Thiết kế chế tạo mô hình hệ thống khởi động thông minh điều khiển ô tô từ xa bằng smartphone

.

TÓM TẮT

Nghiên cứu "Thiết kế chế tạo mô hình hệ thống khởi động thông minh điều khiển ô tô từ xa bằng smartphone" nhằm phát triển một mô hình hiện đại phục vụ cho giảng dạy và ứng dụng thực tế. Mô hình này là công cụ học tập trực quan, giúp người học nắm vững sơ đồ hệ thống khởi động ô tô bằng chìa khóa và Start/Stop, có thể thực hành đấu nối, kiểm tra chẩn đoán lỗi, tạo pan cho hệ thống khởi động. Đặc biệt, mô hình còn là giải pháp nâng cấp hữu ích cho xe chưa có điều khiển khởi động từ xa. Sau khi tinh chỉnh, bộ điều khiển có thể lắp đặt thực tế, cung cấp tính năng khởi động và bật điều hòa từ xa cũng như cập nhập các trạng thái của xe thông qua smartphone, tăng tính tiện nghi cho người dùng. Nghiên cứu mang lại giá trị cao trong đào tạo và ứng dụng thực tiễn, đáp ứng nhu cầu công nghệ xe thông minh, nâng cao trải nghiệm người dùng trong thời đại kỷ nguyên công nghệ.

Keywords: *Hệ thống khởi động thông minh, khởi động ô tô từ xa, smartphone.*

Design and manufacture smart starting system model controlled remotely via smartphone for automobiles

ABSTRACT

The research "Design and manufacture smart starting system model controlled remotely via smartphone for automobiles" aims to develop a modern model for educational and practical purposes. This model is a visual learning tool that helps learners understand automobiles' start system, including start by keys and Start/Stop. It allows students to practice electrical circuit assembly, diagnose, and make faults for the start system. The model also serves as a practical upgrade solution for automobiles lacking remote start control. After refinement, the controller can be installed in actual automobiles, enabling remote start, air conditioning control, and automobile status updates via a smartphone, enhancing user convenience. This research adds significant value in training and real applications, addressing the growing demand for innovative vehicle technology and improving the user experience in the digital age.

Keywords: *start system, remote automobiles start, smartphone.*

1. INTRODUCTION

In recent years, remote control technology has made remarkable advancements, particularly in the automotive field. These developments enable efficient device connectivity and provide convenience by allowing users to control devices easily via smartphones.[1,2] The automotive industry has quickly embraced this trend to deliver modern remote control solutions, enhancing user experiences and meeting the increasingly diverse needs of consumers.

However, educational institutions, particularly the Department of Automotive Engineering at Quy Nhon University, remain limited in implementing effective practical learning models in automotive engineering technology. Although the university has invested in developing theoretical and practical training programs, there is a lack of visual models for remote control systems. This creates difficulties for students in accessing and practicing with modern technology. The absence of practical models makes delivering knowledge about innovative automotive systems less effective, limiting students' ability to apply their learning in real-world situations.

At the same time, the demand for the application of remote control technology in automobiles is steadily increasing. Modern users not only desire convenient features such as remote engine start or air conditioning adjustment but also expect comprehensive control over the vehicle's status without being physically present in the car. This necessitates robust development of remote start and control solutions for automobiles via smartphones to meet user expectations and create a competitive advantage in the automotive industry.

Therefore, the development of an innovative remote-controlled car start system model is not only a significant step in improving teaching methods and enhancing the quality of training at the Automobile Practice Center of Quy Nhon University but also meets the growing practical demand, contributing to the promotion of innovation and technological development in education and the automobile industry. It also provides students with opportunities to access modern technological solutions, preparing them to adapt to the development trends of Industry 4.0. This initiative helps bridge the gap between theoretical knowledge and real-world applications, enhancing students' readiness for future careers.

2. CONTENT

2.1. The process of designing and developing the model

2.1.1. Identifying needs and objectives

The model is designed to support the Department of Automotive Engineering undergraduate training courses at Quy Nhon University, assisting with theoretical and practical learning (focusing on the starter system). Specifically, it supports the following courses:

* Automotive electrical equipment (3 credits).

* Automotive electrical-electronic systems (3 credits).

* Internal combustion engines (3 credits).

* Internal combustion engine practice (4 credits).

* Automotive diagnosis and maintenance techniques (2 credits).

The model offers comprehensive knowledge of the structure, operating principles, and skills needed for testing and diagnosing automotive electrical systems, particularly the starter system. Additionally, it clearly illustrates the connections between electrical devices and IoT applications in automobiles. By integrating advanced electronic components such as microcontrollers, wireless communication modules, and sensors, the model not only elucidates the operating principles but also links theoretical concepts and real-world applications.

2.1.2. Manufacturing process

The manufacturing process of the smart remote starting system model controlled via a smartphone is designed to provide a practical and visual solution for teaching purposes. This model enables learners to understand technical principles and apply technology to real-world scenarios.

Developing the innovative remote starting system model is a promising yet challenging task requiring knowledge, skills, and creativity to overcome technical, financial, and practical application difficulties. The greatest challenge is ensuring the model operates stably in a learning environment, allowing simultaneous point measurement and circuit assembly. It must fully replicate the functions of an actual innovative starting system while maintaining simplicity, making it suitable for educational purposes. It also creates a platform that is easily accessible and applicable to future research and technology development projects.

2.2. Overview of the mode

2.2.1. The starting system using the key

The starting system using the key has been developed into a teaching model to illustrate the operating principles and structure of this system visually. The model fully replicates the main components, including the ignition switch, electrical circuit, relay, and starter motor, enabling learners to observe and practice efficiently.

The model clarifies how the system operates, from key activation to the engine starting process, and allows students to perform practical tasks such as circuit testing, assembly, and repair. It is an effective teaching tool, helping learners master fundamental knowledge while laying the foundation for understanding and accessing more advanced starting technologies.

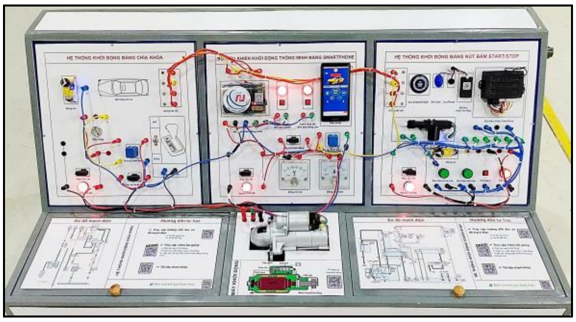

Figure 1. Front view of the smart starting system model for remote automobile control via smartphone.

2.2.2. The starting system using the Start/Stop button

The automotive starting system on the model is arranged scientifically and clearly. The upper section of the model includes the essential components of the system. In contrast, the lower section features the electrical circuit diagram, along with theoretical lessons guiding students to read the diagram, practice connections, inspections, and system diagnostics. These lessons are made accessible through QR codes, making it convenient for learners to access the content.

Like the starting system using the key, this model not only helps learners master the structure of the automotive starting system but also provides opportunities for hands-on practice in testing and operating the system. When the connectors are closed, students can operate and inspect the model to understand the system's operating principles. When the connectors are open, learners can easily practice external connections through the terminals, reinforcing their knowledge of working principles and enhancing their system assembly skills.

Moreover, the model can simulate faults, allowing learners to practice detecting and troubleshooting issues during operation. This enhances problem-solving skills and improves their ability to inspect and maintain the system.

Figure 2. Side view of the smart starting system model for remote automobile control via smartphone.

2.2.3. Starting system controller via smartphone

Currently, various technological solutions are used to control electromechanical systems. One commonly used solution is employing pre-designed boards, such as Arduino boards. Arduino is an open-source development platform designed to simplify the programming and deployment of embedded systems. Arduino offers an efficient solution for developing automation, control, and monitoring applications with its flexible hardware architecture and extensive software libraries. A key feature of Arduino is its compatibility with numerous sensors and modules. Arduino typically uses megaAVR chips and supports communication through protocols such as I2C, SPI, and UART. This versatility has made Arduino popular in academic research and industrial applications, education, and personal creative projects.

Table 1. Technical specifications of the controller.

No	Specification name	Value
1	Microcontroller	ATmega328/ATmega328 P
2	Memory	32 KB (2 KB used for bootloader)
3	Total I/O Pins	22 (14 Digital, 8 Analog)
4	PWM Pins	6 (D3, D5, D6, D9, D10, D11)
5	UART Communication	1 channel
6	I2C Communication	1 channel (SDA: A4, SCL: A5)
7	SPI Communication	1 channel (SS: D10, MOSI: D11, MISO: D12, SCK: D13)
8	Operating Voltage	5V

Moreover, the model can be connected to the controller, transforming a traditional starting system into an innovative system via smartphone. This system can update information about the engine's status, such as speed and temperature, and control other systems like turning on the air conditioning, locating the car, etc., while ensuring safety conditions during startup. Integrating innovative technology enhances efficiency and convenience and helps learners grasp concepts related to automation and remote control, thereby improving their skills and ability to apply technology in real-world scenarios.

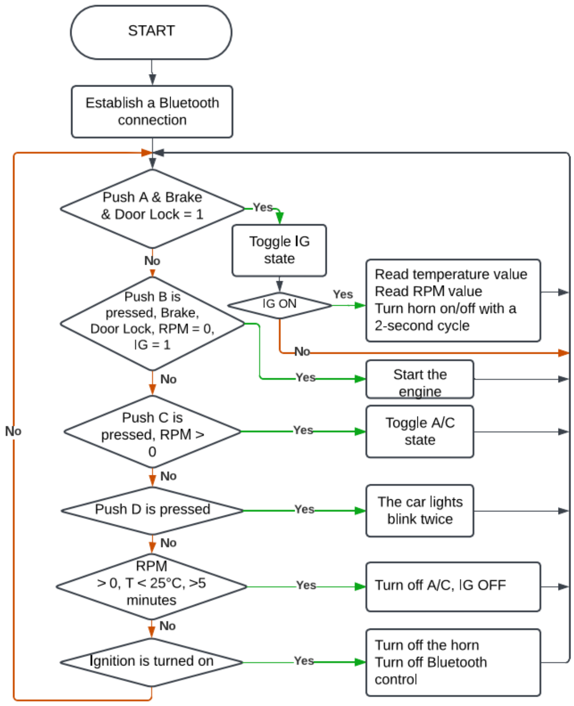

Figure 3. Control flow diagram of the smart starting system.

2.3. Application of the model in teaching

2.3.1. Integration of theory and practice using the model

To complete the learning task, students should first scan the QR code to self-study the theoretical part, ensuring they clearly understand the system's structure and operating principles.

Students can identify each detailed system component visually and dynamically through the model. This helps them understand the structure and function of the components and easily relate to the overall and logical principles of the system's operation.[3,4]

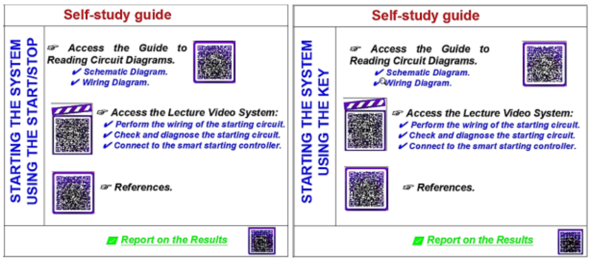

Figure 4. QR code to access the lecture system.

Next, students can connect the terminals and start the system while also measuring the parameters based on the theoretical knowledge they have learned. During this process, students can use the fault simulation tool to emulate faults, observe the system's response, analyze the causes, and learn how to fix the issues. This activity not only helps them master system operations but also equips them with practical troubleshooting skills.

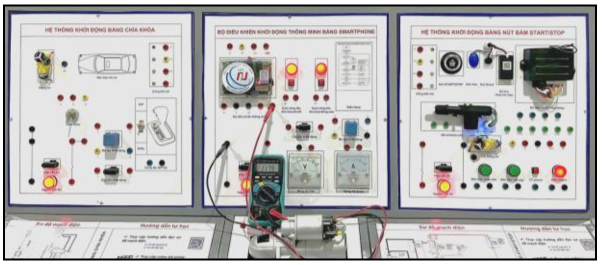

Figure 5. Practicing operation and parameter measurement of the starting system through external terminals.

On the model, disconnecting the terminals allows for practicing reconnection of the electrical circuit through external terminals. This process enhances wiring skills and reinforces related knowledge while improving the ability to apply practical solutions accurately and effectively.

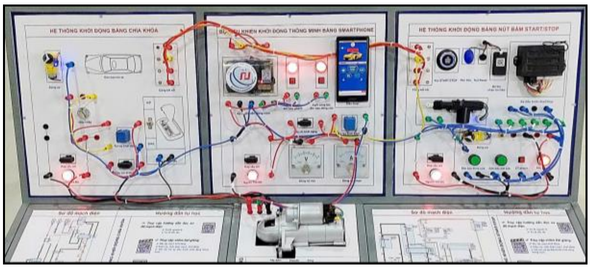

Figure 6. Practicing wiring of key and Start/Stop button starting systems on the model.

Finally, students report their results by documenting the process, measurement parameters, encountered faults, and solutions. They also reflect on lessons learned and propose improvement solutions through a QR code system, enabling students and instructors to quickly track and evaluate the learning process. Through the application, lecturers can assess performance online and quickly generate statistical result reports.

2.3.2. Application of smart starting system controller conversion on the model

Conversion on the model by performing simple tasks such as connecting power and signals like brakes, door locks, engine speed, and cabin temperature, a conventional starting system can be upgraded to an innovative starting system controlled remotely via a remote or smartphone.

The smartphone control application supports smart starting and integrates many other valuable features, such as monitoring the vehicle's operational status, updating cabin temperature, controlling air conditioning on/off, and locating the vehicle. When the engine temperature reaches the desired level, the system automatically turns off the engine to ensure comfort and fuel efficiency. All actions are carried out under maximum safety conditions.

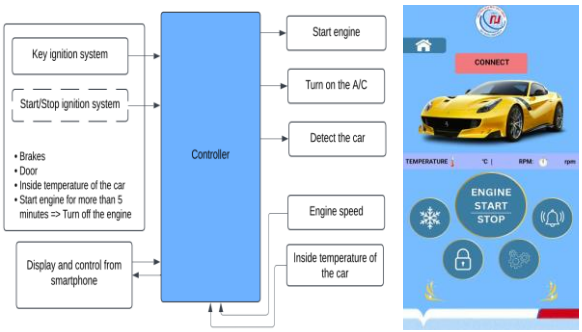

Figure 7. Schematic diagram of control and interface on smartphone.

2.4. Evaluation of the effectiveness of the model application in teaching

A survey was conducted to evaluate the model's effectiveness on two groups of K44 students (16 students/group) from the Department of Automotive Engineering, Quy Nhon University. The groups included a control group (A) and an experimental group (B). These students had completed the course on Automotive Electrical and Electronics Systems. They continued the course on Internal Combustion Engine Practice (Lesson on Maintenance and Repair of the Starting System, 5 hours).

The objective of the survey is to assess the student's initial knowledge and skills regarding the starting system while also determining the effectiveness of the learning process when applying the practical model.

To evaluate the efficacy of using the model, several statistical methods are applied, including:

* The formula for calculating the average score:

$$\bar{X} = \frac{\sum X_i}{N} \quad (1)$$

* Formula for calculating the standard deviation:

$$SD = \sqrt{\frac{\sum(X_i - \bar{X})^2}{N}} \quad (2)$$

Trong đó:

SD: Standard deviation.

X_i: Score of each student.

$\bar{X}$: Average score.

N: Total number of students.

2.4.1. Results of assessing students' knowledge base on the starting system

After surveying two student groups, A and B, with an assessment format that includes a maximum score of 100, the evaluation consists of a multiple-choice test assessing theoretical knowledge (50 points) and an exercise for identifying images and diagrams to evaluate recognition skills (50 points). The percentage of students meeting the requirements is recorded as follows:

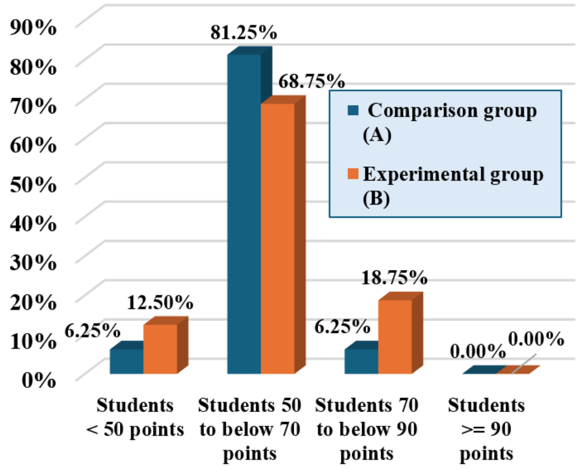

Figure 8. Chart of the results assessing students' knowledge base on the starting system for Groups A and B.

The results show that the two groups, A and B, are relatively similar in ability. Group B has a higher average score than Group A (62.1 compared to 60.4), indicating better performance. However, the standard deviation for Group B is larger (8.7 compared to 7.8), which suggests that the scores in Group B are more varied, while Group A's scores are more stable and consistent. These data are an essential basis for evaluating the effectiveness of learning when applying the model of the starting system that the research team is developing.

2.4.2. Results of evaluating students' practical skills and ability to apply theory when using the model

During the practical course on Internal Combustion Engines, a survey was also conducted to assess two groups of students, A and B. Group A practiced with individual components (traditional method). In contrast, Group B practiced using the model of the starting system. Following this, their practical abilities and the application of theory to real-life scenarios were evaluated on a Toyota Vios (2013) at the Automotive Practice Center, Quy Nhon University.

The survey aimed to evaluate and compare the practical skills and the ability to apply theory in practice among students, with a maximum score of 100. The assessment focused on specific skills, including connection (40 points), measurement (30 points), logical analysis (20 points), and fault troubleshooting (10 points). The percentage of students meeting the requirements for each group is also recorded and analyzed in the following chart:

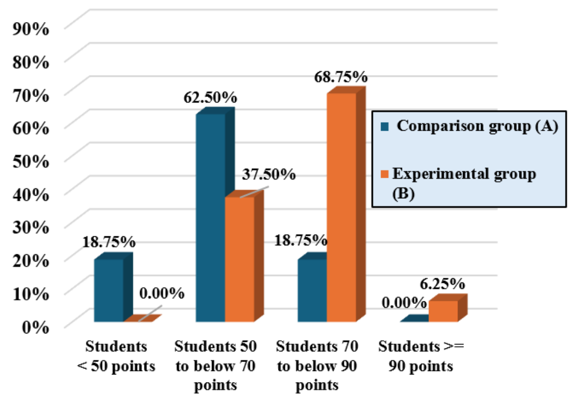

Figure 9. Chart of the results assessing practical skills and the application of theory by Groups A and B when applying the model.

The results show a clear difference in capabilities between Groups A and B. Group B has a higher average score than Group A (74.4 compared to 56.7), indicating that Group B performed better overall. Additionally, the standard deviation of Group B is smaller (9.9 compared to 12.3), indicating that the scores in Group B are more concentrated around the average, reflecting more stability and consistency in the learning outcomes. In contrast, Group A has a larger standard deviation, suggesting a greater spread of scores, which may include students with very high and very low scores.

2.4.3. Results of teaching evaluation by lecturers when using the model

The survey assessed the effectiveness of using the model in teaching with 09 instructors from the Department of Automotive Engineering at Quy Nhon University, including both Full-time and Adjunct lecturers who participated in teaching using the model.

The survey focused on four main criteria: reducing preparation and teaching time, supporting theoretical and practical teaching, reducing the time required to assess learning outcomes, and enhancing teaching effectiveness.

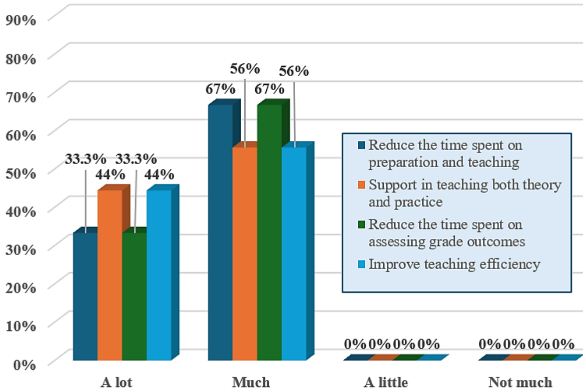

Figure 10. Chart of evaluating the teaching effectiveness of lecturers when using the model.

The survey results are summarized and presented in the chart, reflecting the level of satisfaction of lecturers with each criterion when applying the model in teaching practice. Most lecturers agreed that the model is effective in reducing lesson preparation time and saving time and effort in grading and evaluating student performance, especially for technical and practical content. They also emphasized the model's outstanding ability to simulate real-life scenarios, creating a strong bridge between theory and practice.

However, some lecturers pointed out areas that need improvement, particularly concerning the safety features of the controller when installed in vehicles. Specifically, they suggested solutions to handle situations when the controller malfunctions. Additionally, they recommended adding safety protection mechanisms to the model to minimize risks when incorrect connections are made.

These comments not only clarify the value and effectiveness of the model but also provide important suggestions for improvement, enhancing its ability to meet practical teaching requirements, which will contribute to greater effectiveness in the future.

2.4.4. Evaluation of the effectiveness of installing the controller on the learning vehicle model at the University

The smart engine starter controller, controlled via smartphone, was installed and converted on a Toyota Vios (2013) at the Automotive Practice Center of Quy Nhon University. It has proven effective when applied in practice. The device operates stably, meets the requirements for controlling the engine via smartphone, and provides a modern system that aligns with today's advanced automotive technology.

During the training process, the controller helps students access and practice with dapper starting systems, enhancing their skills in operation, installation, and conversion of conventional starting systems into smart ones. The application of this controller has contributed to modernizing teaching methods and improving the quality of automotive engineering education at the University.

However, to optimize long-term effectiveness, it is necessary to consider the costs of upgrading features and making the system more compact to better align with technology in future modern vehicles.

3. CONCLUSION

A smart starting system model controlled remotely via smartphone for automobiles has delivered practical value in innovative teaching methods and enhanced the quality of education in the field of automotive engineering. The model not only provides an interactive learning tool that helps students master the theory of automobile starting systems but also effectively supports the practice of essential skills such as wiring, operation, fault diagnosis, and converting conventional starting systems into innovative starting systems.

The survey results show that the students using the model achieved a significantly higher average score (74.4 compared to 56.7) than the group following traditional methods, with more stable and consistent learning outcomes. Lectures also highly appreciated the model, emphasizing that it reduces lecture preparation time, enhances teaching efficiency, and improves students' ability to access real-world technology.

This model meets the demand for improving the teaching quality at the Automotive Practice Center of Quy Nhon University and paves the way for new advancements in applying modern technology to education. In the future, the starting system controller should continue to develop to optimize the system, enhance security and safety features, and expand its applicability to modern vehicle lines. This marks a significant step forward, contributing to higher training quality and preparing students to meet the demands of an increasingly competitive automotive industry and labor market.

REFERENCES

1. M. Jang, S. C. Lee, Y. S. Lee, H. S. Han, and S. Choi. Design and Implementation of a Vehicle Control System Using Smart Phones, *International Journal of Control and Automation*, **2017**, *10*(4), 35-46.

2. C R Kiran, T Bathina Babu. Smart Vehicle Control System By Using Cell Phone, *International Journal of Science & Advanced Research in Technology*, **2022**, *8*(7), 562-565.

3. D. V. Dung. *Electrical and Electronic Equipment in Modern Automobiles,* Vietnam National University Ho Chi Minh City Publishing House, Ho Chi Minh, 2004.

4. T. T. Quoc. *Research and Development of the Start-Stop System in Automobiles, Master's thesis,* Ho Chi Minh City University of Technology and Education, 2014.

5. T. T. Ha, D. V. Thang. *Basic Electronics,* Vietnam National University Ho Chi Minh City Publishing House, Ho Chi Minh, 2016.