

# Research on Teaching Model of 3D Printing Course Based on Creativity Cultivation in Primary Schools

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**Abstract.** As a new course, 3D printing course is highly acclaimed for its interest, openness and practicality. This paper explores how to use it to cultivate pupils' creativity. On the basis of Triffinger's three-level theory of creative learning and Parnes's teaching model of creative problem solving, the author proposed the core qualities of creativity, namely, observation, imagination, conception and design, as well as designed the 3D printing teaching model based on creativity cultivation in primary schools which has the following problem solving process "discovery-explanation-imagination-conception-design-printing" to train students' divergent and convergent thinking. Importance has been attached to the exhibition of creative intention while evaluating students' creativity.

## Introduction

In this era of globalization, the international competition is becoming increasingly intense with rapidly developed science and technology. Loads of facts prove that creativity is the core competitiveness of a country. In order to win a place in the intense international competition, the key is science and technology while the essence is talents with creativity as their core characteristic. China's future development trend also indicates that more and more creative talents are needed. Many school leaders and front-line teachers worked for primary education in China have realized the importance of cultivating students' creativity so as to suit the needs of the development of times.

In a narrow sense, creativity is the ability of human beings to provide creative and valuable products. In a broad sense, it means the comprehensive quality that human beings need to provide initiative and valuable products [1] which is composed of three parts: creative thinking, creative tendency and creative expressive ability. According to different frames of reference, creativity can be divided into three levels: society, groups and individuals. The creativity of primary school students displayed in learning activities which is discussed in this research belongs to individual level.

Gilford, an American psychologist, put forward eight characteristics of creative personality in 1967[2]: 1. high independence and consciousness; 2. strong craving for knowledge; 3. great curiosity about everything; 4. broad knowledge and good observational ability; 5. rationality, preparation and strictness in study and life; 6. rich imagination and keen intuition, liking abstract thinking and intelligence activities; 7. full sense of humor; 8. strong will, being able to focus on areas of interest for a long time.

Dong Qi had one scientific explanation about children's creativity: "Children's creativity is obviously inseparable from the activities carried out by children. The way and content of children's activities will show great differences in different ages, which leads to corresponding changes of children's creativity.[3]"

The creativity of primary school students is often based on curiosity and imagination. Most of their creative products are simple and elementary. Compared with the creativity of adults, that of children has following characteristics: 1.acuteness. They can find novelties in common things; 2. independence. Their creativity is generally free from outside interference and previous experience; 3. flexibility. Their attention can quickly change from one kind of object to another; 4. visuality. Their

brain has the thinking characteristic of processing existing images and producing unprecedented images; 5. difference. They may think of different things seeing the same thing.

Compared with other disciplines, 3D printing course has the following obvious advantages in cultivating children's creativity. This course is carried out by solving problems during the process of making material objects, which is beneficial to the cultivation of students' creativity. Through observing the design process of students' works and completeness of their final works, teachers can know the development status of pupils' creativity, and at the same time, give corresponding training and inspiration based on the problems in the design process.

### **3D Printing Technology and 3D Printing Course**

The idea of 3D printing technology first appeared in the mid-1990s. It is a kind of technology which is based on digital model files to create three-dimensional objects, with material being (such as mental powder, ceramic powder and plastics) joined or solidified together layer by layer. The process of 3D printing is roughly as follows: firstly, the computer aided modeling software is used to model three dimensional objects which are then divided into layers, just like "slices". Afterwards, these "slices" will be printed and shaped.

The aim of 3D printing course (whose content is 3D printing technology and its application) is to improve creativity thinking ability and manipulative ability of primary and secondary school students. In accordance with current understanding of 3D printing concept, researchers like Gao Yong proposed the following models in which 3D printing course can be presented: 1.courses based on close learning, assembly and design of 3D printer. 2. courses based on retrieval and printing of 3D models. 3. courses based on study of design software and rapid building of simple models.

In order to improve pupils' ability to solve real-life problems and increase their opportunities of independent thinking and manual operation, the instructional design of 3D printing courses in primary schools should be based on the third model--students explore the design and operation of professional 3D design software independently as well as materialize the designed model through 3D printers.

In China, 3D printing course has received increasing attention and is offered by many primary and secondary schools. However, as a new course, it is at its initial stage and needs further improvement. After referring to a large number of relevant literature and experience of giving guidance and observing classes in primary schools, the authors think that the main problems of Chinese 3D printing course in primary schools are as follows: random teaching content, single teaching method, simple evaluation system and inadequate personnel preparation.

# The Core Quality of Creativity in 3D Printing Teaching

The teaching model of creative problem solving (CPS) was presented by Sidney J. Parnes, an American expert in creative education, which emphasizes the use of systematic way of thinking to solve creative problems, that is, problem solvers try their best to come up with various solutions before making or choosing solving plan, so as to cultivate pupils' creative thinking.[5]

The usage of this model has basic assumptions:

(1) For teachers, they should attach importance to students' creative behavior and establish an atmosphere of free expression, humor and harmony, so as to ensure students' bold imagination.

(2) For students, they should have knowledge reserve in advance. Each student has varying degrees of creativity which can be constantly enhanced by some examples and exercises.

Treffinger, an American scholar, put forward the three-level theory of creative learning on the basis of his definition of creativity. He gave adequate consideration to crucial factors from cognitive and emotional dimensions when cultivating pupils' creativity.[6]

The first level of the theory emphasizes the divergence of pupils' cognitive and emotional factors, requiring pupils to discover things from different perspectives. For the second level of the theory, Triffinger emphasizes complex cognitive process and emotional experience. In addition to requiring

pupils' ability to do analogy, transfer and analysis in terms of cognition, cultivating pupils' imagination in the process of emotional experience is of greater importance. The third level of creative learning emphasizes solving real-life problem. Students are required to use creative thinking while confronting real-life problems and challenges to develop their practical methods and skills (such us conception, design and self exploration which are helpful to problem solving). According to the three level theory of creative learning, it is of particular importance to cultivate and improve the abilities of observation, imagination, conception and design, which constitutes the core qualities in creative learning theory.

To sum up, in order to improve the creativity of primary school students, it is necessary to integrate the core qualities of creativity such as observation, imagination, conception and design into 3D printing course in primary schools. Moreover, with the purpose of enhancing these core qualities, the method of solving problems should run through the whole teaching process which means that teachers let students discover, analyse and solve problems through presentation, inspiration and guidance for the sake of cultivating students' divergent and convergent thinking. For this reason, the author designed 3D printing teaching model in primary schools based on creativity cultivation.

#### **Instructional Design**

#### **Instructional Design Based on Creativity Cultivation**

Instructional design embodies presupposition, that is, pre-design and pre-planning. Sheng Liqun thinks that instructional design is accurate and reasonable pre-planning of all links in the teaching process by using comprehensive and systematic method under the guidance of relevant teaching theories.[9]

Instructional design is the implementation plan presupposed by teachers for the following teaching activities in order to improve the efficiency of classes which is not only the guarantee of smooth teaching activities, but also the key to successful classes.

The instructional design of 3D printing courses based on creativity cultivation in primary schools takes the objective of students' creativity cultivation as the focus of the whole 3D printing teaching. Therefore, the key is how to optimize intermediate links in accordance with this objective, that is, how to choose reasonable instructional strategies and evaluation methods in accordance with the teaching content. The instructional process of this course is in the light of the teaching model of 3D printing course based on creativity cultivation. Instructional objectives and results respectively represent the starting point and the final ideal state of teaching activities. The premise of stimulating students' creativity is the teachers' creation of a relaxed and pleasant environment. In the teaching process, teachers should constantly increase students' abilities of observation, imagination, conception and design through presentation, inspiration and guidance, so as to achieve the teaching effect of cultivating students' creativity.

#### The Analysis of the Characteristics of Learners

The analysis on the characteristics of learners focuses on students' psychological characteristics, capability base, existing experience, knowledge reserve and other actual situations and it is carried out before instructional design to provide reference. The emphasis on analyzing learners' characteristics is a return to the essence of education, which fully embodies the new educational concepts of "taking students as the main body", "respecting students" and "teaching students according to their aptitude".[10]

Primary school period is the best period of education with the fastest change and the strongest plasticity in one's life. Primary school students are often energetic, imaginative and full of strong desire to explore everything. Therefore, primary school period is crucial for creativity cultivation and development. On the basis of stages of cognitive development divided by Jean Piaget, a Swiss child psychologist, the thinking level of primary school students is mainly at the concrete operational stage

(7-11 years old), spanning the later period of pre-operational stage (2-7 years old) and the earlier period of formal operational stage.[11]

The 3D printing course is mainly offered to grade five and grade six students in primary schools. According to the stages of cognitive development theory, the thought of senior students in primary schools begin to transit from concrete image to abstract logic thought which indicates that they can make simple logical reasoning and apply learned knowledge to solve simple practical problems.

# The Analysis of the Instructional Object

As the starting point and destination of teaching activities, instructional object is the first question to be answered for all teaching activities. It is also the essential factor to be considered in instructional design.[12]

The 3D printing teaching model based on creativity cultivation integrates the core qualities of pupils' creativity, such as observation, imagination, conception and design. The instruction object of this study is also grounded on the improvement of core qualities in the teaching model, which consists of the cultivation of creativity from the aspects of curiosity, imagination, conception ability and design ability.

For this reason, besides enhancing students' conception ability and design ability, it is of greater importance to stimulate students' practical spirit of daring to challenge and try in the 3D printing teaching model. This is also an emphasized factor in the later teaching evaluation. Teachers should give timely guidance to students' difficulties and encourage them to practice.

# **3D** Printing Teaching Content Based on Creativity Cultivation

## **3D** Printing Software Used in Teaching

Since up to now there has been no corresponding curriculum standard for 3D printing course, the 3D printing software used by schools offering this course is various, among which the representative ones are: Autodesk 123D Design, Google SketchUp8.0, CAXA entity design, etc. Each of the design software has its own advantages, and can achieve some preliminary functions of 3D printing.

# **Teaching Content of 3D Printing Course**

When designing the teaching content of 3D printing course, the author divides it into three parts (basic introduction, exercise and the comprehensive application) according to the degree of difficulty, with core qualities of creativity such as observation, imagination, conception and design integrated into them.

### **Selection of Teaching Strategies**

Teaching strategy is the key point of teaching design and comprehensive consideration of factors like teaching methods, teaching forms and teaching procedures. It mainly solves the problem of "how to teach".[13] Situational teaching, problem-based teaching, heuristic teaching, example teaching and other teaching strategies can be adopted in 3D printing courses based on creativity cultivation. Teachers need to consider various factors comprehensively and choose appropriate teaching strategies according to specific teaching situations.

### **Instructional Assessment Design**

Instructional assessment is the analysis and evaluation of each link of the teaching process and the teaching effect according to the teaching purpose, which, therefore, is also an important feedback for teachers to know the teaching quality. Although instructional assessment is the last part of teaching design, it is not conducted at the end of teaching activities, but throughout the whole process of teaching activities.



## Conclusion

In order to cultivate the creativity of primary school students, the authors put forward a new 3D printing teaching model. This teaching model, which can train students' divergent and convergent thinking, has the following problem solving process "discovery-explanation-imagination-conception-design-printing". A new evaluation framework has also been suggested by the authors. Emphasis has been laid on the exhibition of creative intention while evaluating students' creativity. Both the creative process and creative works are taken into consideration.

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