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A Study on Analysis of Curriculum for Maker Education using 3D Printer at Elementary School Classroom

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Abstract

The advent of the 4th industrial revolution made the importance of software education to be emphasized, and thus, the Maker Education is attracting attention. This paper analyzes the curriculum to find contents suitable for Maker Education and proposes a workbook design using the results. The curriculum analysis data and workbook examples are expected to contribute to design elementary school curriculum for Maker Education using 3D printer. The workbook-based creative Making activities are, in addition, also expected to improve the computational thinking ability and to provide the insufficient instruction hours of SW education with an expandability.

Keywords: *Maker Education, 3D Printer, Computational Thinking, Software Education*

1. Introduction

The advent of the 4th industrial revolution had great effect on the method of nurturing suitable for the future. The Obama administration, in 2014, declared that the America is 'a nation of Makers' and is promoting so-called 'A Nation of Makers Initiative'. Korea is also implementing various types of 'Maker Initiative' including construction of maker community and project maker education [1,2]. The reasons behind the Maker initiatives became more popular than in the past is that the Making activity itself are more easily performed. Open source hardware, 3D printer, and development of software allowed the making of desired products in a relatively easy way, even without professional production system[3]. The Maker education, where students make products of the learning by themselves, is also important in elementary school classroom that is fundamental for future education [4]. In this paper, we analyze the curriculum to find contents suitable for Making Education using 3D printer at elementary school classroom. This paper is organized as follows: Chapter 2 explains the use of 3D printing in education and Maker Education through related studies. Chapter 3, the process of analyzing curriculum for Maker Education using 3D printer and the results are described. A practice workbook developed based on the analysis are proposed in chapter 4, and finally, chapter 5 provides conclusions and discuss recommendations for future studies.

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2. Related Works

2.1 3D Printing

Lee [5] 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 [6], 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 [7] studied STEAM education where the mathematics and art are linked through 3D printing and suggested the feasibility of STEAM education using 3D printer. Lee [8], 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. [9] 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. Maker Education

The Maker Education was conceptualized by a combination of the cognitive constructivism by Piaget and theory of social constructivism by Papert [10]. Papert's constructivism emphasizes real activities compared to Piaget's one. He argued that, though the learning is composed of learner's thinking, the efficiency of learning is maximized when the learner is devoted to meaningful activity. Papert was interested in method for learners to communicate using the item made by learners themselves as a medium, to induce self-directed learning through communicating these shareable knowledges, and eventually to promote new knowledges. The importance of Maker Education is also found in the fact that Mark Zuckerberg, a founder of Facebook, and Larry Page and Sergey Brin, co-founders of Google were also excellent Maker since childhood. In Maker Education where learning occurs in the process of making, the effect of learning is maximized by the immersion formed in the process of making [12]. This is closely related to the physical computing domain of today software education. The learners are forced to program by themselves when they participate in programming-based Making activities, and in this process, learn the control of various tools through continuous debugging for higher perfection of the program.

3. Curriculum Analysis

3.1. Criteria for Selecting Contents

The criteria for selecting contents were established before analyzing curriculum for Maker Education using 3D printer in elementary school. Table 1 shows criteria for selecting contents for the robot education used in physical programming education [13] Six criteria of practicality, suitability, easiness, activity, relatedness, and expandability and the contents of each criterion are listed. The contents of practicability include those that everyone think of easily because of the prevalence in daily life; suitability, those suitable for children mentally and emotionally considering curriculum contents; easiness, those that can be made and checked easily; activity, those that has high level of activity; relatedness, level of relation with curriculum; and expandability, feasibility of application.

This paper, based on Table 1, selected contents for Maker Education using 3D printer as shown in Table 2.

The contents that induce computational thinking in the course of 3D printing (computational thinking), that use 3D printing output in the course of instruction activity (instrumentality), that can induce various products different by individual and region (individuality), and that can be used not only as an educational product but also in real life (expandability) were selected.

Table 1. Criteria for Selecting Contents of Robot Education

Criteria	Contents
Practicality	Used frequently in daily life.
Suitability	Suitable for children mentally and emotionally.
Easiness	Made and checked easily.
Activity	Focusing on exercise and activity.
Relatedness	Level of relation with curriculum.
Expandability	Applicability and adaptability.

Table 2. Criteria for Selecting Contents of Maker Education using 3D Printer

Criteria	Contents
Computational thinking	Inducing computational thinking in the course of education using 3D printing.
Instrumentality	Using 3D printing output in the course of instruction activity.
Individuality	Inducing various products different by individual and region.
Expandability	Used not only as an educational product but also in real life.

3.2. Analysis of Curriculum related to Maker Education using 3D Printer

Table 3 and 4 show the results of analysis of curriculum of each national and authorized textbook (Practical Course, Physical education, Music, Art, and English) under 2007 Revised National Curriculum (5-6 grades) and 2009 one (1-4 grades) to select contents suitable for Maker Education using 3D printer. The targeted contents were found, from national textbooks, in Korean, Mathematics, Science, Integrated subjects as shown in Table 3. In Korean subject, contents were selected from 'role playing using character figure made by students' and 'making my unique word list'. In Mathematics subject, the extracted contents were mainly from activities of making something and using it in instruction. In Society subject, the contents were also extracted from making something, and especially, in case of making contour lines referring map, the instructions using clay can be expanded naturally to a STEAM education such as utilizing Google-map. The contents of Science subjects were found to be combined easily with the Society subject and the contents of integrated subject were likely to expand to include STEAM and team-based instruction.

Table 3. Contents suitable for Maker Education using 3D printer from National Textbook

Subject	Grade-Semester-Unit	Contents
Korean	1-2-4 Reading using meaning	Making character figures and role playing using them.
	2-2-4 How to organize	Making my unique word list.
Mathematics	1-1-2 Various shapes	Making my unique shape using various shapes.
	6-1-3 Prism and pyramid	Making development of prism and pyramid
	6-1-4 Various Geometric Shape	Making geometric shape using building block.
	6-2-2 Cylindrical and conical	Making development of cylindrical and conical.
Society	4-1-1 Formation of village and life	Making contour lines model referring map.
	4-2-3 Development of local society	Making local symbol.
	5-1-1 United people	Making artifact of stone Age.
	6-1-1 Shape of territory and life	Making model of Dokdo.
		Understanding east-high & west-low topography
Science	3-1-2 Use of magnet	Making toy using magnet.
	3-1-4 Change of surface	Making topography around beach.
	3-2-2 Strata and fossils	Understanding process of strata formation and making strata.
		Understanding process of sedimentary rock formation.
	5-1-2 Electric circuit	Making my unique battery.
	5-2-1 Our body	Making human bony structure
		Making model of heart and studying the structure.
	5-2-4 Solar system and star	Making constellation.
		Making planets of solar system
Integrated	2-2 Neighbor	Making a village that we dreaming of.

The use of 3D printer facilitated the fusion among subjects also in the authorized textbooks. Multiple similarities were extracted such as making stamp both in Practical course and Art subjects and similarities with national textbooks were also found in many contents. The use of 3D printer was found to allow fusion of subjects rather than separation of them, with an example of 'making my unique musical instrument' in Music subject that accompanies learning of mathematical and scientific principles.

Table 4. Contents suitable for Maker Education using 3D printer from Authorized Textbook

Subject	Contents
Practical course	Making my appearance of future.
	Making memo board.
	Making house for animals.
	Making my unique stamp.
	Making family picture-frame.
	Making my unique pot.
Music	Making my unique musical instrument.
Art	Making pictogram.
	Making my unique jewelry/character.
	Decorating my own space of future.
	Expressing the fact of my partner.
	Expression using pictogram emphasizing formative beauty of Hangul.
	Making imaginary animal.
	Making my unique household item.
	Decorating wrapper using stamp / Making signature.
	Making building harmonizing with surroundings.
	Making figure of my local.

The Maker Education using 3D printer, as shown above, was found to be feasible in all subjects. The contents meeting four criterion of computational thinking, instrumentality, individuality, and expandability were observed evenly over the subjects.

4. Practice Workbook

This section describes a workbook developed, based on the results of curriculum analysis, to be used in practicing Maker Education using 3D printer. The proposed workbook, considering similarities of programming learning and Maker Education using 3D printer, was develop with the discovery instruction as a main theme. The workbook is consist of four phases: The 1st phase, introduction of learning theme and goal, introduces themes related to 3D printing and provides learning goals related to curriculum, function, and creativity & personality. The 2nd phase, analysis and design, has three elements of research, writing idea note, and discussion for 3D printing. In the 3rd phase, making and implementation, an actual making is progressed by performing modeling, slicing, and printing. In the fourth phase, the level of achievements are measured against pre-defined learning goals.

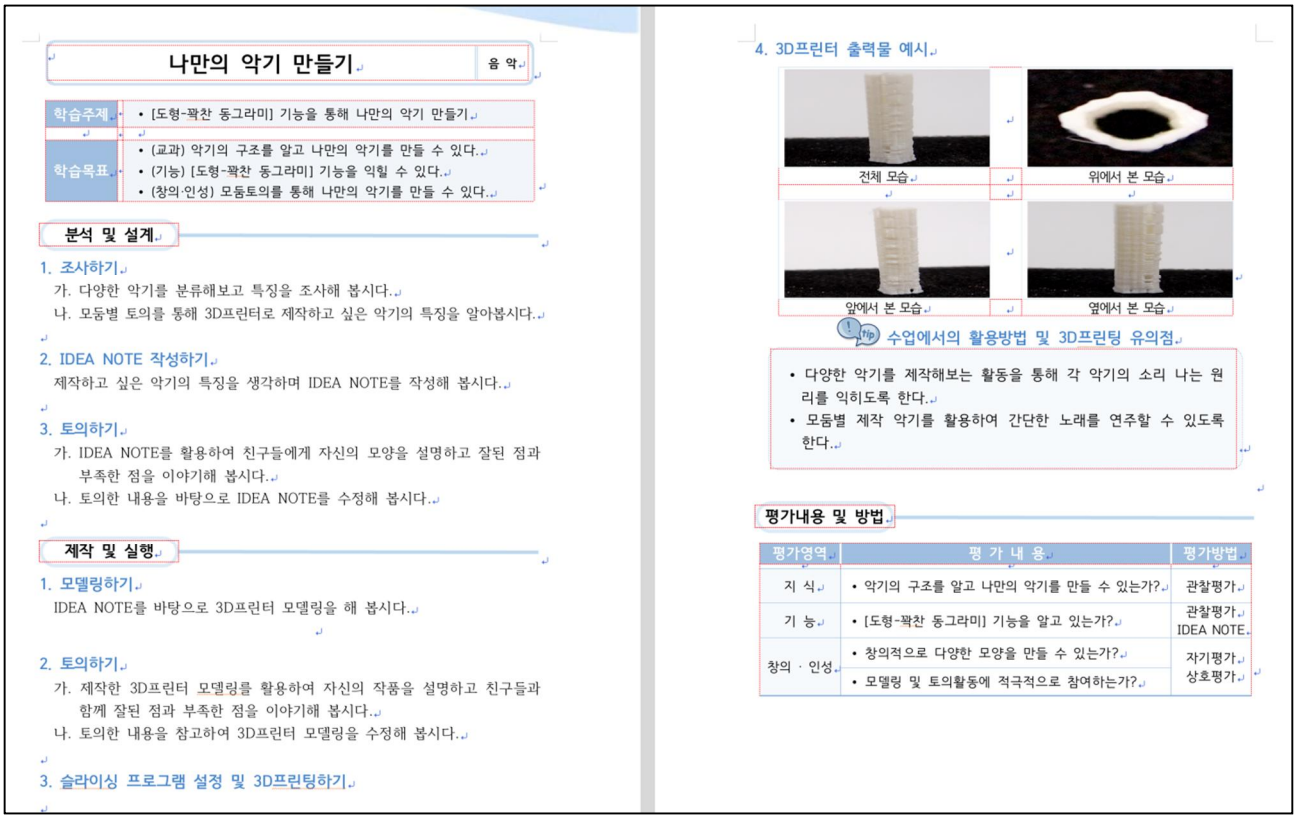

Figure 1. An example of workbook used in the 'making my unique musical instrument' unit in Music subject.

The workbook provided in Figure 1 is for Music subject, however, prompt consideration of mathematical and scientific principles in overall manner and facilitate the fusion of subjects because it addresses even the design of output.

5. Conclusion

The advent of the 4th industrial revolution had great effect on the method of nurturing suitable for the future. Korea is also implementing various types of 'Maker Initiative' over all industrial field. The Maker

Education where The Maker education, where students make products of the learning by themselves, has been implemented actively also in elementary school classrooms. This paper analyzes the curriculum to find contents suitable for Making Education using 3D printer at elementary school classroom and designed a workbook to make the idea in more detail. It is considered, based on these results, that the teaching and learning materials for Maker Education using 3D printer need to be developed and distributed. It is urgent, therefore, to further studies on systematic curriculum analysis for introduction of Maker education using 3D printer and on workbook development.

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