https://doi.org/10.5392/IJoC.2018.14.3.061

Study on Design Education Plan Using Microcontroller Board Prototyping Tool

Wonsuk Nam
Industrial Design Department
Kookmin University, Seoul, Korea

ABSTRACT

Unlike in the past, where the expression of the form was given a priority, with the widening of the scopes of the designs, the proportion of design education institution curricula targeting user experience and the application of technology is continually and gradually increasing. Open source microcontroller boards such as Arduino have initiated attracting attention as a countermeasure against these changes. These prototyping tools have many advantages for the diversification of expression and design verification in the design field and therefore have a high likelihood of being introduced into many design education institutes; however, the tools act as high entry barriers for design students who lack engineering knowledge. Although various educational content and tools have been developed to address the issue of barrier, existing solutions remain insufficient as alternatives for the purpose of activation. In this study, we investigated the present state of related education content and conducted a pilot workshop using a prototype microcontroller board with simplified coding. We intend to use the results of this investigation to develop study material for design education. We started by conducting a survey regarding the pre-university education situation. It was observed that engineering education opportunities are insufficient and the problem of mutual application between educations due to course-based education was not realized. We also analyzed the characteristics of simplified training tools using the microcontroller to establish a direction for educational design and conducted a pilot workshop using the microcontroller toolkit with a simplified coding process based on this content. Students who lack a basic knowledge of engineering technology received instruction, and after completing minimum preliminary training, they proceeded to practical exercises that involved utilizing the toolkit. Through this process, we identified the need for a simple-type microcontroller board with low-complexity for use in educating students majoring in design. We also identified some obstacles that serve as barriers to entry of utilizing microcontroller board. Based on these results, we propose several functional requirements and teaching guidelines for prototyping toolkits for design education.

Key words: *Design Education, Technical Application Design, Microcontroller Board, Design Prototyping.*

1. INTRODUCTION

As discussions of the 4th industrial revolution progress, demand for new user experiences in the market is increasing, and, as a changing creative industry, the field of design must play an important role in meeting this demand. As a result, unlike in the past, the scope of the design targets has greatly expanded to other areas around the manufacturing industry. As required competencies for designers expand and diversify, new directions in design education are being sought to ensure job competitiveness. As part of these efforts, design education institutions are increasingly introducing prototyping tools that can implement interactions. These workshops and curricula are expected to improve creativity and give designers the abilities to cope with technology. Many studies have verified the effectiveness of these approaches in creativity education. Early related studies mainly focused on utilization in the field of interactive design education [1]-[3] but researchers have also emphasized the role of creativity in the field of traditional industrial design [4], [5]. In particular, software-based prototyping tools such as Processing and Adobe XD can complete more complex designs and a number of microcontroller-based hardware tools such as Arduino have also been developed. However, design students and designers face various obstacles pointed out in the universal dissemination. Therefore, in this study, we investigated the problems of the hardware procurement tool and the status of related products as a preliminary examination of design instruction using the prototyping tool for creative education. We then conducted a pilot education workshop to identify solutions to the tool's entry barriers.

* *Corresponding author, Email: name@kookmin.ac.kr*
Manuscript received Jul. 19, 2018; revised Aug. 13, 2018; accepted Aug. 14, 2018

2. THE STATUS OF EDUCATION

In preparing this chapter, we examined the current state of education for learner, firstly, the concept and meaning of prototyping education. Second, we examined the current state of basic pre-college education for presumed target learners. Third, we conducted a field survey of the after-school classes in the elementary school we used as a reference.

2.1 Concept and Meaning of Prototyping

Prototyping for interaction means a prototype in which the interaction of the designer or the experimenter in a way that recognizes the behavior and performs the intended reaction. In general, prototyping for this purpose is important as to in determining whether the designer can perform the expected results through the included functionality. The process thus requires a prototyping tool that can be immediately checked and supplemented to verify that the intent set in the design is working properly and can solve the problem in question. In other words, the main role of interactive prototyping is to implement the interactive design function and to identify design elements that require improvement through experimenter feedback regarding the implementation results. The interactive prototyping that is currently being introduced can be divided into software systems such as Adobe XD and Sketch and hardware systems such as Arduino and Raspberry Pi. Preliminary research on learners has identified a lack of basic coding, electrical, and electronic theory knowledge as a major obstacle to understanding and using such prototyping tools.

2.2 Status of Basic Education

A major obstacle to the acquisition of relevant knowledge is the lack of basic training in electrical fundamentals and programming. Most students who have advanced to design related courses go through the liberal arts track, which provides no courses in which they can acquire the knowledge in question. These students acquire whatever relevant knowledge they possess through elementary and middle school curricula. 2018 design students entered elementary school between the late 1990s to 2007. Therefore, we refer to the 2011 curriculum (7th Curriculum of the Ministry of Education, Science and Technology) [6]. Table 1 summarizes the contents of elementary and middle school curricula related to the composition of electronic circuits. In the elementary course, students learn basic circuit structure and circuit diagrams, and study serial/parallel and simple electronic components through exercises related to the operation of bulbs and motors, soldering practice, etc. In the middle level, they learn about the relationships between resistance, current, and voltage in electric circuits and by studying Ohm's law. The exercises include the use of a DC motor and circuit tester.

Table 1. Status of Basic Education

Grade	Learning Objective	Learning Content
5th grade elementary school	- Electrical circuit diagram and explanation - Creating and understanding electric circuit diagram - Comparison of brightness according to battery bulb serial / parallel connection	- Turn on the light bulb - Brightness comparison according to connection method of bulb
6th grade elementary school	- Classification according to use of electric / electronic products in daily life - Simple electronic circuit configuration	- Understanding simple parts functions such as resistors, capacitors, switches, and LEDs - Understanding the circuit diagram and designing electric / electronic parts as solder and block
3th grade middle school	- Relationship between resistance, current, and voltage - Understanding Serial / Parallel Connectivity Features - Understanding the use of electrical energy in the home - Understanding basic concepts of electricity and electric circuits - Understanding the characteristics and functions of electronic components	- Production of simple exercise device using electric / electronic devices and machine principle - Understanding the characteristics and functions of electronic components such as resistors, capacitors, transistors, and capacitors. - Using circuit tester - DC motor utilization

In general, the elementary and middle school curricula aim to provide students theoretical and practical knowledge of voltage, current, and constant relation, to expand their understanding of the function of each electronic product, and to enable them to implement circuit diagrams and understand resistance value. The content of these curricula demonstrates that current education is limited to the provision of theoretical and practical knowledge related to the simple circuit without providing opportunities to apply said knowledge. In particular, current curricula do not offer students opportunities to build the functions that they compose or construct the circuits they design. Although elementary education curriculum includes practice, secondary curriculum is focused on learning conceptual theory rather than practice, so the applied educational content is quite limited. Table 2 summarizes the problems in the basic curriculum.

Table 2. Basic Education Problems Summary

Problems	Explanation
1. Lack of learning time 2. Imitating learning 3. Lack of practical training due to theory 4. Lack of programming fundamentals 5. Priority subjects placement in college entrance examination	1. Assignment only to 5th and 6th grades of elementary and 3th grade of middle school 2. Lack of learner-led curriculum 3. Middle school courses consist of calculations 4. Absence of learning contents of interaction 5. Assignment to advanced curriculum in high school

2.3 After-School Learning Status

Recently, as the importance of software education has received increasing emphasis. The government has begun promoting software education to improve creativity through computational thinking, and coding education is rapidly spreading throughout the education market. This trend has given rise to high-priced early-coding private tutoring. On the other hand, due to changing educational demands, the public education has been incorporated into the regular curriculum in the secondary education from this year, and the elementary education will be organized in the next year. Over the past several years, many schools have responded to these demands by developing after-school programs. To determine the current state of these programs, we conducted on-site surveys at after-school learning programs in Heungcheon Elementary School in Yeoju City, Kyonggi Province.

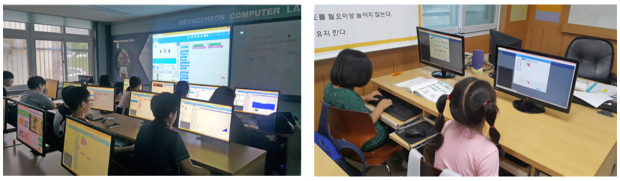
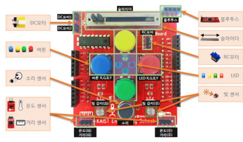


Fig. 1. Heungcheon Elementary School after-school class for coding

In this school, education related to coding and electrical/electronic circuit learning was conducted in the after-school learning specialties/aptitude creative science and computer club. Table 3 provides an overview of the main educational tools used in this club.

Table 3. Training Tools

Tools	Contents	Images
ENTRY	- Educational Software for Elementary and Secondary School Students - Block assembly method coding learning - https://playentry.org/	
E-sensor board	- Introductory Board for Physical Computing - Various extension functions based on Arduino - https://www.neweducation.co.kr/	
JIMU Astrobot	- Robot control through block coding - Support tablet, smartphone app - Share work through the open source community - https://ubtrobot.com/	

Instruction was carried out in two groups, lower and upper grades, and centered on teaching students coding logic through interest and input/output, rather than teaching electric/electronic circuits. In general, it is important to learn coding concepts with a simplified coding tool in the command block assembly form, and to experience physical input/output in cooperation with the sensor board. Table 4 summarizes the relevant learning content.

Table 4. Prototyping class during after-school

Learning topics	Teaching contents
Creating actions using blocks	Move objects using simple block coding
Universal calculator	Outputting operation results using variables
Make parking game	Using logical operations with specific conditions
Playing numbers	Comparison operations using variables
Internet of Things	Understanding concept of IoT
Preparing the sensor board	Understanding, ENTRY and sensor board
Making drum	Making drum with button and sound effects
Hot air ballooning	Using a sound sensor to blow up a hot air balloon
Mystery of the snow	Exploring the pupil effect using a light sensor
A puppy that meets me	Using the slider to control the puppy's motion
BBQ party	Controlling the objects using temperature sensors
Making the radar	Making the moving radar with distance sensor
Controlling characters	Using the keyboard to control the character
Move to target	Using blocks to control movement and move to target
Understanding the scratch	Learning the scratch program's overview
Coding a simple game	Coding the simple games with blocks and sprites
Fly the parrot	Identify the sprite's center and control the character
Fish catching game	Learning the variables and apply to sprites
Playing the piano	Making a piano keyboard and play music

Our examination of the instruction plan and class status of after-school classes confirmed that the understanding of the principle is effectively realized through the use of educational tools controlled by the Korean language and difficulty level and the learning topic that generates the most student interest. On the other hand, increased social interest has fostered a transitional problem that limits student learning—a shortage of professional teachers. To cope with this situation, teachers in charge of providing instruction in other subjects take training courses to acquire the necessary knowledge. However, concern remains that teachers who lack full understanding of the content will not provide effective instruction.

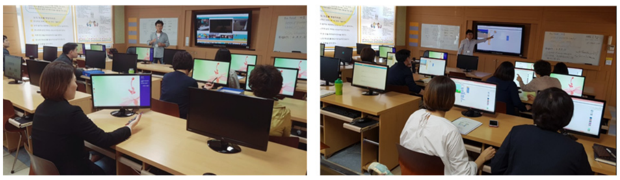


Fig. 2. Teacher training for prototyping class

3. PROTOTYPING TOOL STATUS

Several tools currently on the market aim to achieve prototyping aims. For example, there are prototyping tools for UI design, tools for apps and web designers, and tools for hardware design. In this chapter, we discuss the types of microcontroller board prototyping tools for implementing interactions such as physical computing.

3.1 Microcontroller Board

Typical personal microcontroller boards such as Arduino and Raspberry Pi can be used to configure certain systems even by those who lack sufficient knowledge of computing. As the supply progresses, various functions are installed, and they are used for mass production of small quantity production occasionally. Although, as mentioned above, such tools are simplified, many obstacles, including the difficulty of meeting the needs of design students and designers who lack basic knowledge of engineering, remain. Table 5 compares representative microcontroller board features.

Table 5. Microcontroller board features

Board type	Expand ability	Economic feasibility	Difficulty	Development environment	Performance	Specialized function
Arduino	B	B	B	B	D	E
Raspberry Pi	A	A	C	B	B	C
Intel Galileo	B	D	B	B	C	B
Beagle Bone	A	B	D	C	A	B

A: strong positive; B: positive; C: normal; D: some negative; E: negative

3.2 Educational Tools Status

The microcontroller board's simplicity and scalability make it an excellent prototyping tool, but it is essential for beginners who do not have basic knowledge to learn constantly. To this end, the tool introduces a great deal of educational content and many educational tools so that beginners and non-engineering students can easily understand coding and circuit composition. In this chapter, we discuss the educational tools features designed to address learning difficulty and induce interest.

1) **E-sensor Board**: The E-sensor board is an educational Arduino shield board developed by a subsidiary company of KAIST (Korea Advanced Institute of Science and Technology). It has various sensors for input and output, etc., can be easily implemented in various examples. Figure 3 shows its supported inputs and outputs. The learner has the advantage of being able to naturally progress to advanced applications using Arduino after learning the relationship between input and output through the provided program.

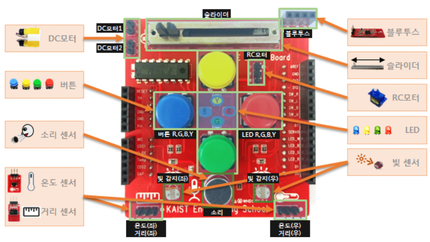


Fig. 3. E-sensor board configuration

2) **Little Bits**: Learners can implement a series of functions simply by connecting each module without additional wiring and soldering work. One particular merit is that learners who do not have electronic circuit configuration experience can develop an understanding of the functions and learn to configure them in a short time. Little Bits consists by four modules--power, input, output, and connection. It is designed to relieve the burden of configuration failure and to help learners understand the principles and applications in a short time.

Fig. 4. Little Bits configuration

3) **micro:bit**: Developed by the BBC as part of an educational campaign called 'Make it digital,' the micro:bit features a variety of functions on a small 4cm * 5cm board and a basic kit is available at a very affordable price of around $ 20. Many companies including Microsoft, Samsung, and ARM cooperated in the development of micro:bit, and the board which is more economical than the performance was developed. Despite its compact size, it is equipped with many functions and has 25 LEDs, 2 buttons, Bluetooth, a radio sensor, a temperature sensor, an illuminance sensor, an acceleration sensor, and a compass sensor. The micro:bit supports multiple operating systems and can be coded in languages such as JavaScript or Python, along with basic block coding.

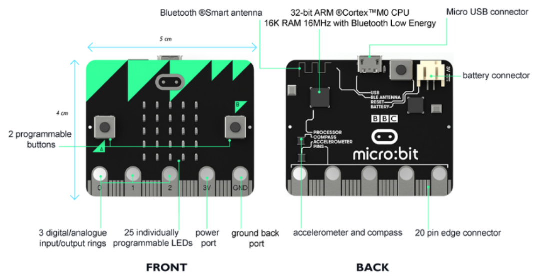


Fig. 5. micro:bit board configuration

4) **Circuit Scribe**: Circuit Scribe, a research tool from the University of Illinois, is a kit that can be used to construct circuits with conductive pens. It consists of a conductive pen and various modules. It is used to fix a module with a magnet by placing a paper with a circuit on a metal plate. This product's distinguishing characteristics are its pen and corresponding drawing function, which it provokes learner interest because of their familiarity, thus inducing natural use and encouraging free circuit composition and learning.

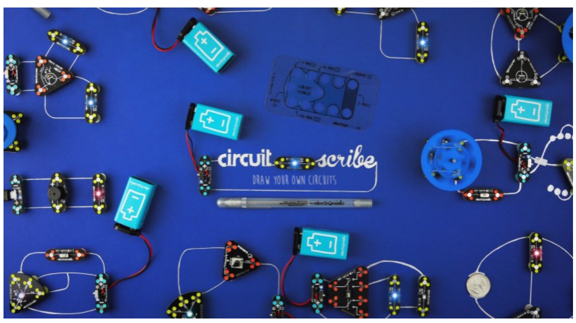


Fig. 6. Circuit Scribe

These educational tools are designed to facilitate functional configuration and solve problems through modularization, simplification of coding, and integration. Table 6 summarizes the features of each tool related to the establishment of future design education research.

Table 6. Status of Basic Education

Tools	Features	Merit
E-sensor Board	- Specializing in lower grade education - Arduino shield type - Built-in input / output	- Education specialization - Integrated type
Little Bits	- Easy combination with modularity - Improved circuit configuration difficulty - Multiple configurations in a short time	- Modularization - Time reduction
micro:bit	- Miniaturization and economical improvement - Integrated basic input / output board - Various extensibility	- All-in-one - expandability
Circuit Scribe	- Easy combination with modularity - induction of interest using conductive pen - Understanding principles	- Modularization - Interest inducing

4. SUB-CONCLUSION

Aiming to identify the obstacles learners face in acquiring and utilizing the knowledge necessary to operate the interaction prototyping tool, our investigation of the current status of basic education and related products, the following contents were confirmed. Many learners lack the basic knowledge required to learn to use these tools. This stems primarily from the considerable shortage of teaching hours devoted to these subjects in elementary and middle school education, and the fact that the curricula focus on theory rather than practice. This can be attributed to the prioritization of subjects emphasized by the college entrance examination system. Also, the practice courses consist of imitation learning rather than the application of principles, which does not help a great deal when it comes to later expressions of creativity. To overcome this, it is necessary to make clear that higher education learners have very low levels of related knowledge and that curricula should be designed to provide them the basic conceptual knowledge they need to understand the principles. In addition, this understanding can be expected to work even if the burden of error is solved. On the other hand, our analysis of the characteristics of the educational tools showed that attempts to integrate and modularize to reduce the burden of the circuit configuration helped significantly in reducing the degree of difficulty; we also found that miniaturization was an important factor in utilization and expandability. Thus, tools should prioritize measures for overcoming the burden of the circuit configuration error by seeking to induce learner interest, fostering conceptual understanding, creating intuitive designs, and so on. Table 7 summarizes the basic guidelines for education design using prototyping based on the conclusions derived from this study.

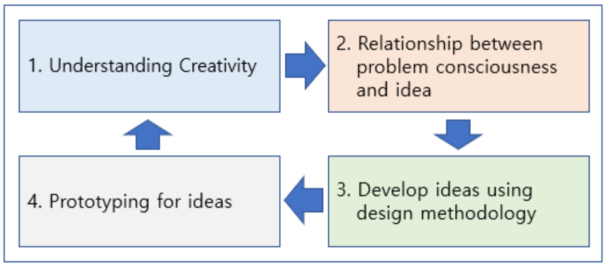
Table 7. Basic Guidelines for Educational Design

Topics	Explanation
1. Creativity 2. Basic principles 3. Coding 4. Circuit 5. Error	1. Significance of prototyping to improve creativity 2. Understanding basic concepts of electric and electronic 3. Reduce the burden on the coding process, re-interpret the coding method 4. Circuit design simplification, intuitive design 5. Eliminate the burden of error, suggest a feedback plan

5. PILOT EDUCATION WORKSHOP

We investigated the current state of basic education for future design and analyzed the characteristics of simplified microcontroller-based educational tools. In addition, to establish a direction for design education research, we conducted a pilot design workshop with high school and university students using microcontroller toolkit with a simplified coding process based on these contents. We conducted the workshop with groups of students who lacked basic knowledge of engineering technology, and used the toolkit with each group. Table 8 shows the relationship between the flow and components of the Pilot education workshop.

Table 8. Relationship between the flow of classes and components



5.1 Education Design

The pilot education workshop was designed not only to utilize the toolkit but also as a form of creativity education based on the prototyping technique. To elucidate the problems in creativity education, we interviewed teachers and students in advance. The teachers expressed the opinion that the related classes involved one-sided lessons in science and technology, and that the theoretical nature of the classes lowered student engagement.

Fig. 7. Teacher student interview

Many students claimed that their interest increased when working in groups rather than individually, and many also regarded the process of pursuing a predetermined answer as a problem. Table 8 lists the major issues in existing classes and the three basic design policies derived from the interview responses.

Table 9. Issues and Basic Design Policy

Issues	Basic design policy
- Subjects with the correct answers - Imitation learning - Toolkit assembly-oriented curriculum - Inadequate systematicity for each step - Lessons focused on science principles - Lack of a critical mind	1. Learning applying the design process 2. Discovery of perspective based on sympathy theme in daily life 3. Freedom of idea expression through solution of difficulty

The educational program was based on basic design process. First, we developed a basic theoretical program for understanding creativity, generating ideas, prototyping to express ideas, discovering idea elements through life observation, design storytelling, understanding the prototyping tool, and expression practice program composed of idea expression. Table 9 shows the content of the program. The aim of the pilot education program was to understand how to use prototyping in design expression. The training was 8 hours in total, and it took 2 days because of the production output time of 3D printing and so on.

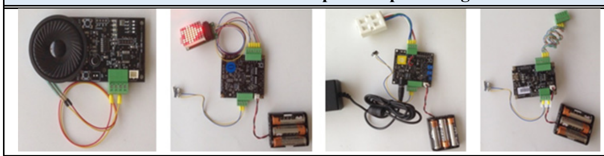
Table 10. Pilot Education Program

Contents of the pilot education program	
Basic theory	1. Understanding Creativity 2. Finding Ideas 3. What is Prototyping for Expression of Ideas?
Expressive Practice	1. Understanding Prototyping Tools 2. Finding Ideas through Life Observation 3. Design Storytelling 4. Prototyping

5.2 Introduction of Prototyping Toolkit

The prototyping tools used in the workshop were a 3D printer and microcontroller boards. Participating students had prior knowledge of 3D printing, and the printing training program was omitted because of the considerable time involved. We chose a microcontroller for this training that implemented a certain function without a coding process, assuming that the coding process would act as an obstacle for learners in acquiring relevant knowledge. Manufactured by Firmware Bank Co., Ltd., this board features 6 types of inputs and 5 types of outputs. Combining these functions makes it possible to combine 30 functions, to omit the coding step, and to adjust each input/ output value through the switch attached to the board. Table 10 shows the input / output functions.

Table 11. Input / Output Configuration

Microcontroller board input / output configuration	
	
Input	1. Digital button: push button switch, doubles use by connecting switches 2. Magnetic switch: Magnetic object detection switch 3. Pressure sensor: Pressure sensing at a specific part of the sensor 4. Tilt sensor: 1 axis detection of x, y, z 5. Optical sensor: detects the brightness of visible light 6. Temperature sensor: -20 ~ 80℃ detection, ±2 degree error
Output	1. Sound: Up to 12 seconds sound storage 2. High Power LED: Individual control RGB LED 3. Motor: ON/OFF control 4. Relay: Control 220V power supply 5. Multiple LED: Light-adjustable LED Matrix

5.3 Education Workshop

Five students majoring in design were placed in a single group and together completed the pilot education workshop using the educational programs and tools. Following the pilot education design, the group developed ideas through each team task. The ideas were arranged in the form of setting up the virtual users and preparing user scenarios accordingly.

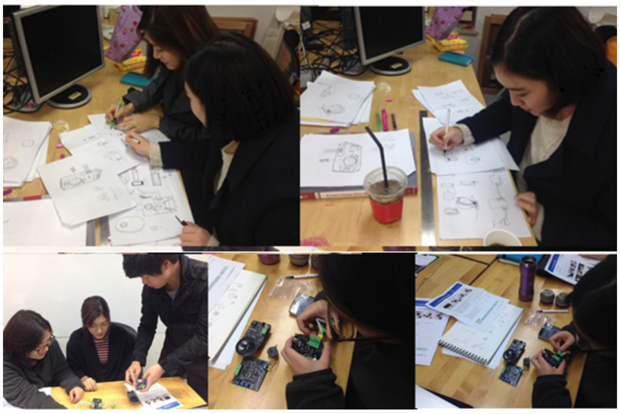


Fig. 8. Group workshop

In 2nd stage, we conducted basic training with the prototyping tools and developed the second idea. The students who participated in this pilot training had already learned basic 3D modeling skills and were familiar with 3D printers, so we only conducted a basic 1hour training with the microcontroller board.

Fig. 9. User Scenarios

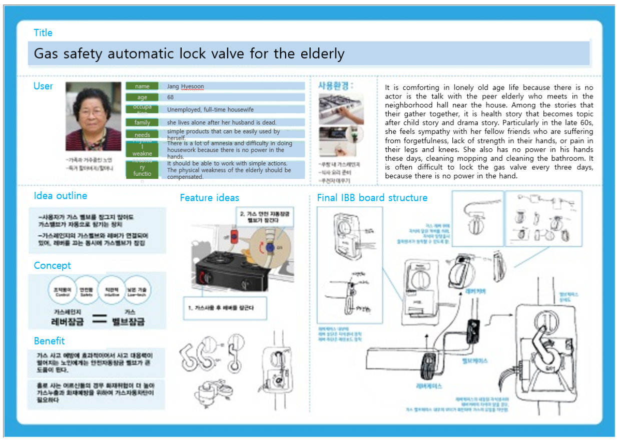


Fig. 10. Idea Development

The prototyping using the microcontroller board was carried out through the second tool education and the materialization of the idea, and the process was made using the structure modeling and the microcontroller board to enable actual operation. The virtual user was a forgetful grandmother and designed a product that could automatically lock the gas ranges to the main valve after use. The prototype used the microcontroller board's magnetic input and motor output sensors, and the structure was fabricated using the 3D printer.

Fig. 11. Automatic lock Gas Ranges

The students who took part in the pilot workshop made positive comments regarding the team problem solving process and the fact that the process was student-led. In addition, students previously had some understanding of the outline and function of microcontroller board products for prototyping such as Arduino, but they were unable to use them because of the difficulty of coding process. However, the students who took part in the workshop also responded positively to the experience of creating prototypes that feature scheduled functions in a short workshop.

6. CONCLUSION

This study focused on hardware prototype learning as a means of effective creative design education, examining existing research and basic education with prototyping tools to understand the obstacles to utilization. Based on these findings, we designed a short-term design education curriculum and conducted a pilot design workshop. The main approaches used to design the pilot education program were the following: First, the problem is not the simple tool education but the problem finding is prioritized. Second, the coding process was minimized to address the entry barriers faced by students without engineering knowledge. Third, the pilot was designed based on a design process familiar to students, beginning with observation of surroundings. Through this study, we constructed a learning process that provides students with knowledge that is important to creative learning and creates an effective education structure that can produce visualized results in a short learning time. In addition, we confirmed the possibility of minimizing pre-education for educators so that related education can be easily disseminated. The findings of this study highlight the need to develop a prototyping tool that maintains the characteristics of coding simplification but has considerable freedom in function configuration; it should also develop appropriate design processes by identifying and analyzing problem awareness, and a related education plan that induces creativity should be developed. In a future study, we will design a prototyping curriculum based on a design process for creative education that can be utilized in the design curriculum complemented by this viewpoint, and undertake more in-depth research into prototyping toolkit design.

REFERENCES

[1] C. Pering, "Interaction Design Prototyping of Communication Devices: Towards Meeting the Hardware-Software Challenge," Interactions, 2002, vol. 9, no. 6, pp. 36-46.
[2] L. E. Holmquist, "Prototyping: Generating Ideas or Cargo Cult Designs?," Interactions, 2005, vol. 12, no. 2, pp. 48-54.
[3] S. Houde and C. Hill, *What do Prototypes Prototype? in Handbook of Human-Computer Interaction,* Helander, M. et al(eds.). Elsevier Science B. V., 1997.
[4] Y. Lim, E. Stolterman, and J. Tenenberg, "The Anatomy of Prototypes: Prototypes as Filters, Prototypes as Manifestations of Design Ideas," ACM Transactions on Computer -Human Interaction, 2008, vol. 15, no. 7, p.7.
[5] W. Buxton, *Sketching User Experiences,* Morgan Kaufman, 2007.
[6] Curriculum 2011, *Science and Technology 7th Curriculum*, Ministry of Education, Republic of Korea, 2011.
[7] W. S. Nam, "A Preliminary Study of the Application of Prototyping Tools for Design Education Plans: Focusing on Open Source Microcontroller Boards," International Journal of Advanced Culture Technology, 2018, vol. 6, no. 2, pp. 107-116.
[8] T. I. Lee, "Factors of Interactive Prototyping for Creative Interaction Design," Archives of Design Research, vol. 23, no. 5, 2010, pp. 27-36.
[9] M. Dieli, "The usability process: Working with iterative design principles," IEEE Transactions on Professional Communication, 1989, pp. 272-278.
[10] T. S. Jones and R. C. Richey, "Rapid prototyping methodology in action: A developmental study," Educational Technology Research and Development, vol. 48, no. 2, 2000, pp. 63-80.
[11] T. Erickson, *Notes on Design Practice: Stories and Prototypes as Catalysts for Communication. in Scenario-based Design: Envisioning Work and Technology in System Development,* John Wiley & Sons, 1995, pp. 37-58.
[12] M. Buchenau and J. F. Suri, "Experience Prototyping," Proc. DIS '00, 2000, pp. 424-433.
[13] J. D. Lim, *A Study on the Development and Evaluation of Interactive Product Prototyping System for Designers*, master thesis, Korea Advanced Institute of Science and Technology, 2005.
[14] Creembox, *A Study on Establishment of Educational System for Advanced Invention with Design Fusion*, creembox, Seoul, 2015.
[15] https://playentry.org/
[16] http://microbit.org/
[17] https://www.circuitscribe.com/
[18] https://littlebits.com/

Wonsuk Nam
He received his B.S., and M.S. in industrial design from Kookmin University, Korea in 2000, 2002 respectively. In 2010, he completed a doctoral course in multimedia science at Wasesa University, Japan. Since then, he has worked in the Industrial Design Department at Kookmin University. His main research interests include design education methods and design philosophy.