

A Study on Engineering Students' Creativity through Art-Infused Curriculum

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ABSTRACT

At present, to enhance students' innovative ability is an important research topic to engineering education. Although engineering students can learn hard engineering techniques step by step through instilled teaching methods, process-based learning methods as well as formulated learning, but there is no conducive to idea generation and creativity promotion. While art has the characteristics of raising questions and breaking the existing thinking, this paper hopes to cultivate students' ability of divergent thinking and enhance their creativity through the implantation of art. In this study, we introduced CAPE teaching strategy, adopted a curriculum of a Taiwan university of science and technology, used case study as main study method to explore art-infused engineering teaching methods and teaching contents. There are four stages of CAPE: inquiry, cooperation, record and reflection. The results show that: (1) The art teachers' teaching contents are corresponding to the divergent thinking categories (Khandwalla, 1993). (2) Classroom contents enables engineering teachers to focus their teaching from purely technical teaching to the technical application level. When the art teacher and the student discuss their creative techniques and presentation form, it will induce students to challenge old methods and generate different solutions.

Keywords: art-infused curriculum, engineering teaching, creative thinking

INTRODUCTION

Human resource quality, which depend on the planning and implementation of higher education, is a key factor for industrial upgrading and improving competitiveness. Therefore, it is an important subject for higher engineering education to develop the creativity and design ability of engineering talents through innovative teaching, and integrate the elements of humanities and arts to designed products (Li et al., 2016). It is encouraging that the government has actively promoted the talent cultivation model of Conceive Design Implement Operate (CDIO) engineering education. The integration of the Science, Technology, Engineering, Art, and Mathematics (STEAM) teaching course, as proposed by the government, includes the existing STEM cross-domain integration concept, and adds "A" - art as an important part. It emphasizes that art could enhance the interconnection and learning between various disciplines, promotes the integration of multiple courses, and stimulates students to integrate their knowledge with new application values or characteristics (Tsai, 2016). In addition, according to past literature, the forward-looking and groundbreaking Chicago Art Partnerships in Education (CAPE) (2004) have integrated art into educational programs and promoted art as an important guide for education. Art could indirectly train students' creativity, self-expression ability, and critical thinking ability, and promote team participation (Wu, 2015). To inspiring students have more creative possibilities and diversity.

Our past observation results for teaching class versus teachers' teaching experience interview in engineering university suggesting that teachers and students were limited by both teaching and thinking inertia. Which indicate engineering teachers are interested in guiding students to produce creative works and teachers prefer to use school elder brother sisters' homework as a case reference in the beginning of the class to help students processing idea generation. Because "right" and "wrong" are the basis of engineering technology, teachers can easily regard the

Contribution of this paper to the literature

- In the creative process of engineering courses, five divergent thinking categories of art-infused curriculum can be clearly divided; art can be integrated into engineering teaching in a more concrete way. Training engineering students have the ability to apply “high-efficiency” engineering techniques and to create “original” works.
- The study found that when art teachers and students discuss their creative techniques and forms of presentation, they would induce students to raise questions and different solutions. However, when students implement their design concepts, they face the technical difficulties and strengthen their learning motivation.
- Through the experimental design of art teaching in this research, it is found the engineering creation is based on the artistic inspiration of innovative concept, and the application of engineering technology as the key point to promote engineering teachers to reflect on their teaching methods and students’ self-examination.

function and efficiency of engineering technology as an important evaluation standard of teaching achievement (Li & Cheng, 2016). These situations cause most students work were similar to the senior students or a partial enhancement of the senior students work. At the meantime, students work mainly focus on engineering technologies and lack of creativity.

To make a comprehensive survey on research topics of industry requirement and teaching needs, and innovative teaching benefits brought by art, as well as current situation of Engineering education; It is worth exploring how to really implement the practical engineering class and make it 100% effectively. Therefore, this study explores the feasibility of teaching innovation through the practice of integrating art into university engineering courses. Following are the purposes of this study.

- A. Explore how art teaching techniques can be used to promote students’ creativity through the expansion of thinking and breaking the idea of engineering education.
- B. Analysis of how art teaching changes the teaching content of engineering teachers and students’ learning attitude.

LITERATURE REVIEW

New Trend in Engineering Education

The purpose of the contemporary Industry 4.0 is to integrate all industry-related technologies, sales, and product experiences to build an intelligent plant with complete adaptability, resource efficiency, and human engineering (Executive Yuan, Republic of China, (ROC,EY), 2015), and its professional technical members shall have innovative applications and high-level integration abilities. The world is challenged by this great transformation in the cultivation of engineering talents, thus, the concept of interdisciplinary knowledge application, heuristic teaching, teamwork, and other teaching strategies are put forward to improve students’ independent thinking ability. The problem-solving ability, as promoted by past engineering education, shall be upgraded and transformed to the abilities of identifying problems and creatively solving problems. “STEM”, which focuses on the teaching strategies of integrating science, technology, engineering, and mathematics seems insufficient for today’s education. Recently, the American education community called for the transformation of “STEM” to “STEAM”, where arts education is integrated into the national education strategy. It is expected that art will play an important part in this strategy, and creative thinking will be applied to STEM projects to inspire students’ imagination and creativity through art (Tsai, 2016; Lo, 2016). The common people can challenge art in the natural attitude of “do not understand”, and the various questions and explorations create opportunities to connect different factors, thus, art plays a key role in provoking doubt and curiosity (Maeda, 2013).

“STEAM” is based on the artistic development of cognitive development. It proposes eight capabilities (Eisner, 2002a). Among them, four abilities emphasize the ability of art to break existing thinking, which has many viewpoints and many answers. Ability to change the target process; Permission to make decisions without rules and the ability to see the world from an aesthetic perspective. (The perspective that problems can have multiple solutions, and questions can have multiple answers; The ability to shift goals in process; The permission to make decisions in the absence of a rule; The ability to see the world from an aesthetic perspective.)

It can be found through engineering education teaching strategy shifting influenced by industrial talent demand, for the education community, the ability to raise questions and break existing thinking is highly anticipated. Through the implantation of art, students have been trained to observe the root causes of the problems and propose innovative solutions.

The Present Situation, Attributes and Characteristics of Engineering Teaching

According to past research, the current situation of engineering teaching is that the concept of traditional education is deeply rooted. The existing examination system is hard to break through, as it is mostly based on theoretical teaching, but lacks practical education, which results in one-way and monotonous teaching methods. In addition, engineering teachers are not professional teachers of creative courses, and are accustomed to the traditional teaching methods, which emphasize theories and teaching for exams. In terms of student guidance, teachers lack innovative, long-term planning and arrangements, and even if they are determined to improve the situation, implementation is difficult due to the lack of relevant resources. This situation causes the phenomenon of students being accustomed to traditional teaching, which excludes teaching methods for innovative courses, and results in students' lack of self-learning and creativity abilities (Zheng, 2001; Li & Hu, 2008; Zhou & Chen, 2009; Yang & Zhong, 2010). In recent years, the pedagogical community has gradually using reversed education and cross-field teaching to replace the cramming education. The open project is a common teaching method of engineering teaching, it let students propose solutions, to discuss with teachers, and put forward creative works (Shanna et al., 2014). In addition to offering a variety of teaching methods and technical guidance, engineering teachers should also consider the teaching assistance during students' operation, as well as propose creative and innovative/creative achievements.

However, we need to discuss the education attribute and the characteristics of the engineering college before we introduce industry specialist. That is the way to solve the problem one for all. First, the nature of teaching objectives is discussed in terms of educational attributes and characteristics, colleges of engineering have completely different goals, as compared to other colleges. The college of management emphasizes "innovation", and thus, applies innovation in practice, as based on "cost-effectiveness", which brings value to the organization; while colleges of engineering and design emphasize "creativity" and "originality". In terms of the expression characteristics of creativity, there are great differences between colleges of engineering and colleges of design. Colleges of design are more explicit and focus on appearance and form, while colleges of engineering put greater emphasis on performance and function. Therefore, under the prerequisite of "usefulness", colleges of engineering have achieved "high efficiency" through various methods and have adopted "new" or "creative" ways to solve problems (Nien, 2016).

Most of the thinking, logic, and performances of colleges of engineering are introverted and difficult to notice. In terms of teaching characteristics, teachers in the engineering field regard "operational efficiency" as the basis for achievements and emphasize the "elaboration" of logic and creativity. In terms of the learning characteristics of students in colleges of engineering, students focus more on the processes and skills, and even though they have active learning attitudes and are eager to solve problems, they cannot fully show their results due to the limitations of time and skill learning, which would influence teachers' judgments of students' leaning effectiveness. (Li & Chen, 2016).

In general, the attributes, characteristics, overall teaching objectives, and achievements of colleges of engineering are based on the "originality" and "high efficiency" of the level of technology applications. Currently, under the circumstance that teachers are used to one-way teaching and focus more on technology, and that students are accustomed to this learning process, although engineering education changes the examination system and the one-way teaching currently, let students learning and practicing through the open project, these customized studying can only let students learning difficult engineering technologies step by step, but not conducive to the generation of ideas and creativity.

The Relationship between Art-Infused Curriculum and Divergent Thinking

The concept of integrating art into education has been around for years, one of the most pioneering team should belong to the Chicago Arts Partnerships in Education (CAPE). Through sponsorship and media co-operation, art creators (artists) from various fields have been sent to the campus to collaborate and co-teaching with teachers. Art creators help students see new worlds in different ways through artistic activities and experiences. The art-infused curriculum has 14 years experiences; its teaching strategy has four stages: exploration, cooperation, record and reflection. The curriculum uses these four stages to develop the teaching structure and content (CAPE, 2008). CAPE past teaching cases are mostly primary and secondary school students. Through the process of art and art type of teaching, effectively enhance students' art and other academic achievements. Diffusion and convergent thinking plays an important role in the creation performance. For engineering college students, an inherent thinking standard can help them learn skills and use them well, but their thinking is linear, convergent thinking is much easier than divergent thinking for them. As art has the ability to raise questions and break existing thinking, it is the ability to divergent thinking. Past studies have shown that teachers use divergent thinking to practice students' minds and develop their ability to create original ideas. As meanwhile, those studies suggest that divergent thinking contribute to the creativity mechanisms and connections. According to Pradip N's research on creativity,

divergent thinking can be divided into five categories: problem structuring, searching, feeling, ideating and evaluating (Khandwalla, 1993). Therefore, this study argues the art-infused curriculum in the university stage should be the medium of creative inspiration. The relationship between creativity and diffusion thinking should be corresponding to the creative process of conceptual transformation, artist's intention and new thinking. The following are five types of divergent thinking:

Problem Structuring: Problem structuring consisted of six mechanisms or subcategories by which the subjects received a better definition of the problem.

Search: Two search mechanisms were uncovered. One is Scan of memory, the other is Scan Call which was a repetition of the three requirements of the objects, a kind of knocking on the gates of the deeper recesses of the mind.

Feeling: Whenever a subject made expressive statements, he or she was deemed to be using the feeling category.

Ideating: Ideating involved the articulation of solutions. This was the most common problem-solving category.

Evaluating: Three mechanisms of evaluating were identified. Constraint Check, Justification and Score. Constraint Check was an attempt to evaluate a potential solution against one or more of the requirements of the problem. Justification was an attempt to prove to oneself that a solution met a requirement. Score was a sort of notching up a victory by announcing that the example embodied all the three requirements.

Art Form Transformation and Thinking Liberation

From ancient times to the present, art has gone through many changes in terms of type, thinking, function, and exhibition value, and people start to explore the influence of art on creative thinking education, as well as its applications.

In terms of art thinking and function- Divergent thinking, with the development of communication technology, network popularization, and replication technology, art has gradually approached these two concepts of conceptual art. First, art works are not limited to the material form of creation, meaning once the concept of a work is formed, it is owned by the author. The artist reveals the meaning of their works through visual thinking, and show their thinking through their concerns regarding the topic and the transformation of their creation, which guides audiences to consider the relationship between artwork, life, and ego. Second, the most precious thing for art is not the final artwork, but the concept of art, which strongly focuses on the transformation of a concept and the creation processes of purposes and new ideas (Danto, 2008; Danto, 1995; Ho, 2015; Cheng, 2007).

In terms of art form- Creative approach, art changes from realism to expressionism, and is no longer limited to vision, but focuses more on thinking. Therefore, art is not necessarily "beauty"; "creativity" has become the mainstream of art. In the past, pure art had difficulties in painting techniques, and while there is no clear barrier between applications, the culture of modern art and daily life and art has entered into a free state of omnipotence (Yeh, 2005). Therefore, modern art breaks through the bottleneck of artistic conception and creation, and has become popular among common people.

In terms of art exhibition value- Exhibition mode, modern replication technology strengthens the exhibition value of artworks. In addition, the autonomous and non-standard features of the Internet break through the limitations of the time, space, and form of exhibitions. While it breaks through the limitations of traditional exhibitions, there is no reduction in the "unique", "ritual", or the "here and now" features of artworks (Benjamin, 1998).

If there is the complete liberation of art expression form and concept, then what is the focus of creation? For the artist, the concept and meaning becomes the core value of the artwork. Art is deeply involved in the actual process of perception, thought and physical action. "The purpose of Education is to create an artist -- a person who is good at various forms of expression." (Read, 2007) Therefore, the artist should have the ability to present the concept of innovation, and display the concept in concrete and excellent form. For students, the artist is an important object of concept learning and cultivating innovative thinking.

RESEARCH METHOD

The art is helpful to Engineering teaching which is derived from the function on the resource of observation on the concerning events and involved characteristics of the suspicions on thinking of the release. However, it is quite interesting to which types of art are merged into the class to reach a good teaching effectiveness.

This study focused on the art of video recording as an engineering teaching material for art type. It is based on criticizing the entire television of media community. The main spirit is to understand "Art vs. Technology" to make the technology and media for more humanity. Moreover, the art creation presents the concepts of the following: "challenges of existing social values"; "Rhythm of Image and Language"; "Symbol and Symbol" as well as "Conflict

and Debate in Real Life.” of four core aspects (Chen, 2010). It considers of humanistic value with regard to the application of science and Technology in Engineering Teaching. It is even better to raise unique perspectives on the issues of social issues. It also gets rid of students in creative thinking from the status of single linear thinking.

On the one hand, “video art” uses a video camera as its creative medium. It combines the attributes on conceptual art, performance art, installation art or dynamic video attributes such as movies, animations and recordings. It is also an important index of mutual conception for aesthetics in time and space. The art of recording performance types is not limited to a single media and technical level but also to (1) the media force that invests in or contends for television, (2) audio-visual recordings and improvised recordings, (3) physical behaviors in video recordings, (4) the spirit of conceptual video texts, (5) feedback videos and technical experiments, Movie and video image conversion, (7) combined with the visual effects of multimedia, and (8) object projection with video recording device. In addition, it extends to the following cases: multi-screen module changes, outdoor space projection, video combined with body performances, video and theater elements, interactive video recording mechanism and programming control images (Chen, 2010)

There are two major reasons for selecting “video art” as part of this study. The engineering application of this art is widely used and very close to practical. First, it does not require a long-term in learning art background and pure high level art. It just needs familiar with the simple video equipment to start working. Second, this art belongs to the art of new media emphasized the point of view to bring creative inspiration to model the issue that makes the most important manifestation. Therefore, it is very suitable for the introduction of social issues and training the innovative thinking.

Research Subjects

This study selects the elective course of engineering image processing of a university of science and technology in Taiwan as the study subject. In order to fit the theme of the engineering course, “video art” is chosen as the art form during curriculum planning, and a “video art” creator is invited to the engineering class. Students and learning background: there are twenty senior students in this class and their learning objective is to obtain technical and practical experience. Assistants and their background: there are seven teaching assistants in the first year of a Master’s degree that are familiar with the technology of this course. Teachers and their background: the original teacher has more than thirty years’ teaching experience, while the art teacher graduated from a department related to art, and has rich experience in video art show management and lecturing. The students are senior students with knowledge of the basic theories, engineering technologies, and logical thinking, thus, they focused more on thinking breakthroughs and the presentation of creation, as developed by the transformation of this course.

Research Field

The classroom for engineering teaching is equipped with computers for operations, followed by open art classrooms and outdoor campus activities. After-school discussions are conducted by the online teaching community, and focus on creation discussions and teaching communication. As the field for students’ concept development and data collection, the library of the college is used as the site for the exhibition of the final achievements.

Teaching Structure and Contents

This course is focus on the artist’s concept transformation, intention creation and new thinking generation, corresponding to the relationship between five categories of students’ creativity divergent thinking such as problem structuring, searching, feeling, ideating and evaluating (Khandwalla, 1993), to exploring current class experiments. “Teaching” and “learning” are the two major parts, which are explained as follows:

Research process and teaching structure

This study selects CAPE as the teaching strategy, develops the theme of large concept, and designs the teaching activities according to the key concepts and fundamental problems; it also integrates art into the course in a systematic manner in order that the teachers clearly understand the teaching objectives. There are four stages of the CAPE teaching strategy: exploration, cooperation, records and reflection, the development of teaching structure and content, as shown in the right flow chart.

First, [teaching materials] teaching exploration is conducted through discussions, where the engineering teacher puts forward previous, original teacher and the artist (referred to as the art teacher), they put forward the class design, put forward to start thinking based on the social issues where technology is the foundation for the engineering class, and the final results are shown in video or image form. Next, [teaching operation and records] Use the art teacher’s concept transformation, intention creation and new thinking generation process as the teaching

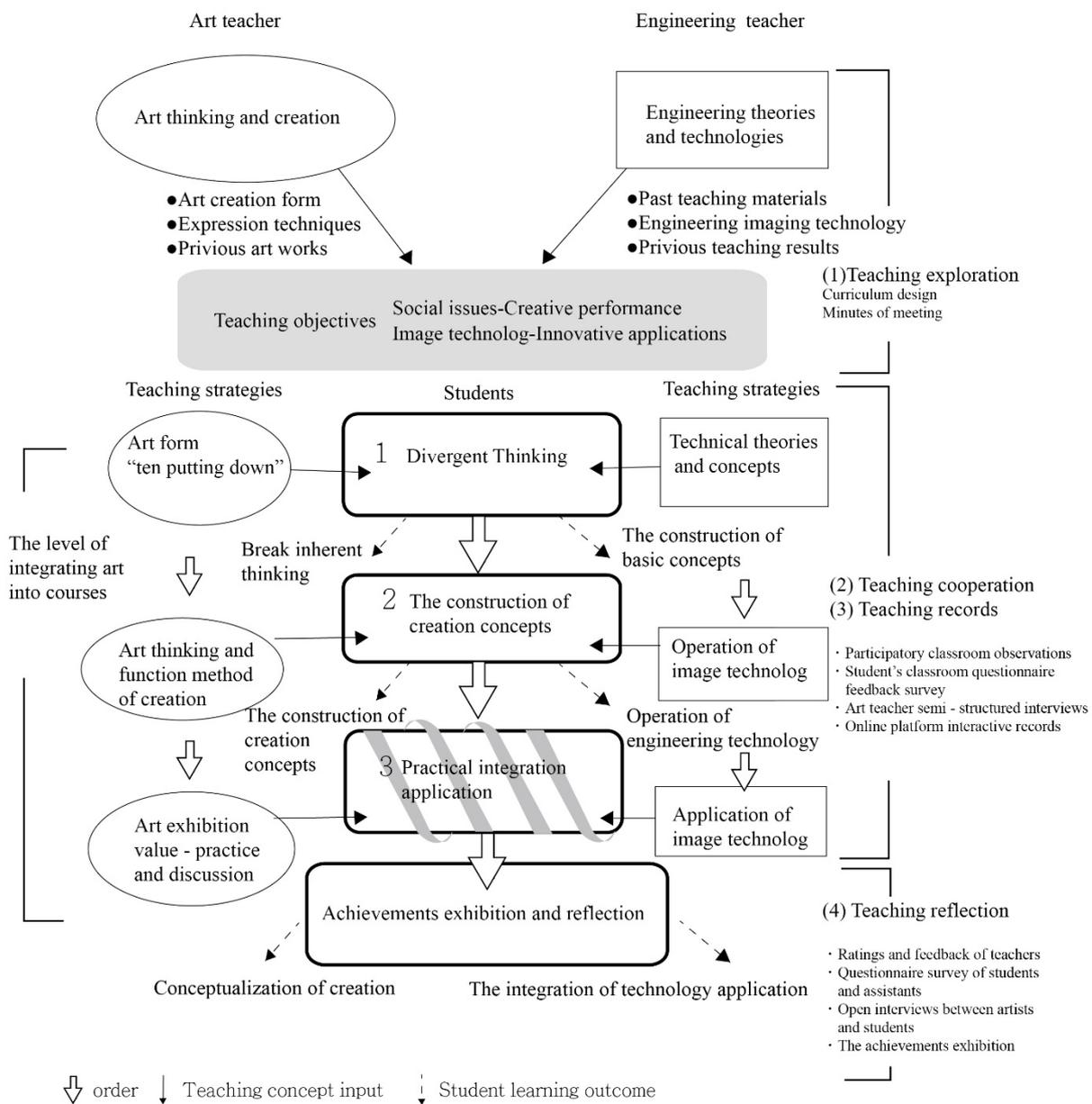


Figure 1. Overall teaching structure flow chart

material for classroom teaching. In order to discuss the benefits of art-infused curriculum to student’s thinking generation, this study take the divergent thinking as the main teaching goal. The original teacher is using video course to provide students technical nutrients. Researchers and assistants conduct course records for the classroom; while [teaching reflection] is the achievements of exhibitions and publications, and provides guidance for reflection. Students that participated in the exhibition introduced their works, and both teachers and students reflected on the “teaching” and “learning” of creation practice and the integration of technological applications. The following is the overall teaching structure flow chart:

Curriculum design

This study adopts “video art” as the art form, and uses the creative thinking of artists to promote engineering teaching; therefore, this study focuses on the teaching design of an art teaching class and creative teaching. According to literature analysis and the results of several discussions with teachers, this study puts forward the teaching goals in each stage, while the art teacher puts forward the corresponding courses, namely, “art form--ten putting down”, “art thinking and function--method for creation”, and “art exhibition value--practice and

Table 1. Teaching structure

Week	Course contents	Course attributes
Week1-Week3	Basic concepts of engineering course	Engineering class
Week4	[Divergent Thinking] Art form- "ten putting down"	Art class
Week5-Week9	Imaging Basic Technology Course	Engineering class
Week10	[The construction of creation concepts] Art thinking and function- the creation method	Art class
Week11-Week12	Imaging Basic Technology Course (II)	Engineering class
Week13	[Practical integration application] Art exhibition value - practice and discussion	Art class
Week13-Week14	Imaging technology class and creation practice	Engineering class
Week15	Final achievements exhibition	
Week16-Week18	Advanced course for imaging technology	

Table 2. Art Teaching Curriculum

Art Curriculum	Curriculum Overview	Class Design	teaching objectives
Art form--ten putting down	art creation, stimulates students' interest in class, through films, cases, and class activities.	(1) Put down shame	Problem Structuring
		(2) Put down advantages	Ideating
		(3) Put down complexity	feeling
		(4) Put down beauty	Evaluating
		(5) Put down fields	Problem Structuring
		(6) Put down correctness	Problem Structuring
		(7) Put down working alone	Evaluating
		(8) Put down words and search for memoires	Search
		(9) Put down thinking	feeling
		(10) Put down owning	feeling
"Dead branches" activity	The images of "dead branches" are interspersed in the teaching briefing. Throughout the entire teaching process, students are required to use the phone or shout out "dead branches" when they see "dead branches" in order to add points.		Trigger the motivation of learning and interaction in class
			Diverging Thinking Problem Structuring
Art thinking and function--method for creation	Art teacher first guides students to find the topics in daily life that concern them, ask questions, and then, encourages students to put forward their topic for creation, including engineering technology and media, and the space and time of the exhibition through "Why", "How", and "What", of the golden rule.	(1) WHY-Issue	
		The answer of living issue	Diverging Thinking problem structuring
		(2) HOW-Techniques and material for image media	
		Sprint	Converging Thinking Limitation to time and space for decision
		Reverse thinking method	Diverging Thinking Evaluating
		Dynamic verb method	Diverging Thinking Search
		Rhetoric 20 method	Diverging Thinking Search
		Irregular tool method	Diverging Thinking Ideating
		Forced associative method :simplified and magnification	Diverging Thinking feeling
		(3)WHAT- Exhibition space and time	
Art exhibition value--practice and discussion	Students are invited to the exhibition space for group experiences and atmosphere, and complete their final result in the strategy table. Each group's ideas are collected and the strategies, techniques, and expressions are discussed online.	Discussion of site survey	Converging Thinking Limitation to time and space for decision
		Through continuous reflections and discussions, the artists and scholars focus on the topic, technology, and exhibition, and provide relevant work cases and posters on the online platforms to stimulate students to think from different aspects.	Converging Thinking Consider for techniques and exhibition for decision

discussion", and constructs the following core concepts and teaching contents. "art form--ten putting down" Art teacher designs classroom activities according to their own creative experience and the abilities required. The definition of "Art Thinking and Function - Method of Creation Art teachers" is based on the art teachers use some questions to guide students to focus on the social issues surrounding their lives. They also proposed the creative techniques and cases of video art to invoke students to ask the techniques and application. It also helps the student to propose how to create themes and establish performance techniques. "Art Performance Value - Implementation and Discussion" is another field of the art teacher to go through online and in-situ meetings to discuss the art works planning with small group of discussion. "Dead branches" activity appears in every art teaching class, the main purpose is to help students focus on class activities and help teachers and students interact with each other. Students must constantly pay attention to the "dead branches" images appearing on the slide and responding with hands or shouts. Teaching structure and the process is, as shown in [Table 1](#) and [Table 2](#).

Table 3. Data Coding Correspondence Table

Source	Identity	Syllabus
Questionnaire of classroom learning (Q)	Student-CS+ number(1-20)	A teaching performance
Questionnaire of course feedback (Q1)	Artist-AR1	B learning performance
Interview (T)	Engineering teacher-CT	C teaching cognition and attitude
Observation notes (N)	Assistance - ST+series No. (1-7)	E other associated behaviors
Record of meeting (MT)	Researcher-RS	
Coding method: Source-Identity- syllabus -Number		

Data Collection and Analysis

In order to establish study validity, this study adopts a variety of data collection strategies and data sources of “triangular verification”, and uses the participatory observation method, in-depth interview method, questionnaire survey, and other methods for data collection, and adopts the qualitative research method for analysis. Data collection includes research processes and teaching structures, which are divided into three phases. Phase One – *Teaching Exploring*: 2 meeting memo of teaching ideas and curriculum design discussing between engineering teacher and artist; Phase Two - *Teaching Cooperation and Recording*: 18 weeks participatory observation of classroom teaching, 3 weeks of course video watching, 3 times of student questionnaire (with feedback) and 1 time semi-structured interview of art teacher; Phase Three – *Teaching Reflection*: scoring and questionnaire feedback (including all participating teachers, teaching assistants and students), an open interview with students and artist, and in addition, since the original classroom teacher and art teacher will discuss the creation with students through online platforms, they will talk to each other about the teaching status at the same time. Therefore, both teachers will also collection the interactive records, the students work presents and work images of the online platform.

There are two parts of the research. Part one focusing on compares the five major categories of students’ idea generating effects and creativity divergent thinking ability influenced by art teaching. As well as the benefits of art-infused curriculum to students’ thinking generation. Part two focusing on data analysis. Through the cross-analysis between “teaching data” and “learning data”, exploring how art-infused curriculum can achieve the aim of engineering innovation teaching through changing the existing engineering courses. This study conducts cross-analysis of teaching and encodes all data sources. (Coding method: Source - Identity - Syllabus - Number); the following is the data coding correspondence table of the in-depth interview of the artist and teacher, questionnaires of classroom learning, and student interviews (See [Table 3](#))

RESEARCH ANALYSIS

The Art Teaching Techniques and Artistic Creation into Engineering Teaching to Break the Inertia of Students Thinking Process

Engineering teachers and art teachers usually discussed the concept of teaching and curriculum design of the inquiry phase. Art teachers always emphasized that students should be passionate about their studies and their love is the most important thing. It needs to interact through classroom activities (MT-AR1-C-2) (MT-AR1-C-3). Engineering teachers do not have the confidence of his own ability in art and aesthetics as well as the past interactive sessions in engineering. They are afraid of facing innovate courses (MT-CT-C-1). However, the art teachers will share past experiences in engineering teaching. They encourage engineering teachers to let students feel free to play and try technology skill. They also proposed to avoid the beauty and ugliness in the form of art exhibitions. This action makes the students be confident and interesting in the presentation of his/her final works. Although engineering teachers still have some worries, they have also given a positive response to works of students. Engineering teacher and art teacher interactive statement:

I usually ask students: “Is there any problem?” Even this interaction makes hard for me. I repel the creative lessons and creative courses. Frankly speaking, we are embarrassed. I am embarrassed to draw pictures because I feel ugly. In my childhood life, I used to have the third place in children’s drawing. I am also good at dancing. But now if you want me to dance, I will not dance anymore. Sometimes, when I am getting older, I really cannot let go. I used to play a role as fortune god of wealth. I also sacrificed for lust. In fact, I tie in with others. In the past, I have tried to ask other teachers to evaluate those study case of students. Unfortunately, students are engaged by the past case study which fell the worse effectiveness. (MT-CT-C-5)

I had a class of Engineering Department students. They are full of interesting and creative abilities are also very good. I would like to mainly participate rather than go to a single course. It will be remember when it is done. It can be written their own mentality. I hope my class is design to play. As matter of fact, it is good for student to know a new theory. The passion is derived from when they love it first. The thinking process can be a good guide. I think the key is how to interaction. I think it is open space to explore themselves. (MT-AR1-C-4)

I feel good but I am worried the reaction of the students. (MT-CT-C-4)

The focus of art teaching is a focus on: interactive curriculum lead to enthusiasm, get rid of inherent thinking framework

In addition to bringing fresh experiences in engineering teaching, the design of art teaching courses requested to build ability of student to learn and make opinions voluntarily. Hence, how the interactive process of art classroom will trigger students to take the initiative to learn and then jump out of the existing framework of thinking in which it is a major focus of art in engineering education. Art teachers employ the teaching material with the art through interaction design such as "listening", "reading", "filming" and "shouting". It is decided to design the class activity with the type as "Deadwood Activity". Art teachers read the teaching report. To prevent the students distracted from copying notes from achieving classroom listening and visual learning consistency, it is demand to ask students to take the initiative to find the "dead branches" in the report. They are also asked to shoot "dead branches" images and shout "dead branches" to grab course credits. Until the end of the class, students actually observe the artist's figure. They found that it look like a branch and then take a teacher figure to ask for extra points (Q-CS1-B-2). The classroom interactive design points are designed to trigger student to think the association events of motivation. This action allows students to break the existing provisions, completely jump off the stable and stereotyped thinking line to answer. The literature review also shows that humans have the ability to learn through visual, auditory and kinesthetic cues. Art exploration activities to enhance and creativity to enable teachers to teach in a variety of ways (Suraya et al., 2017; Land, 2013). Students responded positively to the interactive and interesting aspects of this art course. Some students even suggested that "there are very few courses to allow students to freely discover and explore" (Q-CS1-B-1). In the concept of video art, their body motions have a variety of meanings and symbols. In this class, I saw students breaking the normative process after entering the art class. It also broke through the linear thinking.

In the process of image capture, students learn the power of "Problem Structuring" to divergent thinking. It is the first stage of "step out of the inherent frame".

Another aspect of art teachers focused: the establishment of ideas to replace beauty and ugliness, not limited to the appearance of the items

It is decided to allow students not only to judge the work through beauty and ugliness but also to evaluate the works with multiple views and in-depth views. Therefore, in the two teaching units of "give up stand alone" and "put down the beauty," are designed to allow students to evaluate each other's creative activities. Students can create simple creations through material to collect on the campus and discussing the ways of consensus. Then, they presented the works of their own group created which part is ugly. They try to establish a set of words to convince their peers. His group needs to put forward the work of the other group and understand where it is "beautiful." to join the contest. Students of this activity must use brainstorming to figure out where the other party's artwork is. During the whole process of art activities, the goal is to find students toward the function and the usage to judge their works. It is suggested that students think about the symbolic meaning of a single object, design elements, the formal principles of beauty and the psychological dimensions. It can guide students gradually to different levels to evaluate the work and persuade their peers.

Group A students: "This is what we looked for in the factory yard and all the balloons were on the ground. We felt it was ugly to play games.

Group B students: "It was beautiful and simple, simple, flexible and infinite."

Group B students: "Because it looks fake, it is crooked, so we feel ugly."

Group C students: "I feel that the above things can be used again, so it is beautiful."

Student C: "This is a hamburger. Because the brick above it represents gathering gradually. It is to be built one by one layer because the beam is not stretch. There is a cigarette in the middle. This is a very

artificial part. We began to find cigarettes, and later found the leaves, and gradually the breath of the people. So the leaf is drawn out so beautiful. Hence, the building has a mouse shit in which it will be ruined. (The class laughter)

Group D students: "It looks very saturated in color with layered and green."

From the answers given by the above groups of students, it can be learned that art teachers allow students to judge their creations from the perspective of opposites. It also makes students to recognize the beauty and ugliness of judgments rather than being as imaginative as possible. The students are trained by the concept of change and innovative thinking as well as multi-assessment of thinking. It is no longer limited to the appearance of the object itself to produce a lot of association imagination and cross-domain thinking. In the class questionnaire feedback, students write down: you can put aside the past thinking mode, different ways of thinking and look at things from different views (Q-CS1-B-2). Students peer review and assessment process are made in art class. It breaks single thinking and improve the ability of evaluation divergent thinking.

Reconstruction and definition: constantly trying and making mistakes, from a different perspective to re-construct and define the problem

Different areas often caused communication barriers. Art should be integrated into engineering teaching which have to make students to understand the conversion of symbols and their understanding of artistic creation. They must first get out of their engineering thinking. The reconstructions and definitions of ideas are very important.

In the process of guessing, the student initially approached the field of engineering in the "shameless" unit, "drop right and yourself" and "drop the field" course unit. In the process of guessing, students started to approach the field of engineering in the first step. They used "evolution" or "mathematical" point of view to answer. For example, art educators presented a series of numbers on the screen, asking students to guess their relevance. Students guess them as the same series, odd even, addition, subtraction, multiplication and division. Until the art teacher answers the "rhythm". Students suddenly realized (N-RS-B-6) how the answers are made. Although students constantly guessed the answer in the process, they are aware of the possibility of looking at things differently and finding different answers from the perspective of a manager. Students wrote:

We can have different ways of thinking (Q1-CS1-B-6)

It is different from the perspective of the engineering brain to see the problem (Q1-CS1-B-7)

No longer only simple answers, but also allow us to find different answers (Q1-CS1-B-8)

From the above statements, we can see that the answer is not the most important thing. It is important to make students understand the need to stand from different angles to look at the problem and students consciously learn this concept through this activity. It is crucial to train students start by "Problem Structuring" to Divergent of thinking skills, and then finally to leap over the existing field of engineering thinking.

Breakthrough in performance: not good at more possibilities

In addition to engineering students need to overcome the limitations of thinking and how to break through the existing forms of expression which are also very important. Art educators allow engineering students to give up the original presenting form. They adopted three units to train students. "Put down complex" course unit. Art teaching a difficult problem to ask students to solve by design. Students need rapidly and directly complete the design, unfortunately they cannot use oral expression. Students communicate concepts to team members with hand-painted feet, facial expressions and poorly-drawn pictures. Although clearly observing and feeling the uncomfortable communication among students, they are still able to complete this task and provide answers (N-RS-B-5)

Art teacher: "In fact, there are many things that are not necessarily complicated to solve: it is necessary to train you to practice the ability of simplification. There will always be a simpler solution. Remember the concept: less is more (N-RS-A-4). While students are hampered, they used a variety of different solutions to communicate. Then let students learn to "feeling" the divergent thinking. The more the feeling of obstruction, the better the rebound is effect. The more significant of the benefits of innovation will be achieved.

In the "give up text search memory" of the lesson, art teachers ask students to describe what they see each day in school. Most of the classroom students use single words to answer questions. Art instructors remind students to visualize things in the form of imagery. They ask students to use more about adjectives to describe the appearance of the picture. They also remind students to observe a lot of details (N-RS-A-7). Through searching the past memory

with corresponding counterparts, students can use lot of images to make association thinking. Then, the searching divergent thinking ability is trained.

In the “give up advantage” of the lesson, art teachers share their own creative experiences. While the creation involved the existing limitations, and art instructors used to be visual communication design students. Their graduation creation works are to auditory as the main design concept. They explore their experience to remind student never give up all they known. They should find the original impossible to make it possible. They told student to have the concept of “unless....”. The divergent thinking also has an Ideating to emphasize this concept.

According to the art teacher in the “10 art-style of putting down” teacher and student interaction, we can learn that art instructors are trying to impose or counter-normalize their ways. Let students continue to dig out the answers to the questions from the constraints. Then, students can observe in the student’s reaction to the arts merge into the education class. They are continuously trained in divergent thinking. Students can have unusual and creative questions with answers and reactions. Therefore, this research analysis can correspond to the category of art teaching and divergent thinking. It can be learned that students help students to expand the thinking of art teaching methods. The following is the corresponding relation: The fundamental concept of a breakthrough versus “Problem Structuring”; blocked rebound versus to “feeling”; visible portrayal of the versus to “Search”; give up the self-righteous advantage versus to “Ideating” and break the absolute view corresponds to “Evaluating”.

The Integration of Artistic Creation into the Social Issues and Application of Engineering Technology, the Impact of Engineering Teachers Teaching and Student Learning

The value of art being integrated into teaching: Reflections on the value of art in teaching: reflections behind thinking

Art teachers pay attention to the relaxed atmosphere of the classroom and the students enthusiasm to participate. Therefore, art teachers use unrestricted, encouraging and relaxed ways to respond to student responses. The entire class takes a relaxed and open approach. To increase the sense of students on participation, art teachers in the classroom will raise questions of various sizes and grab points to attract their attention. In the tutors observe the diary:

In the performance in Classroom-

A variety of ways to grab points play a role in the classroom. On the one hand, students are motivated, on the other hand, students are competing against each other (N-ST5-E-11)

Art instructors emphasize to participation, therefore, they throw out small questions to students and observe students’ responses from time to time (N-ST4-A-11)

Face the concept of thinking and creation -

Students find the course very interesting, but may not help with imaging (N-ST6-E-21).

Due to the long-term curriculum, students of Engineering department suddenly turned out to be so-called “no limit”. They need take a moment to think and slowly develop their own view. In the final exam, it is very important to deal with art and creativity to test the integration ability of students (N-ST3-E-21).

Facing with a dazed reaction of students and self-contradictory conditions, art teachers not only did not fall into panic but also highlight that art instructors are good at impressing and affecting from student perspectives. They are not good at linear teaching, complementary with engineering teaching (T-AR1-C-6). Art teachers think art can be a point of inspiration. Hence, it cannot be effective immediately. Therefore, the art teachers in the follow-up guide to the creation of mostly “reverse thinking” of question and the corresponding answer. It inspires students to think, in addition to inspire students’ ideas, and then trigger students to think and reflect on the meaning behind their own behavior. Students also feel the novelty and freshness which become the motivation for students to learn in class and boost thinking (Q1-CS1-B-3)

When students are in the creation of performance, the concept of creation, a well-structured oral and can lead to the creative concept and technology applications.

This shows that art teachers create a happy and relaxed atmosphere, boost students’ participation and thinking, and grasp the interactive relationship between teachers and students. This successfully stimulated students to change their mind. Following a series of teaching process, not only make up the obstacles of students’ thinking, but also urge students to pay more attention to the importance of creativity and core concepts.

Art Creation Process: Students are looking forward to the difference on application of engineering technology and creative presentation

Art teachers use a large number of art teaching methods of divergent thinking in the course of “artistic thinking and function-creation method”. They continually ask students to present concepts by writing and drawing. In the process of thinking, art teachers use forced association method, so that students can simplify and enlarge the connection between concept and image. Students can focus on the overall presentation of the work, and put forward the relevant creative case of video art. Students faced on the application of technology and creative ideas to presented ways, the students questioned:

If I use simple techniques to express my concepts, in fact, the general drawing software is done. Then, how do teachers know that we are not using classroom teaching techniques? If this may not due to low technology, scores will be lower? ((N-RS-E-21)

After reading the fantasy concept of student homework sheets, engineering teachers raised concerns with the researcher and hoped that the students would be able to apply the technology. Therefore, the same challenge was raised:

The technical thresholds of these works are quite low. It is difficult for us to see that students have learned the skills from the classroom. I am really worried about this part. I have no confidence in some parts are not done (T-RS-A-21).

In the achievements of artistic creation and performance, we can find that the engineering techniques applied by students are relatively low barriers. However, they present the concept of works in a creative and precise manner, and are praised by teachers. The following two cases:

Teacher: I think I did well and expressed the concept clearly. However, did you really apply the useful technology, not only with the image processing tools to deal with?

Student: We have applications to engineering technology. You do not have to worry about this. (N-RS-A-35)

This work has three notches in the person’s eyes and mouth, and puts the screens of the three phones. The left and right sides of the eyes are positive, negative, representing a different perspective. The mouth is put some irritating and swearing words to represent different emotional expression. Creative Technology: negative film image processing technology.



The usage of the game screen to express the state of drunkenness. Through the image processing to express the state of drunkenness, it is presented in line with current affairs to simulate the situation after drinking wary of not drunk driving. Creative Techniques: Averaging filters for different mask sizes.



Figure 2. Students’ works-Think YELL and No problem

From the above case study, we can see that students only use film image processing technology to present the concept of human colorful vision. This effectively combines the art device with the image device. The course is designed by the artistic qualities of uncertainty and the purpose-oriented exhibition. These lead to the engineering college students to produce the questioned technical applications. These also guide students to consider the level of technology applications. On the other hand, some students know their own engineering needs and deficiencies. They are aware of the inability to fully teach the required skills during class hours. They also produce “hunger” in engineering learning and application. They even conceived that they should spend more time in learning (Q1-CS1-B-9). The course is designed to enable students to reinforce their learning motivation in the face of technical

difficulties in implementing their design concepts. These reinforce their motivation for learning because of technical difficulties which made them thinking of themselves. Students think about the relevance of the values of the work itself to the learning of technology. They pay more attention to the technical aspects of the application (Q1-CS1-B-8). This action help students thinking self-examination. These can help students develop all aspects of ability. (Tsai, 2016)

Art Shows Presented: Students not only to Escape the Concept of Engineering Technology, but also Stand in Different Aspect to Increase Interaction Design

In addition to considering the application of engineering to work, students need to think about the interaction and presentation of the entire work presentation. Throughout the process of presenting the exhibition, this study found that engineering students employed the exhibition environment, the perception of the viewer, and the timing of the presentation as creative considerations. These items and materials are beyond the engineering and technology. It is emphasis on the feelings by viewer and interaction which achieve the humane design

The following is dialogue with teachers and students in two cases:

The concept of this work is mainly "air pollution". It uses narrow devices to allow viewers to enter the dark boxes and display empty images. These designs make not only the image of the feeling like truth, but also enhance the viewer's sense of oppression in the work space.



The concept of this work mainly shows man-made pollution by smoky smoke and haze. The device, which is quite large in size, uses three layers of translucent cloth and images to allow the viewer to feel visual, tactile and smell when using the device. The students used three layers of cloth of different thickness and texture, and the taste of the cloth concept.



Figure 3. Students' works- Masks outside the world and south thin

Student: We show the air pollution through the density by presenting different materials. When the teacher just came in, you will find that we are using a soft material. The more movement you move which makes the difficult feeling to encounter. Then, the teacher you will touch it by hand. This is a struggle for you. (N-RS-B-34)

Teacher: From the perspective of social concern and creativity, it is a very good work.

However, this technology is a little bit lack of a technology for video processing. These will not affect the whole work's achievements. Actually, you should be attentively! In fact, this means that your head is not only having an engineering problem. The engineering problem eventually went to the end of humanity. Engineering is to solve people's problems. Although you did not show much achievement in engineering, the initial idea is very good. (N-RS-A-32)

The Intersection of Art and Engineering: The Ability to Redefine the Problem and Play the Ultimate Creative Performance

In addition, in the response to the grading, we unexpectedly found out that students have changed the design and concept of the whole course and breaking through existing memorized learning. Students even challenged the combination of engineering and art. They learn the ability to redefine the problem. The students say:

Engineering is purposeful, but art does not have absolute right or wrong. What is the point of bringing them together? (T-CS1-E-1)

This question leads to the artist's teaching concept: "Functional-oriented in engineering versus none of right and wrong in art have fundamentally to be repositioned for both, so-called redefinition" (T-AR1-C-1). The art teacher's observation and question always hold the expected attitude. They even asked students questions when grading their results. They often perceive whether to break through some thinking and improve their ability to solve problems as one of the grading standards. These teaching ideas motivate students to reflect on the implications behind their own behavior (T-AR1-A-3) (T-AR1-C-9). They think the biggest gain is "redefining the problem and rethinking the problem" (Q1-CS1-B-2). The following is a dialogue between teachers and students:

Art teacher said: What is your most creative point?

Student said: There is no creativity in my mind.

Art teacher said: "Are you doing the best? Are you sure you are the least creative of all the groups in it? "My point is you dare to be non-creative idea which is actually super hard. It is difficult for a person to think without any idea, even if it is a little bit hard. I think this can inspire many students' ideas. You have to approach ultimate good to get creative. (T-AR1-A-4)。

Students say: Are you sure posters cannot have a text? They tried to learn to break the framework to make the finished product by themselves.

Art teachers say: Are you brave enough to use words to render. This is actually better.

Engineering Teachers Observe the Arts Merged into the Glimmer of Engineering Education, Extending to the Breadth of Application of Engineering and Technical Education with Depth and Breadth Exploration

At first, engineering teachers are suspicious of the performance in engineering and learning to students. Due to diverse artistic expression, teachers concerned that students cannot focus the concept of topics by the techniques they have learned in the classroom. On the other hand, teachers generally believe that under the condition of no limit, the issues raised by students and the application of technology are integrated. These could happen in the low level in the use of video technology which are not enough for students to learn a breakthrough in engineering and technology.

When art enters the classroom, engineering teachers think that technology needs to be presented precisely. In fact, when he saw the results, some degree of relief is in his heart. He used to focus on technology-oriented, however, when he saw the students are change from focusing on technology to innovative applications part. Therefore, engineering teachers will focus on teaching, from purely technical teaching extended to its application level. In the past, in addition to the classroom teachers, engineering teachers will still put teaching resources online for students to learn. Those students are changed because of the art idea are merged and able to show the results of these technical teaching in different application levels. Students have notable ideas in the topic of attention and the concept of communication. As aforementioned, with the drunk driving and air pollution issues, students did not even think of themselves as artists. Through the study of engineering technology and art integrated into the classroom design, these offer student space to think about social issues. This is a totally different learning way. (T-CS3-E-4).

Art teachers also consider the exhibition as a result. This pressure on both art instructors and engineering teachers can be reduced by the consequences of the results by its lack of success or failure with certain manifestations (T-AR1-E-2). Therefore, the integration of art into the teaching design can extend the breadth of engineering applications (T-AR1-E-2). Students make breakthroughs from indigenous thinking through the divergent thinking training. Differences for students in creative and technical applications are still exists. We still have some improvements in this field.

CONCLUSION AND SUGGESTIONS

The art teachers' teaching contents are corresponding to the divergent thinking categories (Khandwalla, 1993): Fundamental concept breakthrough to the Problem Structuring; Blocked rebound to the Feeling; Visualized oral description to the Search; Give up the advantage of self-belief to the Ideating; Absolute point of view breaking to the Evaluating. Art teaching enables students to learn the ability to redefine problems through divergent thinking. Therefore, in the idea generating stage of engineering course, art-infused curriculum related divergent thinking could be clearly defined. Engineering teacher and art teacher can conduct pre-communication of curriculum planning in a more specific way when they discuss engineering innovation courses. In this way, engineering

students can be taught to have “high efficiency” engineering application and to the creative ability of develop “original” works.

Infusing art into college engineering classroom design is more emphasis on the thinking conversion, rather than purely technical performance. Therefore, classroom design enables engineering teachers to focus their teaching from purely technical teaching to the technical application level. When the art teacher and the student discuss their creative techniques and presentation form, it will induce students to challenge old methods and generate different solutions. When students realize their design concept, they will strengthen their learning motivation by facing technical difficulties.

In the primary stage of teaching exploration, the art teacher and engineering teacher have very different thinking modes. Therefore, there are two important factors in the development of teaching contents. First, the art teacher and engineering teacher should put forward their teaching experiences and materials. In addition, a coordinator familiar with the CAPE mode, and with a certain understanding of the two parties’ resources, is required. Such a coordinator is a key figure in the whole process of teaching exploration. Second, before discussions, the engineering teacher should provide the art teacher with previous class materials and students’ learning conditions to promote the process of the overall course. In the process of teaching cooperation and teaching records, the teaching assistant played an important part. The assistant should face the art teacher, the engineering teacher, and students, and put the demands of the class on the teaching platform to achieve communication and coordination between the three parties. In addition, the teaching assistant policy of the college of engineering was helpful for teaching and technological consultation, and helped the students to find the media of relearning as the bridge for communication between teachers and students (Huang, 2016), which could provide guidance and feedback for the technological operations of students’ technological applications. In the stage of teaching reflection, this study believes that the art teacher should focus on the roots of the problems faced students, and emphasize the concept of creation, while the engineering teacher should focus on the technological learning of students. Therefore, in terms of the arrangements of the overall class processes, it is recommended that teaching in the earlier stage should focus on engineering technology, and construct students’ basic skills and concepts. The teaching of later ages should integrate art into class through intensive art creation courses, strengthen students’ ability to divergent thinking in order to break students’ inherent thinking, enhance the coherence of creation, and promote the overall implementation of the course.

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