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ORIGINAL ARTICLE

# A study on the design education method using 3D pen in an era of manufacturing change

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**Abstract**
With the development of 3D printing technology, there will be a lot of changes in manufacturing. Recently, research on 3D pen using 3D printing technology is increasing. Unlike 3D printing, 3D pen can print products instantly. So, 3D pen will be applied in various fields. In this study, the design education method using 3D pen was studied. The results of this study are as follows. First of all, design education using 3D pen can develop students' creativity and problem-solving skills. In particular, this curriculum can be used in making education. The results of studies are expected to be important data for future education. Moreover, these results could be the basis for making textbooks for future schools. In the future, 3D pen should also be developed for students to use in practice.

**Keywords** Design education · 3D pen · Fourth industrial revolution · Manufacturing change

## Introduction

### Research background and purpose

With the development of artificial intelligence and 3D technology, it is expected that there will be many changes in manufacturing industries for the future. Today, various technologies related to 3D printing technology are developed. So students need to study 3D printing technology from an early age. In particular, 3D pen using the principle of 3D printing is used in various places. Therefore, education reform is needed in this era of change. Therefore, the purpose of this study is to suggest the direction of future education. And this study suggested a teaching method using a 3D pen. Advanced countries such as the USA develop various experience programs using 3D pen. However, there is a lack of research on educational utilization compared to the excellence of 3D pen tools. Students can express lines using 3D pen. The line is the beginning of every design. And students can understand the formation through the lines. For this reason, scientists argue that education using 3D pen helps stimulate and encourage creativity and problem-solving skills. Therefore, this study analyzed the design education method among the various curricula using 3D pen. Also, the results of this study can be a useful material for future education in the era of the Fourth Industrial Revolution.

### Literature review

With the development of 3D printing technology, manufacturing will change in the future. And, various experts have studied many things about 3D printing technology. Among such studies, the typical direction of study is the 3D pen. 3D pen is a tool that anyone can use at a relatively low price. In addition, 3D pen will be popular and widely applied in various fields in the future. Therefore, education on the use of 3D pen is also important. So this paper is going to study the teaching methodology using 3D pen. The prior studies related to 3D pen were as follows. Soo and Soo [1] found in expressing the beauty of traditional Korean calligraphy onto fashion in a new aesthetic sense through the fusion of 3D pen technology and handicraft. Bae [2] verified the effects of the 3D pen aided activity-centered education program on creativity and emotional intelligence of elementary school students. Woon [3] allowed many workers to improve the quality of their product with the accessories they used in practice without any constraints or problems, reducing the difficulties in manual work and improving the design and work

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efficiency with semi-automatic function. Woo et al. [4] suggested the therapeutic potential of the 3D printing pen to improve visual-perceptual and hand functions in stroke patients. Eun and Hee [5] suggested the plan of using 3D pen by investigating and using its case of application, kind, material and how-to-use and producing hair accessories and applying them to actual hairs, which was willing to be the basic data that would be capable of creative hair design by using 3D pen. Ah and Hyun [6] analyzed empirically the relationship between factors influencing intentions to participate in science and technology learning by learners' using 3D pen from the viewpoint of the technology acceptance theory model (TAM). Su and Ho [7] attempted to investigate the changes in creative expressions when students used a 3D pen for description and experience in Korean class that was based on storytelling. Kyung and Shin [8] developed three-dimensional and experimental makeup design focused on Iris van Herpen's fashion. For the theoretical research, the characteristics and makeup characteristics of Iris van Herpen's fashion show and the concept, characteristics, and kinds of 3Doodler were examined based on previous researches, Internet data, and specialized materials. Most studies have conducted studies on the utilization of 3D pen. Some papers carried out research on education using 3D pen. However, these papers were not enough to be used in practical education. So this paper studies the 3D pen design teaching methodology that can be used in educational institutions. These findings can be regarded as theoretical basis data in relation to 3D pen education.

## Research method

In this paper, the design teaching methodology using 3D pen was studied. The findings in the paper will be important support for future education courses. The research methodology in this study was as follows. First of all, in this study, the principles and types of 3D pen were studied in the literature. In addition, the use of 3D pen was analyzed in this paper. These literature studies used papers, newspaper articles, and books. Based on literature review, this study analyzed the educational application of 3D pen. In addition, based on the analysis results, the researcher used a qualitative research method. As for the qualitative research method, in-depth interviews were conducted. The subjects of the in-depth interview consist of teachers who teach 3D pen and students who learn 3D pen. Also, the researcher interviewed experts in related fields. As a result, this study aimed to present a generally available 3D pen design training method. The results of this study can be the theoretical basis data of future design education.

## A theoretical study

### 3D pen

3D pen is a tool that a 3D printer is made in the form of a pen. 3D printing technology is a key technology in the era of the Fourth Industrial Revolution. 3D printer technology is to create 3D products as if printing pictures. In addition, 3D fan technology along with 3D printer technology is very important. The basic principles of 3D pen are as follows. First, plastic filaments are inserted into the main body of 3D pen. They then melt in the main body and flow out through the pen point to create three-dimensional shapes. People can easily create various works through the convenient tool. Typical materials used in 3D pen are ABS and PLA that are commonly used plastic materials in 3D printing. These materials are common in life and are very durable. Currently, scientists conduct research on various new plastic materials. A typical 3D pen is a three-doodler that won the 2014 U.S. Innovation Award and drew the attention from international media. Three-doodler's 3D pen produces heated plastic at the tip of the pen when the button is pressed. Since heated plastic hardens quickly, it can make stable models. So in the USA, three-doodler's 3D pen is widely used for education purposes. Also, students can easily make the desired shape in the air with a three-doodler's 3D pen. And three-doodler's 3D pen has a low fever temperature, which makes it easy for young students to use. Also, three-doodler's 3D pen is easy for anyone to use without special software and computers.

### 3D pen utilization

3D pen can be used in various fields. Especially, 3D pen is used to make food like 3D printer. The application of new technology in food is of interest to many scientists. Therefore, food using 3D pen is spreading around the world, but research is still lacking. Food using a 3D pen is extracted after making liquidity such as chocolate or sugar. In the USA, there are also restaurants that use 3D printing technology to make food. Food using this 3D pen will become popular in the future (Fig. 1).

3D pen can also bring innovation to the work of artists. For example, in the USA, 3D pen is used as new tools in clothing industry. There are two types of clothing that can be classified. The first type is a 3D pen costume. Three-dimensional clothing is made using plastic filaments, a material of 3D pen. And the second type is the outfit that combines 3D pen and fabric material. This type of clothing is made with 3D pen on top of the fabric material. These costumes can implement designers' ideas immediately. And 3D pen is relatively easy to modify and change the design (Fig. 2).

**Fig. 1** Cooking with 3D pen [3]

**Fig. 2** Clothing with 3D pen [1]

## Design education using 3D pen

### 3D pen education

3D pen education is linked to STEAM education, and an educational program is developed to enhance creativity. In particular, 3D pens can facilitate art education and used in the maker field. Because of these characteristics, it can be used in design education. In design education, it can be used not only in architectural design but also in various fields such as costume design and product design. In the USA, many designers use 3D pen to design decorative items. And 3D pens can utilize new creative tools. With the development of 3D printing technology, individuals can easily make products. In the future, individuals will use 3D printer and 3D pen to make the products they want. Under these circumstances, education using 3D pen will become very important (Fig. 3).

### Design education using 3D pen

3D pen's education program can be used in various design curricula to enhance students' creativity. Design targets can range from basic models to art products and paintings. Simple products such as key chains can also be subject to design training. 3D pen's design education program is divided into several parts. The criteria for classification were based on the results obtained through qualitative research. In the first step, teachers explain to students the principles, how to use, and areas of use of 3D pen. Through these lectures, students can have a basic understanding about 3D pen. In the second stage, students make simple forms using 3D pen according to teachers' instructions. Through these activities, students get to know how to use 3D pen. In the third stage, students think of the desired products. At this time, students are at the stage of creating various ideas on their own. They find problems in their daily lives and think about what products

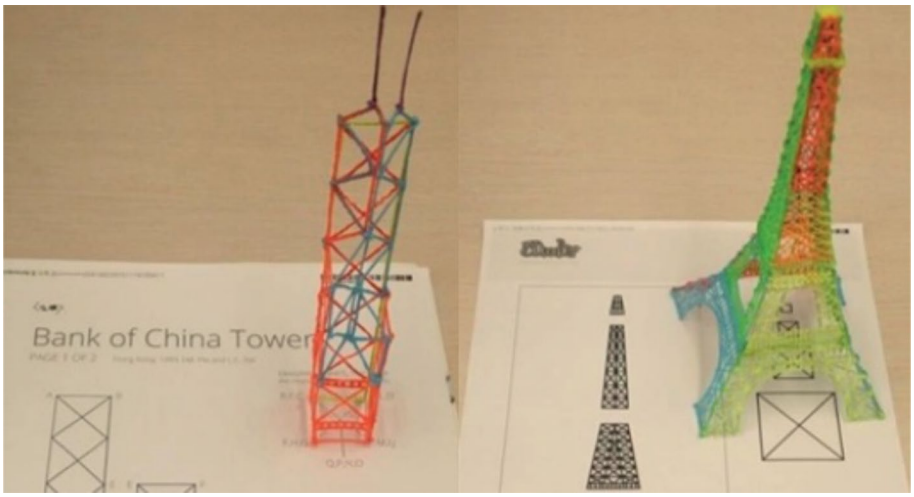


**Fig. 3** Design education using 3D pen [4]

they need to solve them. Through these ideas, students can make creative products. In the fourth step, under teachers' guidance, students draw a floor plan based on their own ideas. These floor plans can be in various forms. In the fifth step, students draw a three-dimensional form of perspective. These pictures are based on the floor plan. Through these courses, students can learn from two to three dimensions of change. In the sixth step, students complete the product using a 3D pen based on prior and prepared drawings. These products can be used in combination with electronics. So the product can be a component that makes up the appearance of electronics using 3D pen. Robot education has also been activated recently. It can make a product that combines 3D pen with this robot education. The appearance of the robot can be configured using a 3D pen. It can also automatically move the robot by attaching various sensors to its appearance. In the seventh step, students present their products to other students. So students can compare and verify products while sharing ideas with other students. Through these courses, students can develop creativity and problem-solving skills (Fig. 4).

## Effect of 3D pen on design education

Design education employing 3D pen has important meaning as an experience activity. Even elementary school students can use the 3D pen easily. Also, 3D pen is easy to transform into new products based on existing products. The effects of specific design education using 3D pen are as follows. First, in the era of the Fourth Industrial Revolution, the ability to solve problems is very crucial. Through this course, students can identify problems in life and develop their ability to solve these problems. Second, this education has the characteristics of play, so students can more likely find it interesting. Students can have motivation for new technology by using 3D pen. Third, students can learn how to cooperate with other students as they complete their work. Fourth, students can develop their artistic abilities. Finally, education using 3D pen can enhance students' creativity.

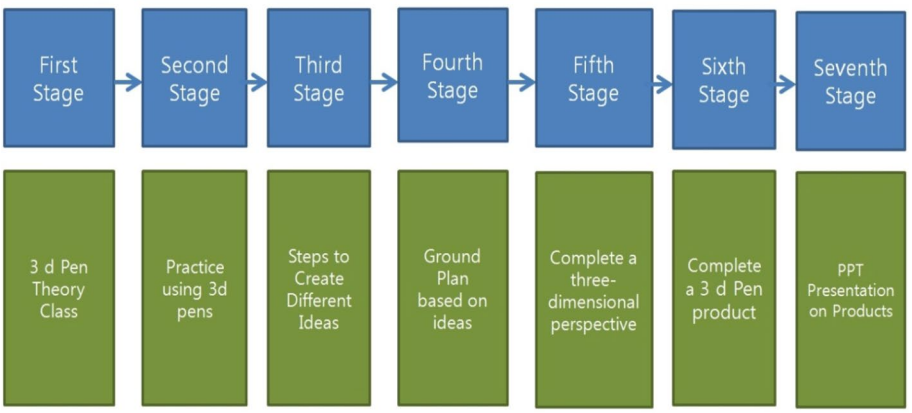


**Fig. 4** 3D pen's design education program

## Future development direction of 3D pen

With the development of various tools, DIY (Do it yourself) culture is spreading worldwide. Under these circumstances, students will solve problems by themselves through this curriculum. And 3D pen is easier for people to learn than 3D printing. In the future, many people can make the desired product based on a 3D pen. When various 3D pen materials are developed in the future, 3D pen will be used in various fields. The scope of creation using 3D pen will also be expanded. And through this process, users will be able to develop their scientific thinking and creative imagination.

## Conclusion

This study conducted a research on design education methods using 3D pen. Through this education, students can learn creativity and problem-solving skills. In particular, this curriculum can be used in making education. Making education will be very important in the future. Students can also develop their own ability to make products through 3D pen. In the future, 3D pen will be a very important tool. However, 3D pen is not very popular yet. Because 3D pen is a new technology, popularizing 3D pen takes a lot of time. Later, various educations using 3D pen will be provided in schools. The results of the study could be used in future education. In the future, as various technologies emerge, school education must also change. Therefore, the results of this study can be theoretical basic data for future school education. Also, the results of this study will need to be verified through experiments.

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