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Design Education Planning for Microcontroller Boards

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Abstract

As the scope of social expectations and roles in the design field are expanding, the demand for design education to cope with changes in the technology environment is increasing. In response to this trend, microcontroller board-type design-prototyping tools have been introduced into design education, and much educational content is being developed. However, there is the perception that students who are majoring in design without engineering knowledge are still discouraged from entry. A variety of educational content and tools have been developed to solve these difficulties, although there are several limitations to their practical application. Especially, in the design education courses in universities, the functional expectation level for prototyping is high, but most of the content developed for solving the difficulties has been developed for the lower education levels, and it could be said that a great deal of learning is necessary to solve the problem. In this study, students were asked about microcontroller board utilization and their satisfaction with their design through questionnaires and with the developed microcontroller board development direction via Focus Group Interviews. Based on this, we tested microcontroller boards that eliminate the coding process and which students can use to create and prototype their work as a suggestion to fulfill demand. After using the board, both the usability and improvement of the product were checked. Confirmation of the usefulness of the free-coding-type microcontroller was obtained through this study along with the possibility of responding to various educational demands by applying the application design related to this product.

Keywords: Design Education; Microcontroller Board; Design Prototyping

Introduction

In recent years, design-prototyping tools for microcontroller boards such as Arduino and related educational content have been introduced as a response to new technological environment changes in addition to education in the field of design education. However, there is the perception that this approach presents a barrier to students who have no knowledge of engineering, and this perception is an obstacle to actively acquiring and utilizing related knowledge. The reason for this can be found in Korea's elementary and middle school education curricula, but in recent years, related education has been supplemented in the basic curricula in response to social demand. However, the educational content and tools developed because of this demand are not actively utilized in the education field at universities. One of the causes of this is the expectation level of the functional implementation of prototyping in design education at universities, but most of the content developed for solving the difficulties has been developed for lower education levels.

In this article, a prototyping tool for design education is proposed which can solve the difficulties based on this recognition and can realize certain functionality in a short period of time. For this purpose, the design requirements were specified through prior research and investigation, after which board prototypes with microcontrollers were produced for educational programs and a functional verification was conducted with questionnaires.

Research background

The current state of basic education for educational design was investigated through previous studies and the characteristics of simplified educational tools based on microcontrollers were analyzed. In addition, to set the direction of educational design research, a pilot study was conducted at the university using a microcontroller toolkit that simplified the coding process based on this content (Figure 1). To examine the utilization of the toolkit, the pilot study was conducted over a short period of time during the preliminary education and practice for university students who did not have a basic knowledge of engineering technology: a total of 8 hours over 2 days on subjects such as 3D printing. It was designed not only as a simple prototyping toolkit but also for creativity based on design methods for the basic design process consisting of a basic theoretical program for understanding creativity, idea concepts, prototyping for the expression of ideas, idea elements through life observation, understanding prototyping tools, storytelling, and prototyping.

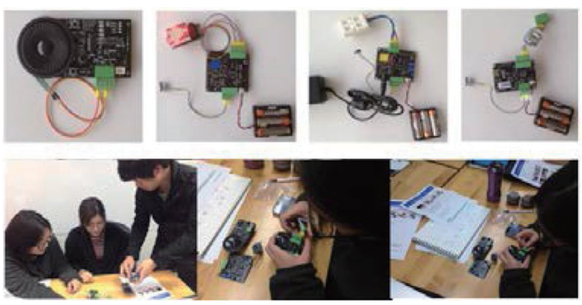

Figure 1. The pilot study.

Teacher and student interviews were carried out in advance to draw out the problems in creativity education. In the interviews with the teachers, there were many points that related to classes that were repeated: the one-sided delivery of scientific and technological knowledge and the interest of the students has decreased because of boredom with the theory lessons. In the student interviews, there was a strong opinion about increasing group interest, and the process of imitating the correct answers was regarded as a problem. The major problems with the existing design course and three basic design policies were set based on these outcomes, the content for which is reported in Table 1.

Table 1. The issues and the basic design policy for the study.

Issues	Basic Design Policy
- Subjects with the correct answers - Learning by imitation - A toolkit assembly-oriented curriculum - Inadequate systematicity toward each step - Lessons focused on scientific principles - Lack of a critical mindset	1. Learning by applying the design process. 2. Discovery of perspective based on a sympathetic theme for daily life. 3. Freedom to express ideas through solutions to difficulties.

Demand survey

A. An Overview of the Survey

A survey is a series of processes in which the characteristics of interest such as opinions or behaviors cannot be measured by creating appropriate questionnaire items to obtain the desired information. This means conducting a research study on a sample population to describe the phenomenon. In this study, the survey design for the students before designing microcontroller prototypes was prepared to find their level of satisfaction with the mainly used microcontroller boards and grasping the necessary functions for microcontroller board development in the future. The survey was conducted on 100 design students attending Kookmin University. The target and scope of the survey are reported in Table 2.

Table 2. The survey target and scope.

Method	On-site Survey
Subjects	100 design students (50 males, 50 females)
Range	- Satisfaction with existing microcontroller boards - The need for new microcontroller board development - The required sensors and functions for the new microcontroller boards
Time period	2018.03.02–2018.03.15

B. The Results of the Survey

The analysis for the survey findings was conducted on the results of each question in terms of mean and standard deviation. An attempt was subsequently made to use the results of the survey as basic data for the microcontroller board development. Table 3 summarizes the results of the satisfaction level with existing microcontroller board usage. As a result of the questionnaire survey, it was found that the design students had difficulty with coding, applying the sensors, using the resistance values, controlling the output values, and interlocking the adjustment values in the prototyping process. In addition, the demand for microcontroller board utilization to carry out a working mock-up and related studying was confirmed along with the demand for application development that can control the I/O values interlocked by using the communication module during the prototyping process. In this questionnaire, we surveyed 37 input devices and 14 output devices to understand the I/O functions required for prototyping and academic performance.

Table 3. Satisfaction level with microcontroller boards.

No.	On-site Survey	Mean	[1]SD
1	Is programming the microcontroller board easily accessible?	2.18	0.82
2	Is the connection (cable connection) between the microcontroller board and the sensor easily accessible?	2.77	0.83
3	Is the communication module easy to use when using the microcontroller board?	2.79	0.89
4	Did you understand the principles and applications of the sensor when using the microcontroller board?	2.02	0.66
5	Is the resistance of the microcontroller board easy to use?	2.12	0.82
6	When using the microcontroller board, were the I/O value interlock adjustments easily accessible?	2.6	0.94
7	Are you satisfied with your current microcontroller board?	2.07	0.79
8	Do you think it is necessary to develop a microcontroller board for the mock-up and study?	4.09	0.71
9	Do you think it is necessary to develop an application for controlling the I/O values?	3.81	0.86

1 = strongly negative, 2 = negative, 3 = normal, 4 = positive, 5 = strongly positive; [1]standard deviation

C. An Overview of the Focus Group Interviews (FGIs)

An FGI is a collective in-depth interview technique. As a representative survey method for qualitative surveys, 10 or fewer people are selected according to certain qualification criteria which focus on exploring and understanding their in-depth motives, attitudes, values, and desires. For the FGIs in this study based on the results of the previous survey, we interviewed seven engineers and designers with experience of board development and conducted in-depth interviews on the development of a new microcontroller board for the student designer. This survey was conducted using an interview method consisting of questions and answers. The survey scope and content are listed in Table 4.

Table 4. The survey scope and content.

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Subjects	2 board developers, 2 application developers, 3 designers	
Scope & Content	1st	- The effectiveness of the microcontroller board development - The microcontroller board primary development specifications decision - I/O cable selection - Bluetooth module selection
	2nd	- Application development based on I/O operations - Communication protocol for the microcontroller board and application interworking

D. The FGI Results

The implications of the FGIs are as follows. The development of a precoding-type microcontroller for design students could solve some of the obstacles caused by difficulties in the coding for the application of sensors for students who lacked engineering knowledge of I/O. The possibility of improving accessibility to the microcontroller board was confirmed, as shown in Figure 2.

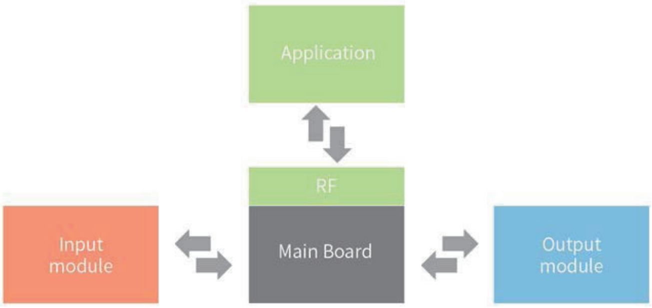

Figure 2. The configuration of the mainboard, input device, and output device from the results of the FGIs.

The input and sensor modules of the first prototype based on the results of the previous survey and the FGIs were selected as two types of limit switches; ultrasonic, electrostatic, tilt sensors; and a microphone, as reported in Table 5. The output device and the sensor modules were selected as a servomotor, DC motor, LED, LED dot matrix, RGB color, and speaker, as conveyed in Table 6.

Table 5. The input module specifications.

1	Limit Switch	A	- Sends an electric signal to the mainboard each time the button is pressed
		B	- Sends an electric signal to the device as soon as it is pressed and released
2	Ultrasonic sensor		- Detects all objects that reflect ultrasonic waves. - Transmits the distance between the end of the sensor and the object in meters.
3	Touch sensor		- Detects the micro-electricity coming from the human body and sends it to the mainboard.
4	Tilt sensor		- Sends the result of the x-axis to the mainboard - Sends the result of the y-axis to the mainboard.
5	MIC		- Inputs sound and sends it to the mainboard.

Table 6. The output module specifications.

1	Servo motor	- Transfer data area: the angle can be input from 0-180°. - Transfer data area: stop time can be input from 0-255 s.
2	DC Motor	- Transmission data area: forward rotation can input 0–255 s. Performs forward rotation for this duration. - Transfer data area: stop time can be input from 0–255 s. - Transfer data area: reverse rotation can be input from 0–255 s.
3	LED matrix	- 8 fonts (D7 to D0) and stop time (s) data are output.
4	LED	- One high-brightness LED configuration - Even if two or more LEDs are connected, they are turned on/off by command.
5	RGB Color	- One LED with three colors - Even if two or more LEDs are connected, they are turned on/off by command. - When the area item (value of 1 or more, retention time) is transmitted, the LED emits light in seconds and automatically turns off.
6	Sound Recorder	- Send a large value (non-zero value) to the transmit data area, including 1 at the master, and the software trigger pulls the device to operate. - Output the recorded sound.

The setting values of the I/O devices required for the application development are summarized in Table 7. The setting values of the input devices have the basic setting values for the ON/OFF function, the step distance, and the time adjustment and the values for the speed control, the number setting, and the interlocking time are determined as the setting values in the output devices.

Table 7. The I/O device settings.

Input	
Limit switch A	ON/OFF function
Limit switch B	ON/OFF function
Ultrasonic sensor	Distance adjustment
Electrostatic sensor	Detection time adjustment
Tilt sensor	X-axis adjustment / y-axis adjustment
MIC	Recording function / time adjustment
Output	
Servomotor	Angle setting / direction control / speed control
DC Motor	Speed control / Direction control / Time control
LED Dot Matrix	DOT ON/OFF / Time adjustment / Text function
LED	LED number setting / LED designation ON / OFF function Adjusting the number of flashes / Adjusting the flashing speed
RGB Color	Color value adjustment / Time adjustment Adjusting the number of flashes / Adjusting the flashing speed
Sound Recorder	Volume control

The free-coding-type microcontroller prototype

Based on the functional requirements for I/O and control set up ascertained through preliminary investigations, a free-coding-type microcontroller board and application prototypes for control were designed. As shown in Figure 3 and Figure 4, the main board is 6.8 cm in length and 6.8 cm in width, and the I/O board was made separately. The connector for the input and output can be divided into input and output according to the situation. For example, it can be composed of one output and three inputs, or two inputs and two outputs, and the connected I/O board was designed to be recognized automatically. The sensor board is 4 cm in length and 3 cm in width, and it can be configured separately from the main board to accommodate various design models. The application for I/O control works on an iOS base; the whole process is shown in Figure 4.

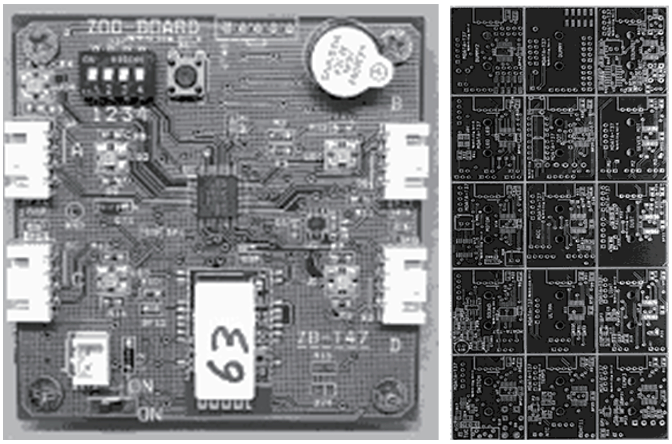

Figure 3. The prototype configuration for the first microcontroller board: the mainboard (6.8 x 6.8 cm) and the sensor board (4.0 x 3.0 cm).

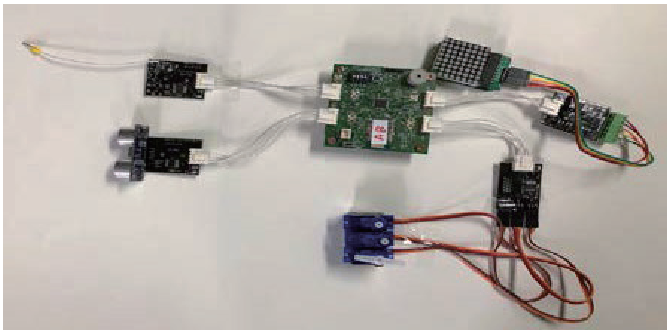

Figure 4. The prototype configuration for the first microcontroller board: connecting the sensor board to the mainboard.

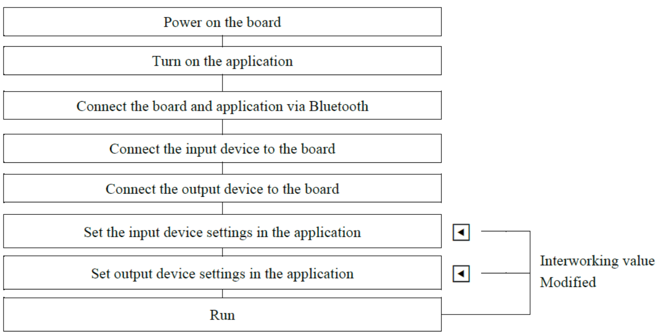

Figure 5. The process of configuring the prototype for the first microcontroller board.

Conclusions

The purpose of this study was to develop a microcontroller board that can be easily used as a basic design prototype for students to acquire relevant knowledge. To achieve this, existing design-prototyping microcontroller boards were surveyed and a questionnaire survey on design students was conducted to understand the requirements. A free-coding-type microcontroller board prototype was fabricated and validated based on the findings. Future research will focus on design education based on the prototype to understand any potential improvements and extend the I/O function of the microcontroller to improve the applicability to cope with various designs. Through this study, it is expected that the prototype can solve the perceived entry barrier to microcontroller board utilization by design students and can contribute to the diversification of design education.

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