesting (different from teachers') layout; | The layout is not the same with the teacher's, but it comes from the modification of the teacher's layout; | The layout is almost same with teacher's layout; | There is no layout because each element is just listed in sequence. | There is no layout because there is no essential elements of a web page: navigation and title; |

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| Design intention | Design intention is a feeling or style visitors could get from the whole design. When we assess the individual intention of a website, the criterion is whether its layout and colors could express a distinctive feeling/ intention. | | | | |
| | Start assessing the category from the following question: Could you get/ interpret an intention (style/ feeling/ implication) from the whole design (layout & colors)? | | | | |
| | If Yes , please use several key words to describe the style(s)/ feeling(s)/ implication(s) that all you get and write them down. Key words: Please rate the degree of your certainty according to your experience. | | If No , please rate the design based on the description of following three levels. | | |
| | The webpage's layout, images, and text color are designed in distinctive ways and they work in concert with each other to clearly express the distinctive intention of the designer. | The layout may be unique, or colors may be distinctive. However, they do not work in concert with each other, so it is not easy to get the distinctive intention. | The design of the webpage are completed. However, visitors hardly get the distinctive intention of the designer from its featureless/general layout and colors. | The design of the webpage completed partly. However, the completed part is not complete enough to get the design intention of the webpage. | The design just gets started, so it is impossible to get the design intention. |
| Colors | Rules: There is a main color in a webpage (the main color doesn't refer to the property of color. It refers to a general assessment for the whole color matching); Different colors (hue, saturation, and brightness) can express different feelings; Color matching should apply similar colors and contrast colors to pursuit the balance between unity and contrast on the basis of the main color; General requirements of color matching: 1) the background is clean and tidy; 2) the text is clear; 3) the colors can express some intention/ feeling; | | | | |

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| <p>Use of Color (assess the index page mainly, subpages are subsidiary)</p> | <p>The colors used in the webpage reach the balance between the unity and contrast, so they are clean, concordant, and attractive;</p> | <p>A main color can be identified from colors of the webpage, and they are generally matched according to similar colors (system) or contrast colors principles. However some color is used pointlessly other than distract visitors' attentions.</p> | <p>A main color can be identified from colors of the webpage, however, 1) the background is messy, and texts are inconspicuous; Or 2) The main color is identified by one solid color, from which it is difficult to get some feeling or intention, even though the background is tidy and texts are conspicuous.</p> | <p>Diverse colors (images, background colors, & text colors) are added in the webpage, however, 1) used colors are unsystematic, so it's difficult to identify a main color and they look messy and pointless; Or 2) Used colors break rules, so the color-matching is inharmonious though they look tidy.</p> | <p>Almost no colors (including images, different background colors and text color) are used in the webpage.</p> |
| <p>Intention's expression of colors</p> | <p>The colors of the webpage (images, background and text) have a distinct individual characteristic, so visitors can clearly get the designer's distinctive intention; or produce some feeling. <i>*Write down the feelings you get from</i></p> | <p>If removing some disharmonic colors, left colors can communicate some feeling to visitors (the feeling might be visitors' individual feelings). <i>*Write down the feelings you get from colors in the following cell.</i></p> | <p>The colors of the webpage (images, background and text) are normal. However, they lack an individual characteristic, from which visitors hardly get the designer's distinctive intention.</p> | <p>Visitors hardly get the designer's intention from the messy and pointless colors.</p> | <p>Visitors cannot get the designer's intention because there are almost no colors.</p> |

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| | <i>colors in the following cell.</i> | | | | |
| The intentions/ feelings (got from colors) | | | | | |
| The directory structure of website | <p>Learning objective: students use a general directory structure to make a website; Assessing standards: There must be an index page and subpages in the website file; The names of subpages should be consistent with anchor texts;</p> | | | | |
| | There are an index and all subpages in the website file, and names of subpages are consistent with the anchor texts; | There are an index and subpage(s) in the website file. Existing subpages are renamed but their names are not consistent with the anchor texts; | There are an index and some subpage(s) in the website file; however, all subpages are not renamed(that is, they were named by "new_page 1, 2 etc."); | There are an index and some subpages in the website file; however, index is not used as an index webpage. | Webpages of the website are not in the same directory; |
| Hyperlink | <p>Objectives: There are no lost links (all existing web pages are linked with corresponding anchor texts); There are enough hyperlinks to ensure that visitors could access corresponding sub webpages flexibly and correctly; Various types of hyperlinks(images, text, email, and http) are used;</p> | | | | |
| | There are enough hyperlinks (different types) to ensure that visitors could access any contents of the website flexibly and correctly. | There are enough hyperlinks to ensure that visitors could access any contents of the website flexibly and correctly | There are no lost hyperlinks, and all hyperlinks are linked correctly. | There are lost hyperlinks , and most hyperlinks are incorrect; | There is no hyperlink in the website; |

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