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임베디드 IoT 과목 설계 및 만족도 분석☆

Design and Satisfaction Analysis of Embedded IoT Course

홍 준 기[1*] 백 종 호[2] 강 민 구[3] 홍 성 찬[4]
Jun-Ki Hong Jong Ho Paik Mingoo Kang Sung-Chan Hong

요 약

최근 IoT와 관련 임베디드 기술 연구가 활발히 진행됨에 따른 IoT와 임베디드 교육의 중요성이 부각되고 있다. 따라서 대학에선 효율적인 임베디드 IoT교육과정이 요구된다. 본 논문에선 아두이노와 스마트폰을 사용하본 논문에선 학부 학생들에게 블루투스를 통해 스마트폰과 아두이노 키트를 연결하여 IoT와 임베디드를 학습하는 수업을 제안한다. 제안한 과정의 프로젝트 수행을 통해 학생들의 평균 기말고사 점수는 중간고사 점수보다 증가한 것을 확인하였다. 또한, 학생들의 수업 만족도 결과를 통해 제안한 임베디드 시스템 수업이 학생들에게 IoT와 임베디드 시스템을 이해하는데 매우 효과적이었으며 75%의 학생이 제안한 과목에 만족하는 것을 확인하였다.

☞ 주제어 : 임베디드 IoT 수업, 아두이노, 스마트폰, 공대 커리큘럼

ABSTRACT

Recently, the importance of the internet of things (IoT) education has been emphasized due to the progress of research on IoT technology. Therefore, universities require an efficient IoT course. In this paper, we propose an undergraduate IoT course using the Bluetooth function of smartphone and Arduino kit. The proposed embedded IoT class uses the Bluetooth capabilities of the smartphone to connect Arduino and activate various sensors to encourage students to become interested in the class. According to students' midterm and final exam scores, students programming skills have been improved since students' projects were in progress during the course. Further, according to students' survey, the proposed IoT class is very effective in understanding the embedded IoT and 75% of the students satisfied with the proposed course.

☞ keyword : embedded IoT course, Arduino, smartphone, engineering curriculum

1. Introduction

Recently, the internet of things (IoT) and IoT education have become very important in the field of electrical and computer engineering education. Programming languages such as C and Java are tedious and difficult for undergraduate students since students check the coding results by monitors. Therefore, students easy to lose interest in programming language especially for the lower grades of undergraduate students. However, Arduino is a good programming language to stimulate students' interest since it can make interesting things like games [1].

Many pedagogical studies have been carried out to induce curiosity without losing students' interest in the programming languages [2]-[5]. Particularly, research and education applying Arduino to the curriculum of engineering education are being actively carried out by using Arduino, which provides an integrated development environment (IDE) [6]-[9]. The goal of the proposed embedded IoT course is to understand the IoT by conducting a project to control the Arduino kit by using a smartphone application via Bluetooth function. Therefore, the measured data from the Arduino kit is sent to the smartphone

1 Department of Electrical and Electronics Engineering, Youngsan University, Yangsan, 50510, Korea.
2 Department of Software Convergence, Seoul Women's University, Seoul, 01797, Korea.
3 Department of IT Contents, Hanshin University, Osan, 18101, Korea.
4 Division of Information and Telecommunications, Hanshin University, Osan, 18101, Korea.
* Corresponding author (jkhong@ysu.ac.kr)
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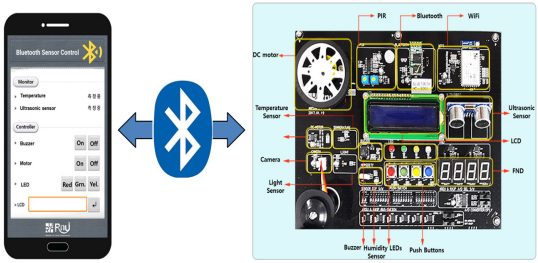
to display the result.

We encourage students to perform projects that mimic IoT devices using a variety of sensors of the Arduino kit. This is more efficient than learning each sensor separately, and it is an effective way of teaching concept of embedded systems.

The remainder of this paper is organized as follows. In Chapter 2, learning materials of the proposed course is described. Chapter 3 describes the course schedule of the proposed course. The methodology assessment of the proposed course is presented in Chapter 4 before the conclusion in Chapter 5.

2. Learning Materials

We assume that smartphone as controller of the IoT device and Arduino kit as an embedded IoT device. The Arduino kit can be controlled by the smartphone applications via Bluetooth function.



(그림 1) 블루투스 기능을 이용한 아두이노 키트와 스마트폰 애플리케이션간의 연결

(Figure 1) Connection of the Arduino kit and smartphone application via Bluetooth function

As shown in Figure 1, a smartphone is connected to the Arduino kit by Bluetooth, and the Arduino kit can be operated and monitored by the smartphone application. The following subsections describe the Arduino kit and the function of the smartphone application.

2.1 Smartphone Application with Bluetooth

This subchapter describes the functions of the smartphone application with Bluetooth function.

(그림 2) 블루투스 기능을 사용하는 스마트 폰 애플리케이션

(Figure 2) Smartphone applications using Bluetooth function

As shown in Figure 1, a smartphone is connected to the Arduino kit by Bluetooth, and the Arduino kit can be operated and monitored by the smartphone application. The following subsections describe the Arduino kit and the function of the smartphone application.

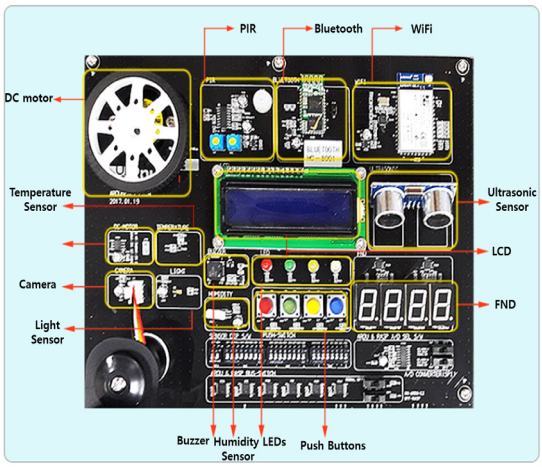
2.2 Arduino Kit

This subchapter describes the sensors and components of Arduino kit. One of the most important parts of the proposed course is to choose the Arduino board and its sensors. However, the several reasons for choosing the Arduino kit are as follows;

- The Arduino kit must have the ability to connect to the smartphone via Bluetooth.
- Various sensors must be attached to the Arduino kit to implement an IoT.
- Omit the sensor connections by using wires to focus on coding. This is because students spent a lot of time to connect the sensor by wires to the Arduino board in the last semester's class.

Therefore, we chose the Arduino kit with sensors and components as shown in Figure 3.

The following Table 1 lists the sensors and components attached to the Arduino kit used in the proposed course. The information of general purpose input/output (GPIO),



(그림 3) 다양한 센서들이 장착된 아두이노 키트
(Figure 3) Arduino kit with various sensors

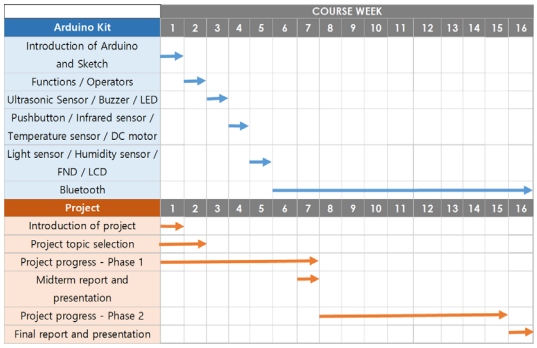
inter-integrated circuit (I2C), analog to digital conversion (ADC), and serial connection are described in Table 1.

(Table 1) Integrated sensors and components of the Arduino kit

	Hardware	Description
GPIO	Arduino	Atmel's 2560 MCU internal board
	PIR Sensor	- BISS0001 Chip
	Ultrasonic Sensor	- Elecfreaks HC-SR04 - Measurement range: 2cm-400cm
	LED	- Lite-On Inc. LTL 1224a module - 4 colors
	Push Button	- Pull-up switches - 4 buttons
	DC Motor	- Unisoinc Technologies BA6208 motor driver - Forward and reverse rotations
	Buzzer	- Piezo buzzer - Maximum 80dB output
I2C	Temperature Sensor	- TI's TMP102 module - Measurement range: -25°C to +85°C - Measurement accuracy: 0.5°C
	FND	- NXP PCA8535BS module - 4 FNDs (seven- segment display)
I2C	LCD	- HITACHI's HD44780U module - 2 lines 16 characters output - English and special character output
ADC	Humidity Sensor	- Honeywell's HIH-4030 sensor - RH Measuring range: 0% to 100% - Operation temperature: -40 °C to 85 °C
	Light Sensor	- Vishay Semiconductors TEMT 6000 - ±60° detection range
Serial	Bluetooth Module	- Roving Network HC05 - Supported Bluetooth versions: 2.1/2.0/1.2/1.1

3. Course Schedule

In this chapter, proposed course schedule of the proposed embedded IoT course is described. As shown in Figure 4, the proposed course calendar is mainly divided into Arduino and project lectures. Classes are held for 3 hours each week for 16 weeks. A detailed description of the proposed course calendar is given in the next subchapters.



(그림 4) 제안한 과목의 강의계획 일정표
(Figure 4) Schedule of the proposed course

3.1 Arduino Lectures

To teach the function of sensors and component of the Arduino kit efficiently, a teaching method that assumes a specific scenario [10], [11]. We have assigned Bluetooth classes to more than half of the courses based on feedback from students last semester. In addition, it also has the

advantage of being able to shorten lecture time by explaining all the sensors and components individually. The detailed descriptions of each class are described below.

1. Introduction to Arduino and Sketch Concepts: Install the Sketch program and show how to implement the simple example code. Also, several example codes are provided to stimulate the students' curiosity.
2. Function / Operators: Students who study in this class have learned C language and Java as prerequisite courses, so the professor does not have to spend too much time to describe functions.
3. Ultrasonic Sensor / Buzzer / Light-Emitting Diode (LED): Example codes of sensors are described as the rear-detection-function of the vehicle. The functions of the sensors are described as follows.
   - Ultrasonic sensor: Measure the distance from the object. The ultrasonic sensor returns the measured distance in cm from the object.
   - Buzzer: The buzzer rings when the vehicle reaches the object within reference distance.
   - LED: Turn on the red LED and the yellow LED alternately in 1 second intervals when the buzzer rings.
4. Push button / Infrared sensor / Temperature sensor / DC motor
   - Describe the components using an example of the fan equipped with the temperature and infrared detection function.
   - Push button: On/off button of the fan.
   - Infrared sensor: detect the user every 5 minutes and stop the fan when the user is not detected.
   - Temperature sensor: it senses the temperature every 5 minutes.
   - DC motor: DC motor is assumed as the motor of the fan. The DC motor rotates when the user is detected and the temperature is more than 24°C.
5. Light sensor / Humidity sensor / FND (seven-segment display) / Liquid crystal display (LCD)
   - Describe sensors and components assuming an indoor dehumidifier.
   - Light sensor: It detects the light in LUX value.
   - Humidity sensor: It measures humidity.
   - FND: Outputs the ON/OFF status of the dehumidifier.
   - LCD: Displays the measured humidity.
6. Bluetooth
   - This step explains the sensor operations by using smartphone applications with Bluetooth function. This is an important part of the teaching concept of IoT with embedded system.

The proposed course reflects the feedback of students who want to study more time with the Bluetooth function. Since students are learning Bluetooth from the 9th week class, students have plenty of time to apply Bluetooth functions to their projects.

3.2 Embedded IoT Project

The phases of the project are divided into two stages. In the first stage, students perform the project using sensors connected to the Arduino kit. Then Bluetooth function can be applied to the students' project carried out in the first stage of the 9th week. Detailed descriptions of the project section are as follows.

1. Project introduction: Describe the direction and purpose of the project. Moreover, several past projects are introduced.
2. Project preliminary Investigation/ Identification of Ideas: students search for existing projects related to Arduino and IoT systems to get project ideas.
3. Project process - Phase 1: This project phase recommended that add and modify the ideas of the teams in the various examples of the sensors in the Arduino kit to promote the project.
4. Midterm report submission and presentation: Students demonstrate and present a project for seven weeks. Through presentations and reports, the professor provides feedback on the progress of the project.
5. Project process - Phase 2: Add the Bluetooth function to the existing project so that the concept of embedded IoT can be applied to the ongoing project.
6. Final report submission and presentation: Students demonstrate and present their project. We encourage

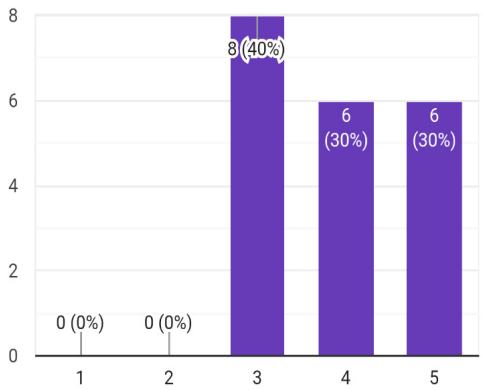
students to feedback on their difficulties of the project to improve the class in the next semester.

4. Methodology Assessment

In this chapter, the effectiveness of the proposed course is analyzed through the students' response. We conducted a survey from students in the proposed course to reflect feedback in next semester. The high scores indicate high satisfaction.

4.1 Students' Interests in Arduino

This subchapter provides students' interest in Arduino, regardless of their programming skills and exam grades.

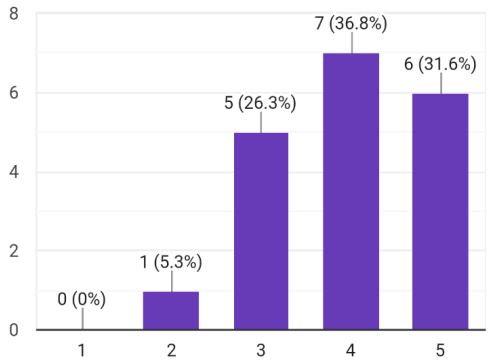


(그림 5) 아두이노에 대한 학생들의 관심
(Figure 5) Students' interest in Arduino

As shown in Figure 5, 60% of the students became interested in Arduino. However, 40% of the students did not change their interest in Arduino programming. This 40% of students feedback that they are not interested in other programming courses. According to the results in Figure 5, we confirmed that students are more interested in Arduino than we expected.

4.2 Students' Self-Satisfaction of Arduino programming Skills

This subchapter provides students' self-satisfaction of their programming skills at the end of course, regardless of their actual programming skills.



(그림 6) Arduino 프로그래밍 기술에 대한 학생들의 자기 만족도
(Figure 6) Students' self-satisfaction of their Arduino programming skills

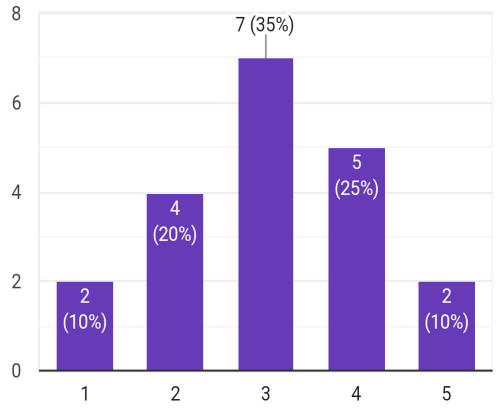
As shown in Figure 6, 68.4% of students responded that Arduino programming skill is improved and satisfied. However, 31.6% of students responded that their Arduino programming skill is not improved and satisfied. This 31.6 % of the students feedback that one semester was too short to fully understand Arduino programming.

4.3 Students' Mid-term and Final Exam Score

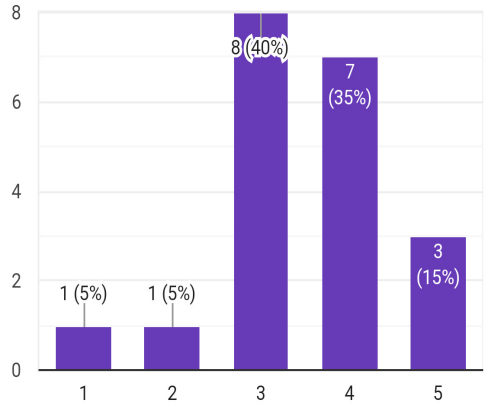
To confirm the improvement of the students' Arduino programming skill, the score distribution of the students' mid-term and final exams are analyzed in this subchapter. The midterm and final exams consist of five code interpretation problems and five code writing problems.

As shown in Figure 7, the distribution of midterm scores for students shows that most of the students are in the middle and others are in the rest of the area. However, we expected Normal distribution of the midterm exam scores, since 7-week classes are a short time to understand the embedded IoT with Arduino programming according to student feedback.

However, the average score of students' final exam is increased compared to score of students' midterm exam as shown in Figure 8. According to the students' feedback and exam score distributions, we found the project and proposed course is very helpful in improving the Arduino programming skills.



(그림 7) 학생들의 중간고사 점수 분포도
(Figure 7) Distribution of the students' midterm exam score

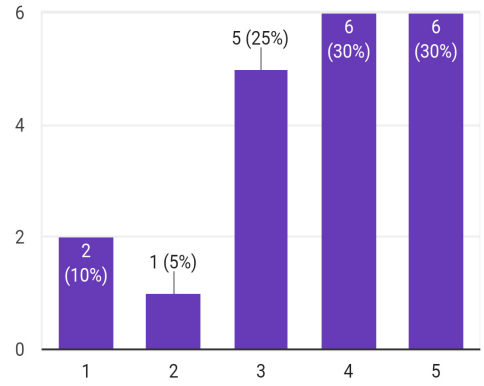


(그림 8) 학생들의 기말고사 점수 분포도
(Figure 8) Distribution of the students' final exam score

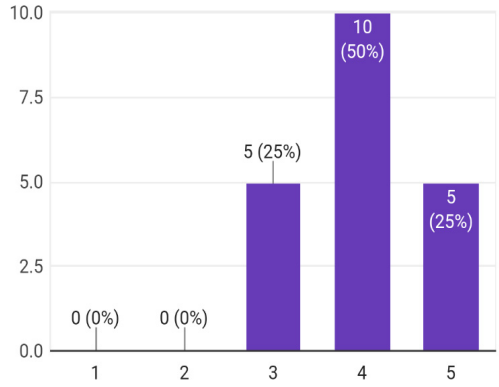
4.4 Students' Overall Satisfaction

This subchapter provides students' overall satisfaction of proposed course during the midterm and final exam periods.

As shown in Figure 9, 60% of the students were satisfied, 25% were moderate, and 15% were unsatisfied during the midterm exam period. According to feedbacks from students at the bottom of the self-satisfactions, students were not satisfied with their programming skills.



(그림 9) 중간고사 기간 동안의 학생들의 전반적인 만족도
(Figure 9) Students' overall satisfaction during the midterm exam period



(그림 10) 학생들의 최종 만족도
(Figure 10) Students' final overall satisfaction

According to students' responses in Figure 10, 75% of students satisfied the proposed course and 25% of the students were neither satisfied nor dissatisfied. According to students' feedbacks, 11 weeks of Bluetooth classes have attracted students' attention and improved the satisfaction. However, none of the students were unsatisfied with the proposed course. None of the students were satisfied with the course and 75% of the students' satisfaction prove that the proposed course is very effective in teaching IoT to students.

5. Conclusion

In this paper, we proposed a course that effectively teaches

embedded IoT by connecting the Arduino kit by smartphone with Bluetooth function. To help students understand Arduino's sensors, they used specific scenarios and conducted IoT projects via Bluetooth connectivity. According to student surveys, nearly 60% of students have improved their skills of using Arduino kit during the midterm.

According to students' midterm and final exam scores, the students' programming skills have been improved by carrying out their project. Moreover, 75% of the students were satisfied with the proposed course. Currently, the authors are studying various teaching methods to increase students' overall satisfaction since the authors expect 85% of students to be satisfied with the proposed embedded IoT courses.

For future work, we will design the intensive embedded IoT with Arduino programming courses to reflect the feedbacks of students who want to improve their Arduino programming skills.

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◐ 저 자 소 개 ◑

홍 준 기(Jun-Ki Hong)
2010년 Carleton University Computer Systems Engineering(공학사)
2017년 연세대학교 전기전자공학과(공학박사)
2016년 한국정보통신기술협회 선임연구원
2017년~현재 영산대학교 전기전자공학과 조교수
관심분야 : 빅데이터, 데이터베이스, 5G통신, IoT, 지능형 전자상거래, etc
E-mail : jkhong@ysu.ac.kr

백 종 호(Jong Ho Paik)
1994년 중앙대학교 전기공학과(공학사)
1997년 중앙대학교 전기공학과(공학석사)
2007년 중앙대학교 전자전기공학부(공학박사)
1997년~2011년 전자부품연구원 모바일단말연구센터 센터장
2011년~현재 서울여자대학교 소프트웨어융합학과 부교수
관심분야 : 차세대 지능형 플랫폼, 차세대 방송통신 시스템, 차세대 영상시스템, IoT/IoMT, etc.
E-mail : paikjh@swu.ac.kr

강 민 구(Mingoo Kang)
1986년 연세대학교 전자공학과(공학사)
1997년 연세대학교 전자공학과(공학석사)
1997년 연세대학교 전자공학과(공학박사)
1985년~1987년 삼성전자 연구원
2000년~현재 한신대학교 IT콘텐츠학과 교수
관심분야 : 모바일미디어, IoT 통신시스템, etc.
E-Mail : kangmg@hs.ac.kr

홍 성 찬(Sung-Chan Hong)
1983년 고려대학교 통계학과(학사)
1990년 게이오대학 관리공학과(공학석사)
1994년 게이오대학 관리공학과(공학박사)
1994년~1995년 LG CNS 컨설팅사업부 책임연구원
1995년~1997년 상명대학교 정보처리학과 전임강사
2010년~2011년 한국인터넷정보학회 회장
1997년~현재 한신대학교 정보통신학부 교수
관심분야 : 정보시스템, 빅데이터, etc
E-mail : schong@hs.ac.kr