

## **Design of STEAM Education Process applying 3D Printer for Computational Thinking**

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### ***Abstract***

*Many practitioners in educational field, recently, are seeking to improve Computational Thinking through SW education. The purpose of this paper was, for promotion of SW education, to design the STEAM education process utilizing 3D printer. The project-based education process emphasized the cooperation in the process of producing common results and proposed a new STEAM education process. The designed products are expected to be used in the elementary school classes by linking with the camp and teacher training programs and the curriculum.*

**Keywords:** *STEAM Education, 3D Printer, Computational Thinking, SW Education, 3D Modeling*

### **1. Introduction**

The core of the recent educational paradigm is to break down the boundaries of the various disciplines and to converge them for communicate with each other [1,2]. The Computational Thinking [3] is a cognitive ability that can be used to solve the problems at hand not in a specific domain but in all areas of discipline and include a method to apply knowledge and skill to develop ability and solution used in processing complex problem and data.

The educational application of 3D printers [4] is for learners to imagine ideas, design them, and output those using printers. The learners, in this process, experience, in addition to development of creative idea, solving problems through modeling and simulation using information communication technology and obtaining concrete result as the output. This experience can be a way of developing 'Computational Thinking'. Given the emphasis on the importance of SW education[5], the exploration of the method for the educational utilization of 3D printers with the aim of Computational Thinking.

3D printer [6] is a printer that produces 3D objects. This technology was invented by 3D Systems founded by Charles W. Hull of the United States in 1884. 3D printers have become an issue in recent because the technology-related patents have been released and this allowed the production of inexpensive printers that can be widely used even at home. The prevalence of inexpensive 3D printers and the social atmosphere where encourages individual personality and creativity made the 3D printer to have great effects on daily life such as manufacturing, fashion, and life accessories.

The purpose of this paper was to design the STEAM education process using 3D printer, an advanced technology, to improve learners' Computational Thinking. Increasingly more studies on the feasibility of educational use of 3D printer have been performed in order to change the paradigm of existing school education by utilizing 3D printer. The development of national curriculum and educational strategies on this theme is, however, still insufficient and the educational environment using 3D printers for elementary school students is relatively inferior. This means that it is urgent to develop systematic textbooks and curriculum that can utilize 3D printers that can replace the main class in elementary schools.

This paper is organized as follows: In section 2, 3D printer and STEAM as related fields are reviewed. The STEAM Education Process is described in section 3. In section 4, the examples of the applying the designed process are presented. In section 5, finally, conclusions and future research are discussed.

## **2. Background**

### **2.1 3D printer**

The output created by the learner him/herself through planning and designing and 3D printing process can be used as a learning tool for various subjects. These almost infinite applications may change the paradigm of education. The previous studies in the field of education related to 3D printers were reviewed.

Kim [7] evaluated the feasibility of applying 3D printing learning to class by studying the development of curriculum and teaching material for 3D printing learning for elementary students based on the curriculum-related contents.

Cho et al. [8] showed that the mathematics class using 3D printer for middle school students can improve their Computational Thinking and allows them to feel a 'hard fun' from the achievement resulting from deep thinking and exploration, by studying the meaning of 3D printer in mathematics education

Lee [9] studied the development of inventive education program using 3D printer and 3D drawing program and reported that the 3D printer-assisted education is effective in improving creativity in elementary school students.

Choi & Yoo [10], in their study on the methods for educational utilization of 3D printing, analyzed and compared various modeling programs and their characteristics and proposed an education program based on creative design model to be incorporated into elementary school curriculum.

Lee [11] studied STEAM education where the mathematics and art are linked through 3D printing and suggested the feasibility of STEAM education using 3D printer.

Lee [12], in her study on the prospect of using 3D modeling-based 3D printer in art education, explored new expression method by 3D-modeling the virtual plastic image on web browser and bringing the image to real space using 3D printer and investigated the feasibility of using such process in art education.

Kim et al. [13] investigated the research trends on 3D printer home and abroad and found that the domestic education program for 3D and the scope are more limited than those of other countries.

### **2.2 STEAM Education**

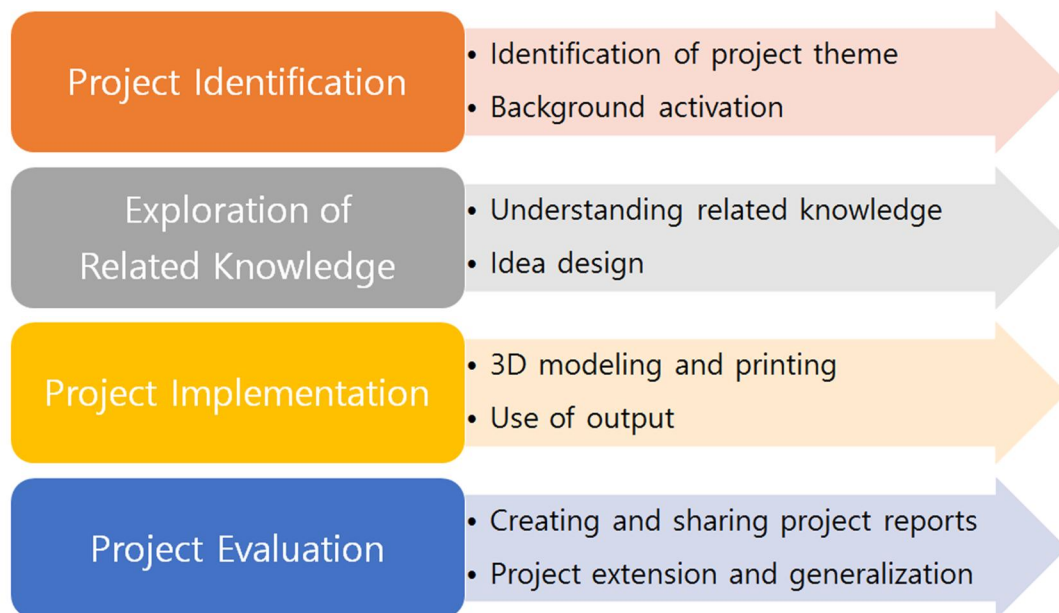
STEAM stands for the first letter of each Science, Technology, Engineering, Arts, and Mathematics. This is a form of educational paradigm that converges science, technology, engineering, art, and mathematics for creative education. The education in the school, up to now, was a way of conveying the knowledge to the students only through the lecture, without considering the convergence with other disciplines. The STEAM education, on the other hand, is an education where the students are allowed to solve the problems by themselves and, in the process, to acquire knowledge by linking and thinking about contents of various academic [14,15].

The main difference between STEAM education and existing education is the presence of 'convergence' [14]. The science education, so far, has been aimed at transferring knowledge within the science curriculum, therefore there was a limit for students to understand integration and convergence among disciplines. The convergence emphasized in STEAM education, however should naturally utilize the knowledge and functions of various subjects in order to solve the real life problems, and convergence should occur naturally in this process. Not all elements of S, T, E, A, and M, in STEAM education, should be included in each problem but the inclusion of necessary parts related to the topic is encouraged. The goal of the STEAM education is to solve this problem, and convergence is a phenomenon that occurs in the process. Another difference is the inclusion of Art (A). The futuristic talents who have completed STEAM education will have the ability to solve everyday problems using mathematical techniques by utilizing technical and engineering elements based on scientific knowledge and with artistic sensitivity [14].

One of the main purposes of STEAM education is to trigger interests in science and technology [14,15]. When the students' interest in science and technology increases through STEAM education, the number of students entering the science and technology field as their career will increase and the capacity of science and technology field will also be strengthened.

### 3. STEAM Education Process

This paper, as shown in Figure 1, proposes a project-based STEAM Education Process designed by basing on existing 3D printing learning model [6], to improve students' Computational Thinking.



**Figure 1. STEAM education process for computational thinking**

The steps for STEAM education process to improve Computational Thinking are as follows: In the Project Identification step, the themes of the project are identified by using various material related to project themes and groups are formed. In the Exploration of Related Knowledge and Design step, students learn knowledges

related to theme. The students, in this step, are encouraged to produce creative more completed outcome through the deeper learning without considering the boundary of curriculum and to survey and idea design for 3D printing by groups after learning related knowledges. In the Project Implementation step, the modeling, slicing, and printing are performed and, by using the outcome, the project activities are performed. In the Project Evaluation step, the project reports by each group are developed and shared and the further learning for expansion and generalization of project are discussed.

Table 1 shows the learning plan for program of 12 sessions developed on each step of project.

**Table 1. Education Process using 3D Printer**

Steps	Theme	Activity
Project Identification	Identification of project theme and group formation (#1-2 sessions)	<ul style="list-style-type: none"> <li>• Identification of project theme and group formation</li> <li>• Review of theme</li> <li>• Exploration about the theme by group and share of ideas</li> </ul>
Exploration of Related Knowledge	Understanding related knowledge and learning function (#3-4 sessions)	<ul style="list-style-type: none"> <li>• Understanding of mathematical and scientific knowledge related to theme</li> <li>• Ideal design by groups</li> <li>• Learning function of 3D modeling by examples</li> </ul>
Project Implementation	3D modeling and printing (#5-8 session)	<ul style="list-style-type: none"> <li>• Idea design and 3D modeling</li> <li>• share of modeling and adjustment/supplementation</li> <li>• 3D printing</li> </ul>
	Producing project outcome (# 9-10 sessions)	<ul style="list-style-type: none"> <li>• Producing products by using 3D outcome</li> <li>• Producing targeted product of group</li> <li>• Share of producing process and adjustment/supplementation</li> </ul>
Project Evaluation	Applying 3D printing outcome and presentation of project report (#11-12 sessions)	<ul style="list-style-type: none"> <li>• Applying 3D outcome</li> <li>• Developing project report</li> <li>• Share of activities of other groups</li> </ul>

## 4. Case Study

### 4.1 Identification of Project

In this 1st step, as shown in Figure 2, groups are created and the themes are selected. The teacher proposes a real life problem related to contents to be explored. The students are divided into several groups and the identification of project theme is checked through discussion in group. The investigation of the theme is performed and the ideas are shared among group members.



**Figure 2. Identification of Project**

#### **4.2 Exploration of Related Knowledge**

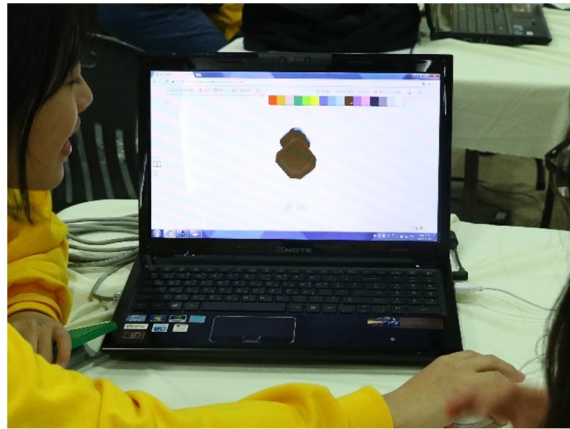
In this step, the understanding of mathematical and scientific principles related to theme is sought based on the knowledge acquired in the 1st step and a target ideas of each group are designed. And the usage and function are learned, as shown in Figure 3, using examples. This step is not only for learning usage of modeling tool but also for learning a method to express their own thinking by using tool.



**Figure 3. Exploration of Related Knowledge**

#### **4.3 3D Modeling and Printing**

In this step, the models designed in each group are 3D-printed. Because the usage of the published many SWs related to 3D printing is difficult, students spend more time in learning how to use software rather than in expressing their thoughts. This paper, therefore, used an easy-to-use SW based on pixel art (see Figure 4). This SW also works in computer and mobile environment, making the modification and share of models to be simple.



**Figure 4. 3D Modeling SW**

The general-class 3D printer has limitation in displaying various colors, meaning that the output work needs to be complemented. The coloring work referring to modeling screen was added in this paper.

#### **4.4 Producing project outcome**

In this step, the co-producing outcome of the group is produced based on the output of individuals as shown in Figure 5. The core of proposed education method is convergence. The ideal situation is where the idea that the team has created can be expressed in the modeling tool used and all the results are output, however, there are many limitations such as time and cost. This paper, therefore, the 3D printer was used only in expressing core part and the rests were made from easily available materials. This behavior is a very important part of STEAM because it allows for student, in future, to grasp the limitations of the tools used in real life, to recognize the limitations of the implementation, and based on them, to modify the ideas.



**Figure 5. Producing project outcome**

#### **4.5 Presentation of Project Results**

In this step, the outcomes are shared through presentation and evaluated each other as shown in Figure 6. The students presents how to apply the outcomes and the project reports are developed by all students. This step is for improvement of outcome by feedbacks to and from each other. The project is concluded by sharing the group activities.



**Figure 6. Presentation of Project Results**

## 5. Conclusion

The core of SW education is the growth of Computing Thinking, and it is important to consider various needs of learners based on their levels or current state of learners in conducting education. Many practitioners in educational field, recently, are seeking to improve Computational Thinking through SW education. The purpose of this paper was, for promotion of SW education and triggering the interest and excitement for learners, to design the STEAM education process utilizing 3D printer, and advanced technology. The project-based education allowed learners to acquire sense of cooperation and to improve their problem solving ability through convergence with real-life problems. These programs developed based on up-to-date technology and issue are expected to help them to grow to a convergence-type talents. The developed STEAM education process using 3D printer can be used easily in school. The understanding of technology and function of 3D printer is expected for student to be interested in science and engineering fields and to provide vision for their own career.

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## References

- [1] H.J. Lim, A Study on Reformulation of STEAM education process and case studies, <http://eduzine.busanedu.net>
- [2] B.R. Kim & H.I. Jeong, "A Case Study on Art-centered STEAM education program using Mobile", Collection of Treaties on Art Education, Korean Art Education, 2012.
- [3] E.K. Lee, "STEAM Education to Enhance Computational Thinking", pp.47-51, 2012.
- [4] W.Y. Kim, "A Practical Study on Data Analysis Framework for Teaching 3D Printing in Elementary School", International Journal of Internet, Broadcasting and Communication(IJIBC), Vol.8 No.1, pp.73-82, 2016.
- [5] Y.D. Lee, etc., "The Development of an Educational Robot and Scratch-based Programming", International Journal of Advanced Smart Convergence(IJASC), Vol. 5, No. 2, pp.8-17, 2016
- [6] W.Y. Kim, 3D Printer Curriculum and Textbook Development, Daegu Digital Industry Promotion Agency, 2014.
- [7] W.Y. Kim, "A Study on Analysis of Curriculum for Maker Education using 3D Printer at Elementary School Classroom", International Journal of Advanced Smart Convergence(IJASC), Vol.6 No.4, pp.60-66, 2017.
- [8] H.H. Cho, etc., "3D Printer and Mathematics in Free term system," The Korean Soc. Math. Ed., Vol. 2014, No.1 pp. 209-215, 2014.

- [9] Y.C. Lee, A Study on the Effects of an Invention Education Program Using 3D Design and 3D Printers on Elementary School Students' Creativity (Master dissertation), Graduate School of Education, Jeju National University, 2015.
- [10] H.S. Choi & M.R. Yoo, "A Study on Educational Utilization of 3D Printing", Journal of the Korea Contents Association, volume 19, issue 2, pp. 167-174, 2015.
- [11] S.G. Lee et al., A Study on Mathematics, Art and 3D-Printing in STEAM Education, Journal for Research in Mathematics Education, volume 29, issue 1, pp. 35-49, 2015.
- [12] K.A. Lee, "A Study on Prospect of Utilizing 3D Printer based on 3D Modeling in Art Education", Korean Journal for Research in Art Education, volume 29, issue 3, pp. 149-174, 2015.
- [13] M.J. Kim & B.Y. Kim, "Studies on 3D printer in the Country and Foreign Countries – Focus on Design Educational Program", KODDCO 2014 Conference, Vol.5, pp. 239-240, 2014.
- [14] G.H. Park, An Understanding and Reality of STEAM
- [15] J.J. Choi, STEAM Education based on Convergence, Monthly Scientific Creativity, issue Feb., Korea Foundation for the Advancement of Science and Creativity, <http://news.chosun.com>