

Utilization of the Electronic Board to Support IIoV-Based Projects in ACS Studies

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Abstract. Optimizing students' skills in the field of Automotive Control Systems (ACS) by utilizing Arduino Uno R3 Built-in ESP8266 as a hardware platform. The Challenge-Based Learning (CBL) approach is used as an instructional method to develop Comfort Safety and Technology (CSIT) in vehicles, which is a transformation of Intelligent Internet of Vehicles (IIoV) technology. This study involved seven students who studied in groups to develop the system for 14 meetings. The study's results showed that this approach was practical in optimizing students' skills in ACS, particularly in designing and developing IIoV-based systems. The implications of the research results underscore the importance of considering rapid technological advancements in the automotive sector and the necessity for continuous curriculum updates to ensure that graduates are well-prepared to work in the industry.

Keywords: Automotive Control System (ACS), Intelligent Internet of Vehicle (IIoV), Challenge-based Learning (CBL).

1 Introduction

The automotive control system is a feedback controller of an automation system that integrates disciplines in mechanical, electronic, and software aspects, also known as Mechatronics, in the development of modern vehicles [1], [2]. In the context of education and training, learning mechanical engineering requires mastery of knowledge and skills in the fields of mechanics, electronics, and advanced control [2], [3]. However, there is a challenge, namely the mismatch of skills needed in the automotive industry [4].

One of the leading causes of this gap is the rapid technological advances in the automotive sector, resulting in delays in integrating the latest technology into learning implementations [5], [6], [7]. This creates a gap in graduate skills with industry demands [8]. To overcome this

problem, an innovative approach is needed through transformation in learning in technical and vocational higher education to produce graduates with skills that meet industry needs [9], primarily for engineering skills in mechanical design, electronic circuits, and microcontroller programming, understanding of the design process, engineering, and testing [10].

Technological transformation through learning in higher education is crucial [5], as implementing the latest technology in the automotive sector for learning is very important [11]. However, it requires supporting media, one of which is the Arduino microcontroller board, which functions as an electronic control [12]. This microcontroller board allows integration between hardware and software, which is ideal for Internet of Vehicles (IoV) applications [13].

The transformation of sustainable IoV development engineering technology through learning [14], [15], can be fulfilled through the Challenge-Based Learning (CBL) learning approach. This approach provides instruction in improving technical skills [16], [17]. This results in a sophisticated control system for connected and automated vehicles aimed at providing driving comfort [18].

This research aims to promote technological transformation in learning for engineering and vocational higher education, particularly in automotive control system skills, by utilizing the Arduino Uno R3 microcontroller board's built-in ESP8266 with a focus on the engineering project of developing Comfort Safety Information and Technology (CSIT) based on Intelligent Internet of Vehicle (IIoV) on motorcycles. This implementation can optimize the technical skills of automotive engineering students in the field of automotive control systems through the Challenge-Based Learning (CBL) learning approach.

1.1 Automotive Control Systems

Automotive control systems are a combination of automotive mechatronics, which encompasses mechanical engineering, electronic control, and software design, all of which are crucial for product innovation [2]. This technology aims to optimize vehicle efficiency, such as stability, performance, and safety [1]. Additionally, it optimizes energy efficiency in electric vehicles [19].

1.2 Intelligent Internet of Vehicle (IIoV)

The Intelligent Internet of Vehicles (IIoV) is a field of science that integrates the Internet of Vehicles (IoV) with artificial intelligence (AI) in vehicles [19]. IoV aims to provide a secure and reliable network for cars, enabling users to enjoy various services [20]. The role of IoV is to enhance data processing and decision-making through communication feedback between vehicles and other devices [21].

1.3 Comfort Safety Information and Technology (CSIT)

Integration of Information and Technology for Comfort Safety (CSIT) with IoV, including Vehicle to Network (V2N), which is an intelligent transportation system that improves safety, security, and comfort for passengers in autonomous vehicle applications [22], [23]. This innovation utilizes sensors, actuators, and an electronic control unit (ECU) as electronic

controller components [24]. The benefits of this technology for future automotive applications include increasing driver satisfaction and facilitating various passenger needs [1], [25].

1.4 Challenge-based Learning (CBL)

Challenge-based Learning (CBL) has become an increasingly popular pedagogical approach in engineering higher education, but its implementation varies across institutions [26]. Based on a systematic review, CBL can improve competencies through real-life challenges, teamwork, and stakeholder collaboration in the context of education in the sustainable industrial 4.0 era [27]. The results of the implementation demonstrate that CBL can enhance students' soft skills through communication, collaboration, and problem-solving [28]. However, these results are not sufficient; instructional design aims to structure instruction with a student-centered approach [29].

2 Method

The Intelligent Internet of Vehicles (IIoV) on motorcycles was developed as a prototype product by seven students of the Automotive Engineering Education Study Program as a final assignment for the Automotive Control Systems (ACS) course. The automotive control systems engineering technical skills competency involves implementing the achievement of learning objectives to produce automotive control systems engineering technical skills that meet graduate needs. The Challenge-Based Learning (CBL) instructional approach is used to achieve the learning objectives in automotive control engineering. The stages are (1) engage, (2) investigate, and (3) act, as shown in Figure 1.

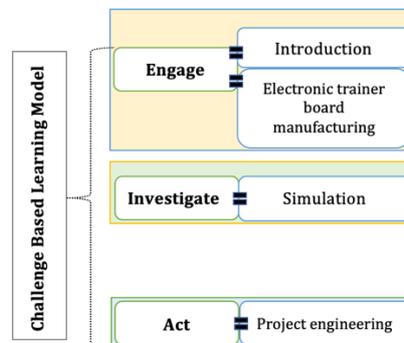


Fig. 1. Challenge-based Learning (CBL) instructional design

3 Results and Discussion

3.1 Engage

Data collected from the results of field observations distributing questionnaires before and after treatment, analyzed to obtain information to determine student perceptions on (1) understanding of theoretical material, (2) readiness of simulation plans, (3) practical skills possessed, (4) collecting learning resources, and (5) involvement in learning participation. To

produce an automotive control system engineering supported by automotive mechatronics textbooks and Comfort Safety Information and Technology (CSIT) autotronic simulators, Figure 4, the following engagement data before and after learning, Figure 2.

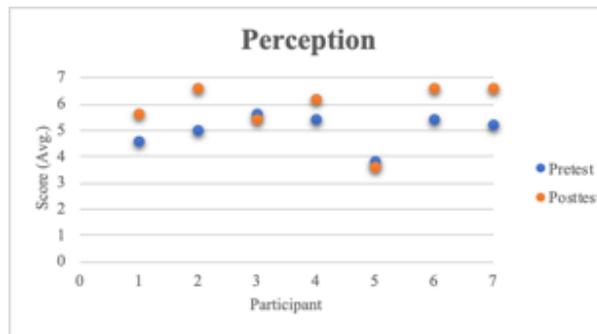


Fig. 2. Student perception



Fig. 3. Design and fabrication of electronic board trainer

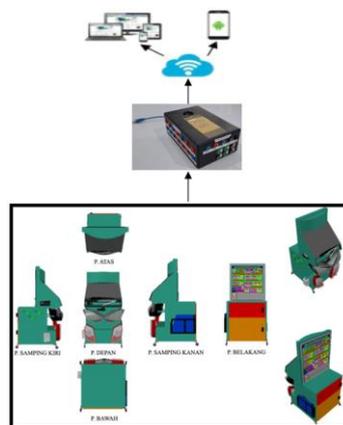
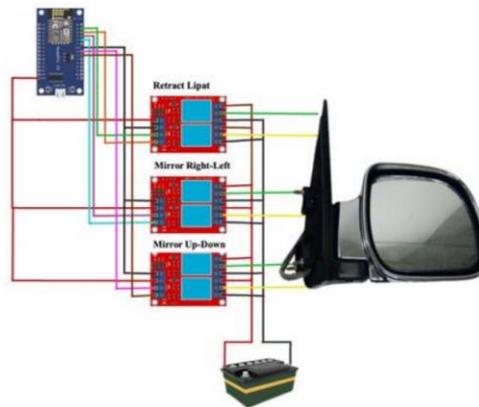


Fig. 4. Layout of the implementation of the CSIT trainer and simulator product based on IoV

Figure 2 shows a significant increase in students' appreciation of the introduction to control system theory and electronic trainer board fabrication, utilizing the Arduino Uno R3 with Built-in ESP8266 as a hardware platform. Figure 3. These results prove that students gained a better appreciation after learning, results similar to the research results [30] [31].

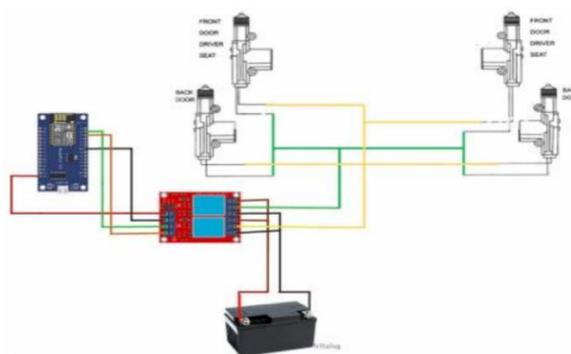
3.2 Investigate

At this stage, students conduct simulations to address the challenges presented by utilizing the Arduino Uno R3 with the Built-in ESP8266 electronic trainer board and the CSIT simulator. The practical simulation consists of 5 experiments, namely, (1) Retractable Rearview Mirror and Electric Mirror IoV, (2) Door Locks IoV, (3) Smart High Lamp, (4) Smart Power Windows IoV, (5) Windshield Wiper IoV, with the help of the CSIT simulator media. Documentation of the results is in Figures 5, 6, 7, 8, and 9.



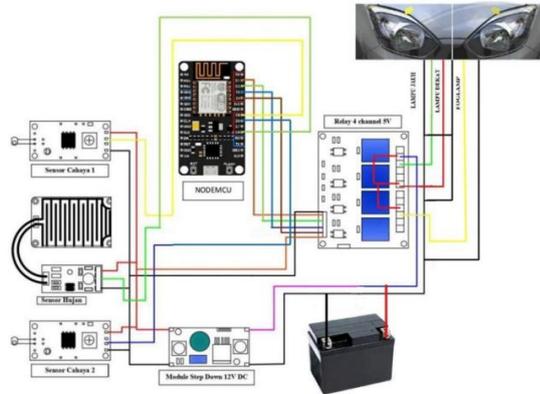
Video link: <https://youtube.com/shorts/n-8fUzymCFw?si=o353dGguX24geH6Z>

Fig. 5. Retractable rearview mirror and IoV electric mirror



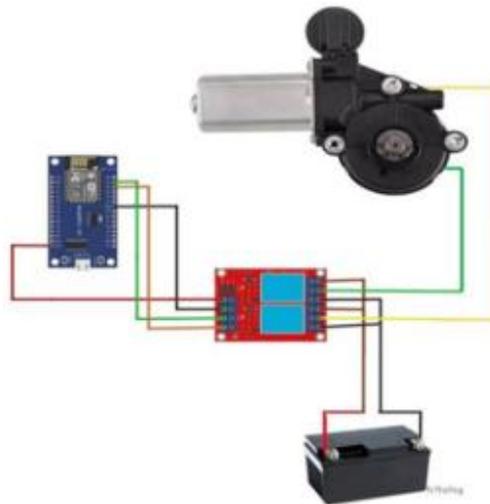
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Fig. 6. Door locks IoV



Video link: <https://youtube.com/shorts/J-gMlFv6N8?si=k8iNpcvPsJxSbvyt>

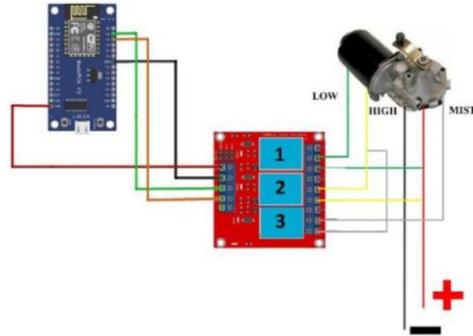
Fig. 7. Smart high lamp



Video link: https://youtube.com/shorts/Cqa3LiRfXXw?si=V7Ca7_vvjv5h2BTx

Fig. 8. Smart Power Windows IoV

Figures 5, 6, 7, 8, and 9 provide documentary evidence that students have completed the challenges given for each experiment. Students can complete the experiment in an average time of 180 minutes. The results of this simulation indicate that students' skills in the field of automotive control systems surpass those depicted in Figure 10. These results are as previously done by [32] [33].



Video link: https://youtube.com/shorts/SubgYdl7Zio?si=Ug_AosrMxb8jsiV

Fig. 9. IoV Windshield Wiper

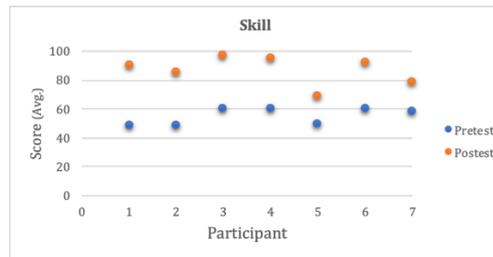


Fig. 10. Average student skill score

3.3 Act

At this stage, students, based on the results of their investigations, undertake engineering projects for automotive control systems utilizing artificial intelligence (AI).

- a. Layout mechanical design

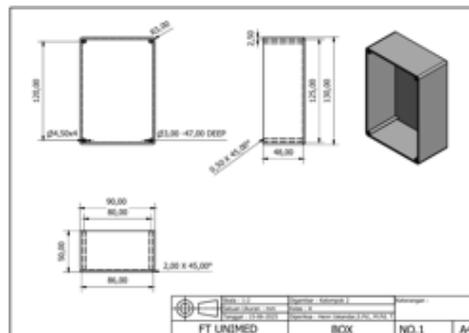


Fig. 11. Layout mechanical design

b. Hardware Design

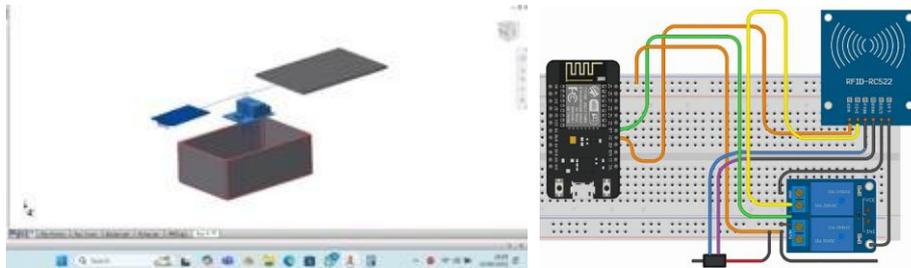


Fig. 12. Hardware wiring design

This system utilizes the Arduino Uno R3 electronic board module, Which Incorporates ESP8266 functions as the main control center (Figure 13). The module is connected to the RFID RC522 module, serving as a sensor to read card media, and is equipped with a 5V relay, packaged in a 6 x 20 cm plastic box. The ESP8266 can receive commands from the cloud via a webhook or API endpoint and execute them.

```
#define BLYNK_TEMPLATE_ID "MPL67PvMkLfs"
#define BLYNK_TEMPLATE_NAME "VOICE RELAY"
#define BLYNK_AUTH_TOKEN "TvdXlXXL3Dp9y5QanzqaVDbgg4zkdlwY"

#include <ESP8266WiFi.h>
#include <BlynkSimpleEsp8266.h>
#include <SPI.h>
#include <MFRC522.h>

// WiFi credentials
char ssid[] = "hay";
char pass[] = "aiichann";

// PIN Konfigurasi
#define RELAY1_PIN D3 // Relay 1 = kontrol via Voice (aktif 5 detik)
#define RELAY2_PIN D4 // Relay 2 = kontrol via RFID
#define BUZZER_PIN D0 // Buzzer
#define SS_PIN D2 // RFID SDA
#define RST_PIN D1 // RFID RST

MFRC522 rfid(SS_PIN, RST_PIN);
BlynkTimer timer;

// UID kartu yang dikenali
byte uidTerdafTar[] = {0xF3, 0x5D, 0xAB, 0x12}; // ganti sesuai kartu kamu
bool relay2Status = false;

// Fungsi: Relay 1 (voice) nyala 5 detik jika akses sudah diizinkan
BLYNK_WRITE(V1) {
  if (!relay2Status) {
    Serial.println("Akses belum diberikan. Tempel kartu RFID dulu.");
    return;
  }

  int state = param.asInt();
  if (state == 1) {
    digitalWrite(RELAY1_PIN, LOW); // ON
    Serial.println("Relay 1 ON (5 detik via voice)");
    timer.setTimeout(3000L, []() {
      digitalWrite(RELAY1_PIN, HIGH); // OFF setelah 5 detik
      Serial.println("Relay 1 OFF otomatis");
    });
  }
}

BLYNK_WRITE(V2) {
  int state = param.asInt();
  if (state == 0) {
    digitalWrite(RELAY2_PIN, LOW); // ON
    Serial.println("Sistem Dimatikan");
  }
}

// Fungsi: baca kartu RFID
void cekRFID() {
  if (!rfid.PICC_IsNewCardPresent()) return;
  if (!rfid.PICC_ReadCardSerial()) return;
}
```

Fig. 13. Hardware control coding

c. Software, as an interface, allows users to control the vehicle without physical contact. Web and voice assistance can be developed through the control panel. This is because the Google Assistant and Gemini platforms provide pre-programmed voice commands, as shown in Figure 14.

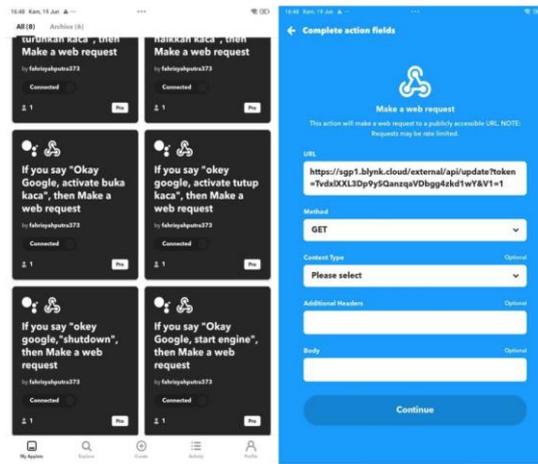


Fig 14. The interface display uses the Android operating system

- d. The automotive control system function test was conducted on the AI-controlled smart lock starter motor prototype to ensure that each component was functioning correctly. The first test was on the RFID card, specifically the ON/OFF function. Next, using voice commands with Google Gemini to give commands such as START ENGINE NOW or TURN OFF ENGINE. However, this test was carried out repeatedly because of testing constraints on the hardware, specifically an unstable internet connection. Additionally, the hardware device only supported 2.4 GHz WiFi and 4 MB of storage memory; therefore, the system's performance speed needed to be at least 80 MHz.



Video link: https://youtu.be/qtyY1XfPZLY?si=_I1YvBw2RnANhTit

Fig. 15. Test the function of the smart lock starter for AI-controlled motorbikes via voice

4 Conclusion

This study demonstrates that the Challenge-Based Learning (CBL) instructional model, supported by an IoT-based autotronics simulator and an Arduino Uno R3 with an integrated ESP8266 board, can significantly drive technological transformation, increasing student engagement and effectiveness in the learning process. This applicable and measurable learning model helps students innovate and develop their technical skills in the field of automotive control systems, specifically in the development of an AI-controlled smart lock motor starter.

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