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Convergence Education Modeling for Teaching Integration of IoT with 3D Printing Based on Manufacturing Chemical Product by Production Companies

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Abstract

This study aims to apply Arduino and 3D printing technology considered as a key subject in the age of 4th industrial revolution which is a step 1 for customizing and applying the process of production by chemical molding companies producing environment-friendly biodegradable packaging materials to the 3D printing teaching in universities. Step 3 is applied to IoT for Arduino application, and 3D printing technology is also used on the basis of teaching creative integrated human resource. Integration of Arduino with 3D printers is based on the assumption that middle- and high-school students can learn it step by step to higher levels and university students majoring or not majoring in computing science can also have computing skills for solving 3D printing-based problems. For IoT application in this study, the 3D printing technology is applied to the external shape of products for producing an Arduino-based lighting fixture. The applied 3D printing technology is further extended to teaching modeling of producing packaging materials by chemical product molding companies in the age of 4th industrial revolution.

Keywords: *Arduino, 3D Printing, IoT, chemical product, packaging material*

1. Introduction

Development and popular use of smartphone contributes to more application of software, IoT(Internet of Things), 3D printing and AI(Artificial Intelligence) in the industrial field of the fourth industrial revolution. Many manufactures apply them to their products to develop intelligent products. They know the importance of software, and want to employ human resources with software skills, and software education aims to enhance computing capability solving various issues, and creative ability of problem solving used in everyday life. In actual teaching, however, learner education in the normalized frame structure is carried out, rather than creative teaching [1].

Arduino is an open-source electronic platform based on easy-to-use software and hardware, and provides tools and development environment completed with a single-board microcontroller to allow everyone to use it. Arduino allows users to configure circuit diagrams easily. Furthermore, it is also allowed to develop products using data and control information by controlling various sensors and external electronic devices to

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implement interaction. It is an open platform to allow everyone to learn and use it for designing circuit diagrams required for producing IoT-compatible products. Thanks to this benefit, it is easy to implement various products interworking with various sensors related to IoT [2].

As software education is a subject since 2018 in Korea, it aims to teach how to use different hardware and software. The Ministry of Education reorganized the curriculum in 2015 to specify the subject of information as a compulsory subject in middle school, followed by elementary and high schools in sequence. Universities are also strengthening their programing education. They intend to convert the education paradigm by enhancing the basic knowledge of humanities, social science and science technology to grow creative integrated human resources. Arduino is one of the tools used for programming education, and many exemplary studies reveal the usability of teaching programming with Arduino [3][4].

Integration of Arduino with 3D printing is unlimitedly extensible, and application thereof to the manufacturing industry is very likely to enhance time and cost efficiency and cost effectiveness of production. Development of 3D printers contributes to an explosive increase in using them for various industrial fields and educational programs, showing a fast growth trend. Cheap FDM(Fused Deposition Modeling) 3D printers are used to manufacture part of external and internal components used in teaching, and integrated teaching of IoT using Arduino for internal operation with 3D printing for producing IoT-compatible products with Arduino is implemented. Software required for FDM 3D printers continues to develop and is one of essential tools to train creative human resources [5].

This study aims to suggest a teaching method for integrating Arduino with 3D printing technology required for creative software education to design step-by-step software coding education required in manufacturing products, enhancing special and temporal capability by means of the 3D printer technology which is the final step of manufacturing, and applying it to the chemical product molding process to enhance physical computing and computing-based thinking from basics to its application.

2. Related Studies

2.1 Open-source Development Environment and Technology for Arduino

It is easy and convenient to use Arduino to design circuit diagrams based on the open source thereof. Everyone can change and use them for their purposes. Arduino is one of open-source micro controllers based on hardware and software easy to use.

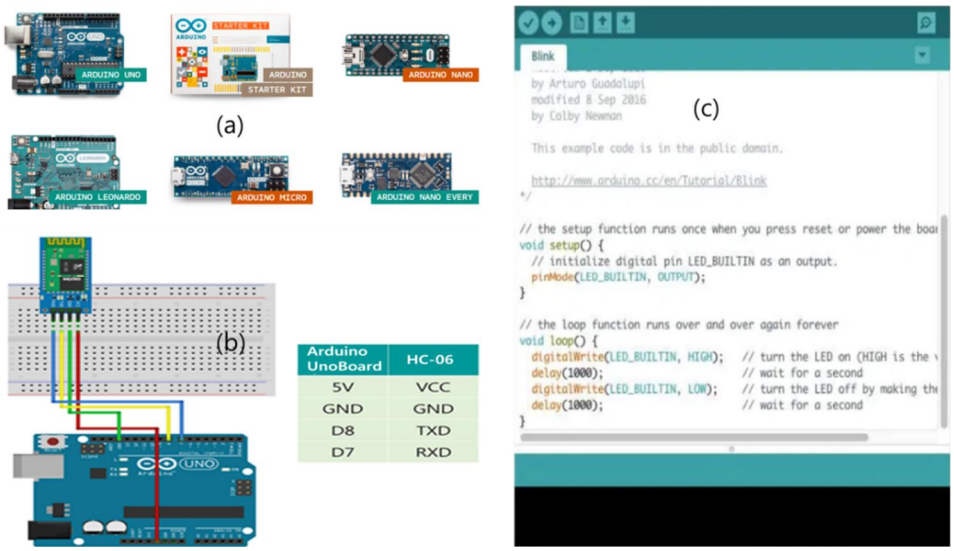

Figure 1. Arduino type and integrated development environment

There are many Arduino types including UNO, STARTER KIT, NAMO, LEONARDO, MICRO and NANO EVERY. Arduino provides an integrated development environment to its users to allow them for program coding, debugging and compiling easily. Moreover, the provided Arduino library allows developers to apply required modules easily, and implements a simple process of editing programs and uploading the developed sources on hardware. Developers without long-term experiences can upload the fully developed sources on firmware by means of USB, and develop various IoT products like 3D printers [6]. Figure 1 shows (a)Arduino type, (b)Arduino and Bluetooth module connection diagram, (c)The integrated development environment.

2.2 3 D Printing FDM

3D printing is an additive manufacturing technology for stacking materials one layer by one layer to form a shape. The most common material used for 3D printers is thermoplastics, epoxy resin, metals, photopolymers, and edible materials including chocolate among various materials. The 3D printers are used to manufacture products fast, and complement the weakness in the traditional manufacturing process. Application of the 3D printing technology has many advantages, to name a few, reducing the product marketing time, eliminating the burden on the molding cost in the manufacturing process, and customizing product manufacturing. The components of FDM (Fused Deposition Modeling) 3D printer as one of 3D printer types widely used and popular are made by heating and extruding thermoplastic filaments while making layers from the bottom [7].

3. Step-by-step Coding with Arduino

The method suggested in this study is classified into the beginner, intermediate and advanced levels to teach coding. In the level of beginners who use Arduino for the first time, the composed modules and circuit diagrams are applied to controlling hardware and examining sensor movement by simple coding. For the beginners, the processing sequence is first implemented, followed by providing unit programs for each of various sensor modules for easy implementation. Basic description about the characteristics of various sensors and processed modules is provided to make a unit project in the intermediate level. In the step of using sensors and implementing them as one subject after being accustomed to the beginner level, modules are provided to combine various sensors to make a project. In the advanced level, the 3D printing technology is comprehensively applied to making and assembling boxes for products to complete the Arduino project.

Table 1.Coding in each Arduino step

Beginner level	Intermediate level	Advanced level
Implementation of communication using modules for each sensor unit	Unit project sensor implementation	Realization using sensor by combining 3D printer
-PC-Arduino communication through USB - Simple light-on implementation - Speaker control implementation	- Implementation of fine dust concentration meter - Smart flowerpot implementation	-Arduino implementation by making a measurement box with 3D printing -Mood light with 3D printing

Table 1 illustrates the curriculum in each step along with examples. It includes the process from basic module communication to implementing one product. The 3D printer is integrated with the process of each step to be used as a creative product.

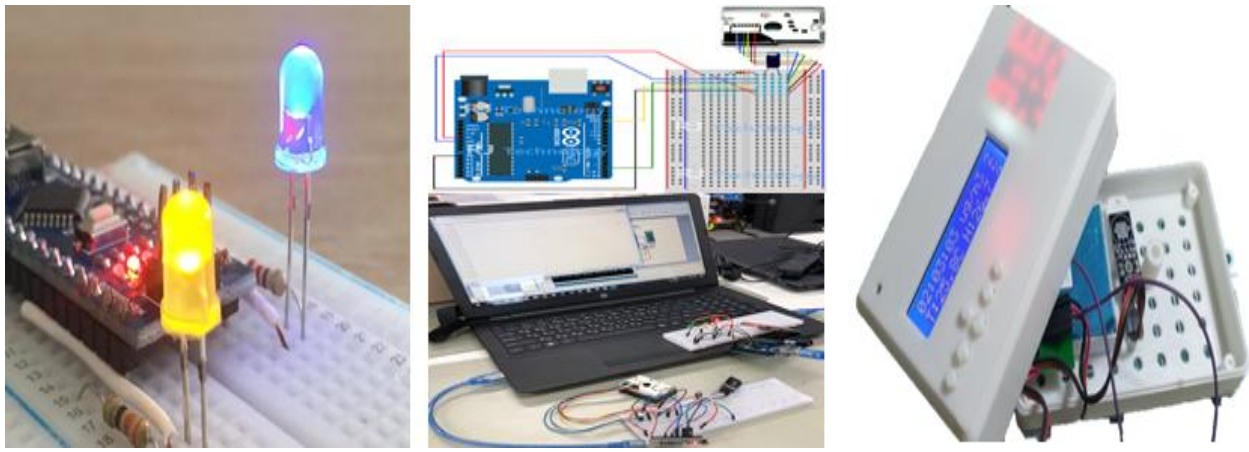

Figure 2. Examples of beginner, intermediate and advanced levels

Figure 2 shows the unit module for processing and controlling circuit diagrams, e.g., LED lights in the beginner level, the module for using various sensors to measure fine dust in the intermediate level, and the exemplary module assembled by integrating the process part with a 3D printer in the advanced level.

4. 3D printer and Arduino convergence education method

Through the beginner and intermediate levels in this study, various sensors in the Arduino board are used to implement IoT to enhance the physical computing capability. In the advanced level which is a comprehensive level after the aforementioned 2 levels, a 3D printer is applied to IoT to enhance spatial and visual capability to manufacture external products or internal components with the 3D printer and make the students feel satisfied, and allow creative feasible fused product design. An open source platform easily approachable can be used as a program for manufacturing 3D models.

This improves the process of 2 steps for templet rendering and 3D printing which is a conventional non-teaching process in universities, middle- and high-school to create a curriculum of reproducing the process in the industrial fields for applying 3D printing technology and manufacturing products and normalizing 3D printing in the curriculum through the process composed of 8 steps: step 1 of designing products and scanning the target object; step 2 of rendering; step 3 of manufacturing the 3D printing mock-up; step 4 of heating a mold plate by using recycled microwaves; step 5 of combining the heated mold plate with the mock-up; step 6 of using a recycled vacuum appliance for absorption in step 5, plastic model vacuum equipment was used to derive cost-effectiveness efficiency compared to metal molds; step 7 of mass production with the mock-up; and step 8 of using a recycled freezer to quick-cool the output product (limited to the products for food). It is proposed because food container can be easily derived and printed out by 3D printing. This aims to introduce a normalized curriculum for 3D printing to reproduce the same process of industrial field applying the 3D printing technology to manufacture products, and teach students. Students can find various shapes and components of products manufactured and implemented with 3D printers for better understanding and creativity thereof, and will be more confident of and interested in coding completed through 8 steps by manufacturing a piece of work from step 1.

For coding in each step of Arduino suggested in this study, it is required to plan a subject to be implemented in the final advanced step. When the subject is chosen, the next step is to code each module of various sensors ideal for the subject in the beginner and intermediate levels. The project suggested in this study is about a lighting fixture to integrate product molding in the advanced level with the 3D printers for the process carried out in each step.

It was selected to convergence the external part of the IoT product with 3D printing output. Because a typical RGB LED module used in implementing lighting fixtures is a communication module for learning in the beginner level, and is used in one subject of mood lights in the intermediate level, it is easy to understand

the module to connect the board to the module. Figure 3 shows the process of 3D-printing a cube with a templet not requiring difficult 3D-modeling, after downloading the shape of desired lighting fixture from the open source platform. The next step is to assemble the sensor and the board developed with Arduino with the 3D model.

Although the shape of lighting fixture is made in 8 steps for implementing 3D printing teaching suggested in this study in an actual manufacturing line, the process of manufacturing the shape of lighting fixture is simple in the beginner and intermediate levels, and it is a plan to lead the industrial field education for applying 3D printing and IoT in middle and high school, and universities by expanding and applying the environment-friendly packaging material production line of chemical product molding companies.

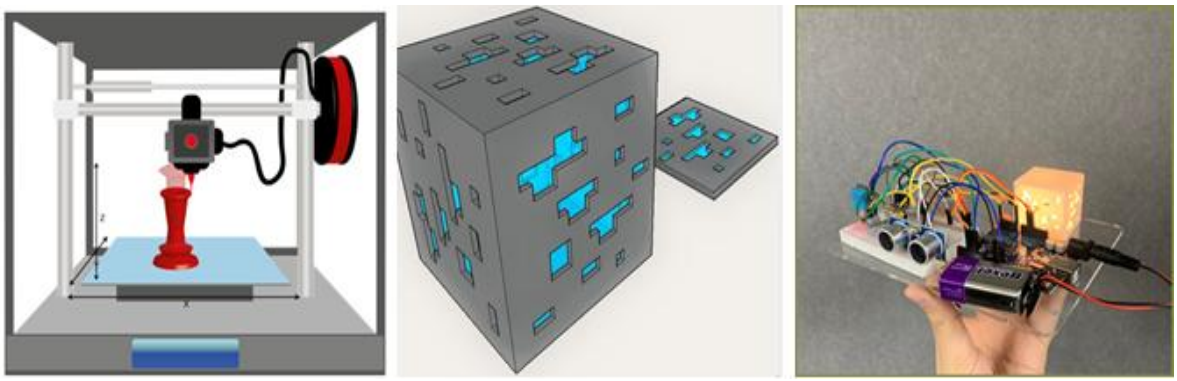

Figure 3. Integration of 3D printer with Arduino

5. Conclusion

Arduino and 3D printing technology are classified as the most important elements in the age of 4th industrial revolution. Because conventional cramming education is not helpful to students who need creative thinking, a new type of education is required.

Starting from the communication module based on 3 levels of beginner, intermediate and advanced for coding in each Arduino step suggested in this study, and Arduino, an efficient step of coding is provided by means of communication of sensors. Step 2 is for the students who completed the basic coding course corresponding to the beginner level. The intermediate level is designed for creative coding to implement the sensors learnt in the previous step with the subject of one unit project. In the final advanced level, 3D printing is used to get a result from the previous step but fully completed.

The 3D printing process composed of 3 steps has 8 detailed steps to teach students the process 100%-the same as the 3D-printing manufacturing process in the industrial field. This study suggests a strategy for integrating Arduino with 3D printers to enhance computing-based thinking and experience-based teaching as the objective of education. As an efficient way to educate students on 3D printing, you can simply derive food container products and print them out easily with 3D printing. It is further planned to extend and disseminate 3D printing technology to apply a teaching method through a production process to the packaging materials for everyday products of chemical product molding companies.

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