Application of 3D Printing Technology in Maker Education for Primary and Secondary Schools

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Abstract: This paper analyzes the application status of 3D printing technology in maker education in primary and secondary schools in order to improve teaching quality and stimulate students' interest in learning and proposes corresponding methods and measures based on the analysis. The application of 3D printing technology in maker education for primary and secondary schools has realized the organic integration of education and humanism, prompting students to accumulate rich learning experiences, develop good study habits, and improve students imagination and creativity.

1. Introduction

In the year 2015, the Ministry of Education promulgated the "Guiding Opinions for the Comprehensive and In-depth Promotion of Educational Informatization During the 13th Five-Year Plan Period (Exposure Draft)". A clear statement is made regarding the need for further strengthening the planning of educational information over the next five years, exploring new educational models such as STEAM and maker education actively, as well as enhancing the use of 3D printing technology in maker education for primary and secondary schools from a policy perspective. All major primary and secondary schools across the country have joined the wave of 3D printing maker education, and many schools have been included in the overall planning of education, making 3D printing technology a broader development prospect.

2. Overview of 3D Printing Technology and Maker Education

2.1 3D Printing Technology

3D printing technology is a rapid prototyping technology that uses bondable materials such as powdered metal or plastic and constructing objects by layer-by-layer printing based on digital model files. The characteristics and advantages of 3D printing technology are fast manufacturing speed, reproduction of three-dimensional technology, and considerable economic benefits.

2.2 Maker Education

Maker originated in the United States. It refers to transforming existing technologies into natural objects through creativity from certain interests and hobbies. In this process, it is necessary of sufficient theoretical knowledge, innovation, practice, and sharing. The advent of the Internet age has made people's innovation a reality, which in turn encourages more and more groups to join the ranks of makers. However, there is still no clear definition of Maker Education. Until the first meeting of the Maker Education Expert Committee held in Shanghai in 2016, many scholars and experts gave a brand-new definition of maker education at the current stage through collective discussions: That is to say, maker education combines maker warmth and education. It is a quality education based on students' learning interests, using digital teaching tools, advocating sharing, and cultivating students' problem-solving, cooperation, and innovation abilities.

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3. Application Status of 3D Printing Technology in Maker Education for Primary and Secondary Schools

3.1 Scarce Equipment

As a new type of technology, 3D printing technology has not yet been popularized in some economically backward areas or township primary and secondary schools in China for its relatively expensive. Even if 3D printing technology is introduced in some schools, the quantity of using 3D printers is very few [1].

3.2 Lack of Uniform Curriculum Standards

For maker education in primary and secondary schools, different stages of schooling have different opening times for 3D printing technology. A few primary school courses offer learning courses related to 3DOne modeling software in the fourth grade, while in some schools, the 3DOne printing class is only offered in the seventh and eighth grades [2]. From the perspective of teaching materials, there are many types of 3DOne modeling software and teaching materials in the market. According to the current survey, the 3DOne textbooks used in primary and secondary schools include "3DOne 3D Solid Design" edited by Professor Chen Jimin of Beijing University of Technology and "Maker Academy - Interesting Design of 3D Printing" co-written by Suo Shihui and other three teachers, and "Easy to Play with 3DOne and 3D Printing" written by Mr. Shen Zhihong. Because of the lack of approved curriculum standards, it isn't easy to popularize the application of 3D printing technology for maker education in primary and secondary schools [3].

3.3 The Traditional Teaching Model is No Longer Suitable for Maker Education

From the perspective of the teaching mode of maker education, more emphasis is placed on students learning by doing and creating while learning. Therefore, the traditional teaching mode is no longer suitable for maker education with 3D printing technology. At the same time, the survey found that 3D printing technology has not been applied in information technology courses, and it is rare to apply 3D printing technology to other subjects.

3.4 It Takes a Long Time for Teachers to Prepare

The application of 3D printing technology in maker education for primary and secondary schools requires first establishing a 3D model, then copying the established model to a 3D printer through an SD card or USB hard disk, and printing a physical model through the printer. However, teachers must do much preparatory work in the specific application process of 3D printing technology. Among them, the establishment of the model takes the longest time. In addition, it is necessary to organically combine the printed mold with the courses to be taught, which is also time-consuming and laborious.

3.5 Insufficient Teaching Staff

In maker education for primary and secondary schools, most of the 3D printing technology teaching workers are part-time information technology teachers, and there is a lack of professional teaching materials and personnel.

4. Application Strategies of 3D Printing Technology in Maker Education for Primary and Second Schools

4.1 The 3D Printer Application in Maker Education

A key difference between maker education and traditional knowledge learning is the combination of traditional knowledge learning and educational practice. It pays more attention to students' hands-on experience in the learning process and advocates learning by doing, creating by doing, and doing by learning so that students can discover and solve problems while learning and finally realize the fundamental purpose of creative creation and practical innovation [4].

3D printing technology mainly includes two parts: 3D design modeling and 3D printing output. Among them, 3D design modeling is the key to 3D printing technology, and 3D printing output is to

transform innovatively designed 3D digital models into entities. The application of 3D printing technology in maker education for primary and secondary schools is mainly presented in the following two forms: A professional 3D design software course can be learned and explored in different ways, depending on the design requirements; a simple 3D design software course can also be learned as part of software learning. Students will be able to use simple 3D design software when they have completed a certain learning task to complete the design of other works independently, and they will use 3D printing to complete the design process.

While applying 3D printing technology, teachers can complete design modeling through 3D design software and by personally experiencing the observation and exploration of problems encountered in daily life. Ultimately, unique, novel and creative works will be designed by hand to cultivate teachers' and students' imagination, thinking, and problem-solving abilities.

One of the most noticeable differences between 3D printing and traditional printing is the type of "ink" used. 3D printers use ABS resin ink, a thermoplastic polymer that is extremely strong, durable and easy to process. PLA (polylactic acid) recycled plastic is made from raw starch materials extracted from renewable plant resources, has excellent degradability, and is recognized worldwide as environmentally friendly. It is controlled by a computer program that slowly heats the material in the print head to become a liquid, then heats it, and then rapidly cools it in the air to become solid. Finally, a solid model is formed using a 3D digital model, and the printing process has been completed.

In middle school maker education work, teachers and students can make their ideas into reality by using 3D printers. Then, the knowledge points or a particular problem in the subject are presented using 3D printing technology. The application of 3D printing technology in maker education for primary and secondary schools can also organically link subject teaching with 3D printing technology, such as printing representative characters in Chinese, mathematics, and physics, three-dimensional spatial, graphic structures, and abstract magnetic force lines, which can help students better understand the essential and difficult knowledge in the text [5].

4.2 3D Scanner Application in Maker Education for Primary and Secondary Schools

The 3D printer can transform the 3D digital model into a physical model, and the source of the digital model also needs to be modeled by the 3D scanner. To better understand the principle of the 3D scanner, our unit purchased two handheld 3D scanners from abroad. However, due to the lack of understanding of its performance and corresponding Chinese instruction manuals, it isn't easy to use the equipment. Although the model was scanned on a computer and a 3D image emerged, it was blurry.

For this reason, the author made innovative changes to the equipment required for the 3D scanner: (1) The 3D scanner is equipped with a tripod for photography to ensure the quality of photography. (2) Since the 3D scanner needs to perform 360-degree scanning of the scanned object, an adjustable-speed and rotatable turntable were purchased as a platform [6]. (3) To ensure the modeling quality, an LED shadowless photography light with adjustable luminosity and color temperature was purchased. Through innovation and the use of maker thinking, the problem of blurred imaging was finally resolved. It also created a good experience environment for the application of 3D printing technology in maker education, successfully completed the 3D scanning modeling of still life and portrait, and obtained high-quality 3D printing design models.

4.3 Application of 3D Design Software in Maker Education

Currently, the commonly used software for 3D printing technology includes Pro/E, CATIA, Solid Works, Inventor, ZW3D, 3Done, 3DS MAX, MAYA, Light wave, etc. Solid Works, Inventor, ZW3D, and 3Done are modeling software for 3D printing technology. In addition to the functions of 3D modeling, UG, Pro/E, and CATIA also have other functions, such as subsequent force analysis and model optimization, while 3DS MAX, AYA, and Light wave are mainly used to make 3D animation software. These software programs provide many powerful functions, and the cartoons played in people's daily lives and on television are all produced using these programs. Unfortunately, most 3D design software is very difficult to learn, and many students will feel fear when hearing about 3D printing technology. Therefore, maker education uses 3Done software to implement and teach

modeling to reduce the difficulty of using this technology. The software interface is simple and easy to operate, making the whole design process easier to learn. Through the learning and experience of 3D modeling software, students also quickly mastered the skills and methods of using 3D modeling software and then designed their own creative models.

A 3D design program can provide better assistance to beginners with modeling problems during the learning process. For example, when creating a 3D model of a hexahedron, it is simply necessary to click the mouse. As the mouse is clicked at any point on the mesh surface, another hexahedron is generated. Then, click anywhere on the mesh surface to create another hexahedron. It is only necessary to input the corresponding value when the mouse is dragged, and the parameters of the hexahedron will be changed accordingly.

3D printing technology can be applied to design teaching models in different disciplines. Take the "Intelligent Robot Design and Production Course" as an example, and maker education can design robot solutions according to their imagination and planning. Robot structural accessories and appearance can be modeled through 3Done. The first step is to generate the STEP format file on the computer and then use the Replicator G slicing software to convert it into the X3GG format that the 3D printer can recognize. Finally, print out the designed 3D robot model, and assemble it into a creative robot with intellectual property rights.

5. The Advantages of 3D Printing Technology in Maker Education

It is common for teachers to adopt the teaching method of "indoctrination" and "cramming" in schools, especially in the primary and middle grades. A lot of theoretical knowledge is required for students to memorize by rote, making it difficult for them to apply what they have learned to their daily lives, and they lose interest in learning.

The advent of 3D printing technology can make a boring classroom more interesting. By utilizing three-dimensional printing technology in maker education for primary and secondary schools, students are no longer merely reading texts or observing graphics, but rather use a computer to create a three-dimensional model based on theoretical knowledge and print it out using a 3D printer, instead of simply read text or observing graphics. It is the learning process through which students can absorb and apply knowledge. It can make the knowledge learned more vivid and interesting, and at the same time, greatly enhance the enthusiasm and initiative of students in learning and promote the improvement of students' ability to discover, analyze and solve problems.

Maker education pays more attention to students' hands-on ability. Of course, it also includes openness and sharing, encourages students to try boldly, and breaks time, space and age limitations. At the same time, it also pays attention to the personalized learning method. Through Internet technology, students can control the learning process independently. In addition, 3D printing technology, which is gradually becoming known to people, has now become the link and bridge to realize the promotion of maker education. The application of 3D printing technology in maker education for primary and secondary schools has brought a revolution of the times to comprehensive practical and information technology courses for primary and secondary schools.

6. Conclusion and Discussion

6.1 Conclusion

Maker education integrates information technology and creates a new world of innovative education. As a result of 3D printing technology, which can quickly convert a virtual 3D digital model into a physical model, teachers can devote more time and energy to innovative design projects, making the abstract concept of maker education more intuitive and visualizing the design ideas. Both teachers and students can cultivate their own innovative thinking, innovative spirit, and creative ability through playing, learning, and making in maker education so that students' imaginations will be more abundant, assist students in moving from "thinking" to "creation" and then to "innovation" and to realize the purpose of innovative design in creative manufacturing.

6.2 Discussion

As 3D printing technology continues to improve and is optimized, it has become a very integral part of people's lives and has become an integral part of their education. With the help of 3D printing technology, as part of this initiative, students can cultivate their innovative abilities more efficiently. It is expected that teachers and students will actively participate in the design process, analyze course tasks carefully, unleash their imaginations, and then print out their personalized models at the end. In order to further promote the application of 3D printing technology in maker education, more primary and secondary schools are expected to introduce 3D printing technology and begin to play a more prominent role in developing teaching services, educational reforms, and teaching models based on 3D printing technology.

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