The influence of 3D printing on the education of primary and secondary school students

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Abstract. As a product of high and new technology, 3D printing is applied to the education industry, and its impact on the education of primary and secondary school students is also of great significance. In creation, students can improve their practical ability and comprehensive quality. Observing objects before modelling helps to improve their observation and concentration. In the use of software modelling, we can give full play to their imagination to build models, improve their creativity and spatial imagination, stimulate students' enthusiasm for learning, and cultivate the habit of autonomous learning. After the completion of modelling printing, students can reflect on the problems found in time and improve them to improve their ability to think hard and solve problems. At the same time, both the modelling process and the analysis and thinking are inseparable from the mutual help of teachers and students, which also promotes the interactive learning and enhances the collective sense of honour. In the process of communication, which can promote students' communication and learning, so that teachers and students can make progress together.

Keywords: 3D printing, primary and secondary education, hands on ability, creativity.

1. Introduction
With the development of modern science and technology, 3D printing technology came into being. As a virtual reality technology, 3D printing technology is also an extension of multimedia technology. In China, the relevant policies issued by the government and the strong support of relevant enterprises for the technology make the technology not only develop rapidly in the manufacturing fields of industry, medical treatment, aerospace, fashion design, but also promote the development of the education industry. 3D printing technology plays an important role in Creative Education and STEAM education in China, which makes the learning style of primary and secondary school students more creative and interesting. Therefore, both small and refined 3D printing pens and high-end 3D printers are gradually entering students' classrooms, which will become an effective tool for future education development.

2. Domestic and international development status
Since the President of the United States repeatedly emphasized the importance of 3D printing technology in the 2013 State of the Union address, European and American countries have vigorously carried out the combination of 3D printing and education for primary and secondary school students. It aims to improve the practical ability and creative ability of teenagers. Up to now, almost all primary and secondary schools in the United States have opened 3D printing related courses, and a relatively perfect 3D printing education system has been formed. The United Kingdom, France, Germany, Israel, India
and other countries followed closely, vigorously promoting 3D printing courses. Among them, Israel, Germany and other countries have done quite well in this kind of science and technology education. China's Ministry of Education, influenced by Western European and American countries, also gradually carry out 3D printing education work. Government department policies have also been introduced one after another. In 2013 released the "National Science and Technology Support Program manufacturing field 2014 annual alternative project political performance guide". This document system introduces the specific contents of supporting the development of 3D printing industry. Since then, in China's primary and secondary school classrooms, especially in the cities like Beijing, Shanghai and Guangzhou are configured with 3D printers. And in 2017, the Guideline for Comprehensive Practical Activities Curriculum for Primary and Secondary Schools was issued [1], which clearly pointed out that 3D printing-related courses were offered in primary and secondary schools, and innovative laboratories were built.

3. The impact of 3D printing on the education of primary and secondary school students

3.1. Improve observation and concentration

3D printing is a rapid prototyping technology. Based on the digital model, it uses powder metal or plastic and other adhesive materials to construct objects by layer printing, which is a form of additive manufacturing [2]. The prerequisite for achieving 3D printing is the construction of a 3D model. The steps to construct a simple model are divided into two main steps. Firstly, the object is first carefully observed. Then use the software to restore the object to a certain scale. Students can only restore an object by carefully observing its shape characteristics at all angles, and even the shape characteristics of its internal cross-section. Observation is the basis for the development of abilities, and everything is done with observation as a starting point. Under traditional education, students acquire the geometric features of three-dimensional objects with their eyes. This is only a superficial perception, but lacks contact with the actual object. 3D printing technology can be a good way to improve this aspect. In the process of eye and hand contact, the properties of the object are better understood. Most common 3D printers used are manual 3D printing pens with PCL cryogenic filaments. The manual 3D printing pen requires students to work independently to complete the print job, which is done layer by layer. In order to complete the print, students need to understand the geometric characteristics of each layer. During the printing process, the students' attention and concentration are equally tested. Students have to control the speed and diameter of the filament out more precisely, which can control the roughness better.

3.2. Enhance creativity

3D printing technology is the product of creativity and benefits for the education of young students. At the same time, young people are the creators of higher innovative products of science and technology in the future. The process of 3D printing is: idea conception - 3D modelling - printing entity - reflection and improvement. In the idea generation session, students build simple models by observing things and understanding the geometric features of shapes. Based on this, they add their own unique ideas to the model. This makes the model more versatile and creative. In the creation process, students not only exercise their hands-on skills, but also develop their thinking and improve their creative ability. Therefore, primary and secondary school students are not only the beneficiaries of the development of science and technology, but also the pioneers to help the future development of science and technology.

3.3. Improve independent learning habits

In the traditional teaching, some abstract teaching concepts are involved. Teachers can only describe them through some pictures or animations, but the cost of animation is high and the production period is long. Nowadays, 3D printing can be used to turn abstraction into concrete and intuitive physical drawings. After the students understand the abstract teaching concepts, it is more conducive to motivate them to learn and improve their independent learning habits. For example, in chemistry, student will learn about the composition of water molecules. How exactly do you understand that a water molecule
is made up of two hydrogen atoms and one oxygen atom? By using a 3D printing pen or other 3D printing machine, the teacher can print out three spheres. Two of them are the same shape and size, and the other one is slightly larger. The two slightly smaller spheres are located on either side of the slightly larger sphere. As they learn that a water molecule is made up of three different atoms, students will have questions about a number of issues. Why are the three spheres not the same size? Why is the slightly larger sphere in the middle and not the other spheres in the middle? Why does a water molecule have to be one hydrogen atom and two oxygen atoms to reach a stable state? Out of curiosity and desire to know. Students will independently consult the information and solve their doubts. Thus, it is evident that teenagers' contact with 3D printing course can materialize the abstract teaching concept. This will not only stimulate students' memory, but also allow them to understand the concepts in depth and change passive acceptance to active learning[3].

3.4. Develop spatial imagination

Albert Einstein, winner of the Nobel Prize in Physics, said, "Knowledge is not as good as imagination, because knowledge is limited; imagination surrounds the world." Spatial imagination is an important dimension of imagination. Students with excellent spatial imagination tend to do well in geometry [4]. Industry professionals tend to use professional modelling software, such as 3Ds MAX, Pro-E, SolidWorks, Rhino, etc. Simple modelling software for the education industry mainly includes: 3D Magician, 3D Artist, 3D one, etc. These software are more in line with the cognitive and learning abilities of adolescents. Figure 1 is the editing interface of 3D one, which contains some simple editing commands. Students can use the simple modelling software to draw spatial 3D entities, in order to develop spatial imagination and enhance the comprehension of three-dimensional geometry. The new standard education emphasizes quality education and aims to cultivate students' comprehensive literacy, especially the mastery of spatial comprehension. As students grow older, their knowledge and understanding of three-dimensional geometry gradually deepens. There is a gradual recognition from simple individual objects to combinations between individuals. Simple individual objects can be facilitated by pictures or objects provided by the teacher. However, for combinations of geometric objects, students are often unable to form spatial concepts in their minds. With simple modelling software, several 3D objects can be combined. The software allows 360° observation of geometric features in different directions, thus stimulating students' imagination of space.

3.5. Develop reflective and problem-solving ability

3D printing technology as applied to industry often starts with the construction of a prototype in solving real-world problems. But this prototype does not always meet the actual needs. The optimal solution to the problem needs to be found in a later stage of continuous revision. This approach of building prototypes first and then refining them is applied to the education industry as well. The student's knowledge of the model exists only in terms of the observation of the model in the software. The shape of the model is roughly the same as the model they want in their minds. However, the printout is not 100% accurate. For example, if you print a water cup, the thickness of the water cup can be set artificially in the software. The thickness is too thin may lead to water spills, and the thickness is too thick may be too heavy or unattractive. The criterion for judging whether a physical object meets the expectations is whether it meets the needs in terms of application. This requires students to reflect on the model and open their minds to optimization of the model. Only by reflecting carefully and improving on it can we really solve real problems. And from this, students can improve their self-confidence. At the same time, 3D printer is not a simple toy, it is a veritable industrial and innovative mechanical product. Students will need to learn how to use the 3D printer, how it works, and modelling software in the process. When the machine breaks down, they also need to learn how to troubleshoot. The students will develop critical thinking, patience in solving machine malfunctions, and perseverance in solving that problem.
3.6. **Promote cooperation**

3D printers coming into the classroom can transform any course into an interactive learning experience. Whether it is for the observation of the actual object, planning the geometric characteristics and spatial location of the model, reflecting on the need to refine the model after modelling, or the solution to a malfunctioning device, we can talk to each other. Work with your classmates and teachers to complete the work. The collective wisdom is huge and the solutions to the problem are countless. There is a sense of satisfaction for each participant in the final product of excellence. The classroom is no longer a one-sided transfer of knowledge from the teacher to the students, but a communicative learning process. Not only do the students learn, but the teacher also learns from the experience to improve the quality of teaching.

4. **Conclusion**

3D printing technology is considered to be one of the most important symbols of the third industrial revolution. Its application prospects are bound to be even broader. The introduction of 3D printing technology into the classroom will certainly cultivate and improve students' hands-on skills, independent innovation, teamwork and independent thinking ability. However, there is still a long way to go for 3D printing to be widely used in China's education industry. The main issues are still focused on: government and corporate investment, teacher training and certification, construction and maintenance of science labs, and development and improvement of curriculum systems.
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