

Advantages of Using 3D Printing in Education

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Abstract – This article describes the use of modern 3D printing tools in the learning process: their use in various educational fields, as well as the advantages of these means compared to typical teaching tools.

Keywords – Fused Deposition Modeling, 3D printing, slicer, g-cod, layer, STEAM, education, Computer Aided Design.

In anticipation of the description of the possible advantages of using 3D printing in education, we consider modern technologies that implement it.

3D printing works, starting with a digital model in a 3D CAD (Computer Aided Design) file, and then creating a physical three-dimensional object. An object is scanned - or an existing object scan is used, which is processed by software known as a “slicer”. Slicer converts the model into a series of thin two-dimensional layers and creates a file with instructions (G-code), taking into account the specific type of 3D printer.

The type of 3D printer that is most commonly found in classrooms is called the FDM Deposition Modeling (Fused Deposition Modeling).

In his article, Etinn H. and Timiryazev V.A. give the following definition of layered printing: “Additive technologies are the latest production methods for various products, including metal ones. Technologies can be used both to create the product and to process the created product, and the resulting material has the same mechanical and physical characteristics as the products of a conventional blacksmith or foundry”[1]

The 3D printer applies the necessary combination of raw materials (plastic, metal, rubber, etc.), and then builds the object by adding one layer at a time, a 2D layer after a 2D layer, until it is fully designed and completed in accordance with specified design criteria from the source CAD file.

To use 3D printing in education, you need to bring objects from the computer screen to the real, physical world - and transfer them to the hands of students for verification, analysis and other processes that use physical manipulation.

Here are just a few examples of how students in schools and students in higher education can use the 3D printer in the classroom:

- Historian students can print historical artifacts for study;
- Graphic design students can print 3D versions of their work;
- Geography students can print topographic, demographic, or population maps;
- Chemistry students can print 3D models of molecules;
- Biological students can print out cells, viruses, organs and other biological artifacts;

- Mathematics students can print 3D models of problems to simplify and visualize their solutions.

Here are some of the ways 3D printing technology bridges the gap between the physical and digital worlds - find what you need on the screen and then print it in practice.

As the cost of 3D printers is becoming more and more affordable, they are no longer just another technology gadget for students, but have become an important and useful educational tool. They make learning and education better, more interesting, more entertaining and easier.

3D printing is one of the tools that helps students comprehend and visualize their projects, developing their work from the stages of sketch design to the final product.

Consider some of the key benefits of 3D printing in education.

In terms of growth and development, future designers, engineers, and artists will be students affected by 3D printing.

Creates a stir. 3D printing offers students the opportunity to test their designs from the model stage to the actual creation of the model. This creates both excitement and a better understanding of the design process, as they gain practical experience from design to model creation. Individual elements are more clearly visible when the student builds the project layer by layer. Excitement is also associated with the ability to explore details in reality, and not just on the screen or in the textbook. 3D printing also brings the world of theory into the physical world, where students can see and touch, opening up new possibilities for learning and teaching.

Complementing the curriculum. No matter what curriculum is used, 3D printing can help students and teachers work better. 3D printing frees students from passive consumption of information on the screen without thinking about productivity. Unlike ordinary classrooms, where students are easily bored, they become active and involved participants through the concept, design and implementation of their projects and interaction with a 3D printer and teacher.

Provides access to previously unavailable knowledge. Since most 3D printers are pre-mounted, plugged in and working, this is an interesting advanced technology for students. Students will learn that it is entirely acceptable to fail on the first try, and then try again to improve the results. When students begin to realize that failure is part of the

process, they are less afraid of trying to bring new and different ideas to life. This strengthens the confidence of students, and teachers enjoy the fact that students are motivated and confident.

Opens up new learning opportunities. An affordable 3D printer offers unlimited learning opportunities for students. 3D printing gives students the opportunity to experiment with ideas, expanding and developing their creative potential. It is not easy for young students to understand without visualization. The visual learning environment improves their understanding of the world, allowing them to touch and see their projects. 3D printers open up new possibilities for presenting information to young students in an economical and efficient way.

Helps solve problems. The 3D printer offers a variety of learning opportunities. They need to learn how different 3D printers work and how to manage them, as well as how to troubleshoot and solve problems. This is an art that many students cannot practice during their regular studies. By learning to troubleshoot and solve 3D printer problems, students learn to be persistent and endurance in overcoming difficulties. This can help students solve their problems in life.

So, for example, when studying anatomy, problems arise with the use of visual materials and 3D printing is able to solve them. As Makmenamin P.G. wrote in his article *Kuali M.R. McHenry S.R. and Adams J.W.* : "... additive manufacturing or three-dimensional (3D) printing allows you to create reproductions of an opened (body) person and other anatomical samples that eliminate many of the above problems. "These 3D prints are accurate, high-resolution color reproductions based on data obtained from surface scans or computed tomography." [2]

Developing students' creative skills can help develop a passion for original thinking and creativity that can later be applied to business. 3D printing contributes to student achievement and prepares them for college. They develop confidence that allows them to take complex courses, such as courses at STEAM. As students develop and improve their imagination, they also develop innovations where the student creates their own unique 3D projects that can help educate others and solve various problems that arise both in the learning process and in everyday life.

As can be seen from the above, 3D printing allows each student to dream more and better plan their future destiny.

Some people may not know what 3D printing is, or they are not interested. But whether we know it well or not, we

must admit that 3D printing affects our lives and unconsciously changes many things. For example, industrial production, medical applications, food production and even the field of education are changing with the growth of 3D printing. We will have a more convenient, efficient and innovative future, a future in which everyone can realize their creative potential.

What 3D printing can bring to the field of education is not only the experience of new technologies, but also the revolution of the educational regime. We can say that 3D printing is more associated with the implementation and application of quality education, which has been discussed for a long time. This is a combination of books and practice in the true sense of the word and the embodiment of the use of creative abilities, practical abilities and practical skills of applying knowledge by students. In addition, it can increase student interest and improve their autonomy in new ways.

Currently, the application of the 3D printing industry in education mainly includes the following methods:

1. Extracurricular (extracurricular) education

Out-of-school (extracurricular) education is currently a popular way of learning. Many primary and secondary schools and universities encourage students to participate or even organize such interest-enhancing courses, events, etc. Colleges and universities mainly use the form of associations to enrich students' lives and enhance their emotions, while primary and secondary schools can enrich student lives and improve interaction between parents, teachers, and children. 3D printing is not only suitable for this development path from technology to operation and timeliness, but also helps to attract student interest.

2. The use of instruction in primary and secondary schools.

With the promotion of quality education, more and more primary and secondary schools are realizing the importance of developing knowledge and skills. In this regard, the effect of using 3D printing is remarkable. It provides a combination of textbooks and applications that are easy for children to understand, and increases children's ability to craft, ability to work together, etc. through design and printing. It also helps stimulate children's interest in learning.

3. Teaching at lyceums and universities

Currently, more and more lyceums and universities have begun to create "creative laboratories." 3D printer appears in an increasing number of classes of lyceums. This is based

on preparing the future technical talented person. Lyceums and universities also focus more on combining technology and knowledge. They gradually abandon traditional teaching methods, give students more open education and training, and make textbook knowledge more effective in practice.

4. Research and development.

3D printing technology is mainly used in scientific research of institutes and universities, which depends on the ease of use of 3D printers, especially desktop 3D printers. It is more suitable for the research environment of lyceums and universities, more convenient for students to use, more efficient from design to production and achievements.

In the future, 3D printing will make the educational industry more attractive. We look forward to the emergence of more and more innovative talented people in the future. After the development of the 3D industry, many designers and manufacturers began to use 3D printing instead of the traditional process of manufacturing industrial products. The reason 3D printing can be accepted and approved by designers and manufacturers is because it can save a lot of cost and time. The product can be subjected to endless testing from the very beginning of production to final copies. This allows students to be trained in specialized professional areas in a process integrated with various stages of production.

For students who choose medicine as their future profession, 3D printing also carries many innovative methods. For example, as Murphy S.V. wrote in his article and Atala A. : "Additive manufacturing, otherwise called three-dimensional (3D) printing, stimulates major innovation in many areas, such as engineering, manufacturing, art, education and medicine. Recent advances have allowed 3D printing of biocompatible materials, cells and auxiliary components into complex three-dimensional functional living tissues. 3D bioprinting is used in regenerative medicine to meet the needs for tissues and organs suitable for transplantation. Compared with non-biological 3D printing, bioprinting is associated with additional difficulties, such as the choice of materials, cell types, growth and differentiation factors, as well as technical problems associated with the sensitivity of living cells and tissue design. The solution of these difficulties requires the integration of technologies from the fields of engineering, biomaterials, cell biology, physics and medicine. Three-dimensional bioprinting has already been used to generate and transplant several tissues, including multilayer skin, bones, vascular grafts, tracheal splints, heart tissues and cartilage structures." [3]

3D printing is a watershed in higher education schools and training centers. It provides a whole new level of creative teaching and understanding for students. And with greater accessibility, more than ever, bring 3D printers to the classroom.

Simon Ford and Tim Minschall in their article “Where and how 3D printing is used in training and education” [4] identified 5 studied categories related to the use of 3D printing in the education system:

1. Teaching students of 3D printing
2. Training of teachers of 3D printing
3. Design and creativity training
4. Creation of artifacts to aid in learning
5. Creation of assistive technologies.

After exploring these categories, they came to the following conclusions: “... there are many future areas of research that scientists could develop to deepen our understanding of the adoption of 3D printing and practice in the education system. ... We hope that these questions will help researchers begin empirical studies of the use of 3D printing in the education system, and that the development of answers to (posed) questions will serve as the basis for 3D printing policy in the field of education ”[4].

3D printing can be applied at all levels of education, from primary schools to universities. Not to mention the fact that almost any subject can be easily taught using a 3D printer. This can help make the learning process more interesting.

These are just a few examples, but the use of 3D printing in education can be a fairly large area.

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