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Implementation of RFID-based Smart Door Lock Prototype Using Arduino Uno as Interactive Learning Media

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Abstract

Purpose: This study aims to design and implement an RFID-based smart door lock prototype using Arduino Uno as an interactive learning medium for automatic door security technology at UPTD Graha Teknologi Sriwijaya.

Research Methodology: This study uses a descriptive method with a qualitative approach. Data were collected through observation, interviews, and documentation at UPTD Graha Teknologi Sriwijaya. System development applied the prototype method through requirements analysis, initial design, prototype construction, functional testing, evaluation, and implementation.

Results: The prototype integrates an Arduino Uno, RFID RC522 reader, RFID card/keychain, 16×2 I2C LCD, SG90 servo motor, buzzer, 18650 lithium-ion battery, step-up charger, switch, and a 3D-printed smart home model.

Conclusions: Functional testing shows that registered RFID identifiers trigger the opening sequence and feedback, while unregistered identifiers are rejected, and the door remains locked. The prototype therefore provides a practical demonstration of RFID identification, microcontroller-based decision making, automatic actuation, and user feedback.

Limitations: The study does not evaluate long-term durability, advanced cybersecurity, large-scale deployment, or statistical learning outcomes.

Contributions: The study offers a reproducible educational prototype concept that connects embedded-system components with an observable learning interaction in a science-center environment.

Keywords: *Arduino Uno, Learning Media, Prototype, RFID, Smart Door Lock*

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1. Introduction

Technological development has encouraged the use of microcontrollers and automatic identification systems in security applications (Aretha, Rachmah, Sholikhah, Afifah, & Radianto, 2024). One implementation is the smart door lock, which replaces or supplements conventional mechanical keys with electronic authentication. Radio Frequency Identification (RFID) is particularly suitable for this type of application because an RFID reader can obtain an identifier from a tag or card without direct physical contact (Aretha et al., 2024; Hidayatullah, Hadary, & Marindani, 2024). In a

microcontroller-based system, the identifier can be processed to determine whether access should be granted or denied (Hermawanto, Habibi, & Hasyim, 2022).

An automatic door security system also has educational benefits. The relationship between an input device, a processing unit, and output actuators can be demonstrated physically, allowing learners to observe the complete process rather than only reading a theoretical explanation (Leo, Azis, & Emidiana, 2021). The Arduino Uno is useful in this context because it provides a relatively simple microcontroller platform for connecting RFID readers, displays, actuators, and indicators. Therefore, a physical prototype can simultaneously function as a demonstration of embedded system principles and as an example of access control technology (Hidayatullah et al., 2024; Ilham, Ihsan, Yofinaldi, & Paduloh, 2024).

UPTD Graha Teknologi Sriwijaya uses direct demonstrations and interactive teaching aids in science and technology education. Visitors can observe exhibits, read captions, receive explanations from guides, and interact directly with the available equipment (Nugroho, Ladjamudin, & Bariroh, 2020). The study documented numerous educational exhibits, including science games, energy demonstrations, measurement devices, mechanical demonstrations, and other interactive tools. However, the study also found that some exhibits were relatively old and that the available educational media did not include an RFID-based automatic door security demonstration. This created an opportunity to introduce a contemporary digital-security topic through a tangible learning medium (Pamungkas, Haryanto, Saputra, Alfaridzy, & Hafidz, 2024).

Observation at the research site was conducted from March 16 to March 30, 2026. Interviews were conducted on May 11, 2026, with the Head of Publication and Educational Services and the Head of Science and Technology Demonstration. The interviews focused on the condition of existing teaching aids, the way information was delivered to visitors, the need for more interactive media, and the potential use of a smart door lock prototype. These activities established the practical context for the development described in this study.

Therefore, the research problem is not simply how to make a door lock work, but how to translate the working principle of RFID-based access control into a compact, understandable, and interactive educational exhibit (Pardani & Yulianti, 2026). The resulting prototype must show the relationship between RFID identification, Arduino processing, access decisions, servo movement, visual feedback, and audio feedback. The design must also be simple enough for visitors from different age groups and backgrounds to understand.

Previous studies have demonstrated RFID-based door locks using Arduino and related microcontrollers, with most applications emphasizing physical access security, authentication, laboratory or residential locking, IoT integration, or operational convenience (Rahmi, 2021). Some studies have also developed automatic-door trainers for formal technical learning. However, these approaches generally position the system as either a functional security device or a subject-oriented trainer, rather than as a compact public-facing science-and-technology exhibit whose primary purpose is to make the authentication process understandable through direct interaction. The novelty of the present study lies in repositioning the RFID door-lock architecture as an interactive educational exhibit at UPTD Graha Teknologi Sriwijaya. The prototype combines five design characteristics in one demonstrator: (1) RFID-based contactless identification, (2) Arduino-based real-time decision making, (3) servo-driven physical actuation, (4) simultaneous visual and audio feedback, and (5) a self-contained 3D-printed Smart Home presentation with independent power. This combination is intended to expose the input-process-output chain of access control in a form that can be observed and operated by visitors without requiring a full-scale door installation. Therefore, the contribution is not a claim of a new RFID algorithm, but a new educational framing and integration of established components into a context-specific interactive learning medium (Rahmi, 2021; Rizal, Diharjo, & Ridwan, 2025; Pamungkas et al., 2024; Sari, Sulaiman, & Apdilah, 2025).

Based on this gap, the objective of the study is to design and implement an RFID-based smart door lock prototype using Arduino Uno as an interactive learning medium at UPTD Graha Teknologi Sriwijaya. The study specifically examines whether the integrated prototype can clearly demonstrate the sequence of RFID identification, UID verification, access decision, servo actuation, and user feedback within a compact physical model. The study also documents the component integration and functional behavior needed to reproduce the demonstrator, thereby providing a practical reference for the development of similar educational embedded-system exhibits.

2. Literature Review

2.1 Smart Door Lock and RFID-Based Access Control

A smart door lock is an electronic access-control mechanism that verifies an identity and then controls a locking actuator. In the prototype developed in this study, the verification identity is the UID of an RFID card or keychain. The Arduino Uno acts as the decision-making controller, while the SG90 servo provides the physical movement needed to simulate unlocking and relocking. The LCD and buzzer provide immediate feedback to the user (Sianturi & Sitio, 2025; Zafitri, Satra, & Alwi, 2025).

RFID enables identification without requiring direct contact between the tag and reader. The RC522/MFRC522 module used in this study operates at 13.56 MHz and communicates with the Arduino through SPI. The research documentation describes a typical reading range of up to approximately 10 cm and a fast response suitable for access-control demonstrations. These characteristics support the choice of RFID as an input technology for a hands-on learning exhibit (Aretha et al., 2024).

RFID also has limitations that are important to communicate in an educational context. Reading performance can be affected by surrounding materials, especially metal and liquids, and the reading distance of the selected module is limited (Villanueva-Loredo, Ortiz-Lopez, Leyva-Ramos, & Diaz-Saldierna, 2023). RFID-based access systems can also require careful consideration of power continuity and authentication security. Because the present prototype is educational, these limitations are treated as part of the learning context rather than as reasons to design a production security system.

2.2 Arduino Uno, Actuation, and User Feedback

The Arduino Uno was used as the central controller in the prototype. It receives the UID from the RFID reader, compares the UID with a registered identifier stored in the program, and then determines the appropriate output response. This architecture clearly illustrates the input-process-output relationship that is important in embedded-system education (Suryono, Supriyati, Dadi, Kusumastuti, & Khambali, 2025; Zafitri et al., 2025).

The SG90 servo motor was used as the actuator. When access was granted, the Arduino sent a control signal that moved the servo to the opening position. After the programmed delay, the servo returned to the closing position. The LCD 16×2 provided textual feedback, such as system readiness, checking status, access granted, and access denied. The buzzer provided an auditory indication so that the result of authentication was not communicated visually only (Saputra et al., 2024; Septian & Andrasto, 2020).

The prototype uses an independent power arrangement consisting of 18650 lithium-ion batteries, a two-slot holder, a step-up charger module, and an ON/OFF switch. The power arrangement allows the exhibit to be operated without continuously relying on a computer USB connection. The 3D-printed smart home model houses the electronic components and provides the system with a recognizable physical context for visitors (Pardani & Yulianti, 2026; Rifal, Kusmantoro, & Harjanto, 2024).

2.3 Educational Media and Research Gap

Educational technology media are more useful for demonstration when learners can see a concept, interact with it, and receive immediate feedback. Existing research on Arduino and RFID has shown that automatic door trainers and RFID-based systems can support practical learning, while other studies have developed RFID door locks for laboratories and residential environments (A. H. Nugroho et al., 2020). These studies establish the technical feasibility of RFID-based access control, but they leave an opportunity to integrate the same technology into a public science-center exhibit designed around explanation and interaction rather than permanent security operation (Pardani & Yulianti, 2026; Rifal et al., 2024).

Therefore, the research gap is defined by the intersection of technology, presentation, and educational purpose. The intended user of this study is not a technician operating a permanent security installation but a visitor learning about digital technology in a science center environment. The prototype consequently emphasizes the visibility of the process, simplicity of interaction, compact physical presentation, standalone operation, and explanatory feedback. The distinctive contribution of this study is the integration of the complete access-control chain card detection, UID verification, decision, servo movement, LCD status message, buzzer indication, and automatic relocking inside a recognizable 3D-printed Smart Home model. This design turns an otherwise abstract authentication concept into a directly observable sequence and provides a physical bridge between embedded system theory and everyday smart home technology (Hermawanto et al., 2022; Jenaro, Sulistyo, Santosa, & Widodo, 2021).

This study does not formulate a statistical hypothesis because the design is descriptive and qualitative. Instead, its working proposition is that an integrated RFID-Arduino demonstrator can provide a clear, functional, and interactive representation of automatic access control for educational use. The proposition is examined through functional testing of registered and unregistered RFID identifiers and through consultation with relevant personnel at the research site (Arasid, Zakaria, & Abdullah, 2025). Accordingly, the novelty is evaluated at the level of educational-system integration and demonstrator design, not through claims of superior security performance against existing commercial door-lock systems.

3. Research Methodology

3.1 Research Design and Site

This study used descriptive research with a qualitative approach. The descriptive design was used to document the condition of educational media and to describe the resulting prototype, while the qualitative approach supported direct observation, interviews, documentation, and interpretation of prototype performance. The research was conducted at the UPTD Graha Teknologi Sriwijaya, located in the Taman Budaya Sriwijaya complex in Jakabaring, Palembang, South Sumatra.

The research site is a public science and technology education facility that provides interactive exhibits for students and the general public. This study identified the need for an additional teaching aid related to digital security, RFID identification, microcontrollers, and automatic access control. This site-specific need became the basis for the prototype requirements.

3.2 Data Collection

Observation was conducted from March 16 to March 30, 2026, to examine existing teaching aids, their level of interactivity, and the availability of educational content related to digital security and RFID. The observation showed that the institution already used direct demonstrations but did not yet have an RFID-based smart door lock exhibit.

Interviews were conducted on May 11, 2026. The first interview was with Mardesa, Head of Publication and Educational Services, using 12 questions concerning existing teaching aids, interactive educational needs, visitor information delivery, and the proposed smart door lock medium.

The second interview was with Firdaus, Head of Science and Technology Demonstration, using 10 questions concerning exhibit conditions, technology demonstrations, microcontroller-based teaching aids, and the use of Arduino and RFID. Documentation consisted of photographs and supporting records of exhibits, observations, interviews, and prototype development.

3.3 Prototype Development Method

The system was developed using an evolutionary prototype approach. The first stage involved identifying requirements and preparing the initial design. The second stage involved assembling the hardware and developing the Arduino program. The third stage involved testing and evaluation. If the results were not consistent with the intended functions, the prototype could be refined and tested again. After the required functions were achieved, the final prototype was prepared as an educational medium (Suherman & Kurniawan, 2023).

The principal system flow is organized into inputs, processes, and outputs. An RFID card or keychain is used as an input. The RC522 reader obtains the UID and sends it to an Arduino Uno. The Arduino compared the UID with the value registered in the program. For a valid UID, the output consisted of an access-granted message, servo movement to open the door, and supporting indication. For an invalid UID, the system displays access denied, activates the buzzer, and leaves the servo in the locked position (Setiawan, 2023).

The software was developed using the Arduino IDE with C/C++-based programming. The program initializes the serial communication, SPI interface, RFID reader, LCD, servo, and buzzer. The loop then checks for a new RFID card, reads its UID, performs the matching process, calls the appropriate access function, stops the RFID transaction, and returns the display to standby mode. The components used in the prototype and their respective functions are listed in Table 1.

Table 1. Prototype components and their functions

Component	Role	Educational function
Arduino Uno	Main controller	Demonstrates embedded processing and control
RFID RC522	Reads RFID UID	Demonstrates contactless identification
RFID card/keychain	User identity	Demonstrates authentication input
LCD 16×2	Displays status	Makes system state visible
SG90 servo	Door actuator	Demonstrates automatic mechanical control
Buzzer	Audio indicator	Provides immediate feedback
18650 battery + step-up charger	Power supply	Demonstrates portable operation
3D-printed Smart Home	Prototype housing	Provides visual and physical context

3.4 Functional Testing

Testing was conducted using a descriptive qualitative approach and black box principles. The test focused on external behavior rather than the program's internal structure. The test conditions included registered and unregistered RFID cards and tags. The main observations were RFID reading, access status, LCD output, buzzer response, servo movement, and response delay (Putra & Lestari, 2023; Raharjo & Prasetyo, 2023).

An acceptable registered card condition was defined as the system reading the card, recognizing its UID, displaying an access-granted message, and moving the servo to the opening position before returning to the locked position. An unregistered card condition was defined as the system reading the card but rejecting the UID, displaying an access-denied message, activating the buzzer, and maintaining the locked position.

Because the prototype is intended as an educational demonstration, this study evaluates functional behavior and usability-related suitability rather than long-term reliability, resistance to attack, environmental durability, or production security performance.

4. Results and Discussions

4.1 Prototype Implementation

As shown in Figure 1, the final prototype integrates the principal components into a compact smart home model. The RFID reader is positioned externally so that visitors can easily tap a card or keychain. The LCD is positioned where the status message can be seen directly. The Arduino Uno, power components, and wiring are arranged inside the model to maintain a cleaner appearance and protect the electronic assembly (Nasution & Fahri, 2024).

The implementation establishes a complete input-process-output chain. The RFID card or keychain provides the identity input. The RC522 reads the UID and communicates with the Arduino through SPI. The Arduino compares the UID with the registered identifier. The results are then transmitted to the LCD, servo, and buzzer. This architecture makes the system behavior visible and easy to explain during demonstrations (A. P. Nugroho, Prasetya, & Dewi, 2024).

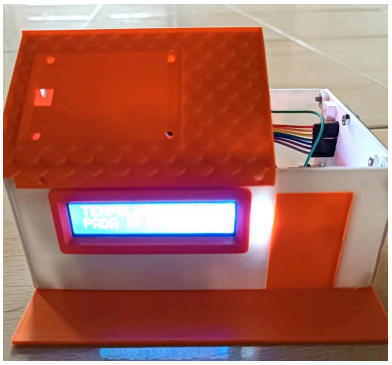


Figure 1. Overall RFID-based Smart Door Lock prototype

4.2 System Architecture and Operation

The system begins when the ON/OFF switch is activated (Figure 2). Power from the 18650 battery arrangement is regulated through the step-up charger and supplied to the electronic components. Arduino Uno initializes the RFID reader, LCD, servo, and buzzer. The LCD then enters a standby state and instructs the user to present an RFID card (Firmansyah, Bachtiar, & Syahputra, 2024; M. F. Hidayatullah & Sari, 2024).

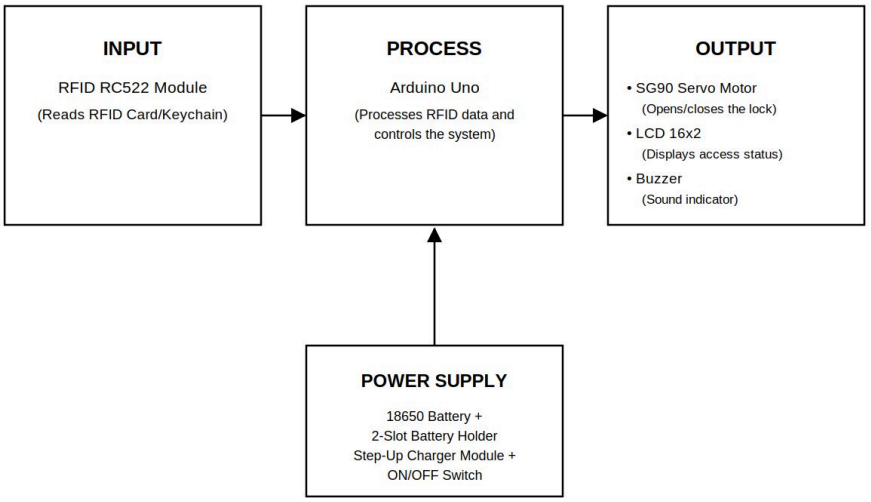


Figure 2. Block representation of the prototype system

As illustrated in the flowchart in Figure 3, when a card is placed near the RC522, the reader obtains the UID and sends it to the Arduino. The program checks whether the UID length matches the expected length and then compares each UID byte with the registered UID. If every byte matches, the program calls the access-granted routine. The LCD displays an access-granted message, the servo moves to the open position, and after the programmed opening interval, the servo returns to the closed position(Kusuma & Ardianto, 2024).

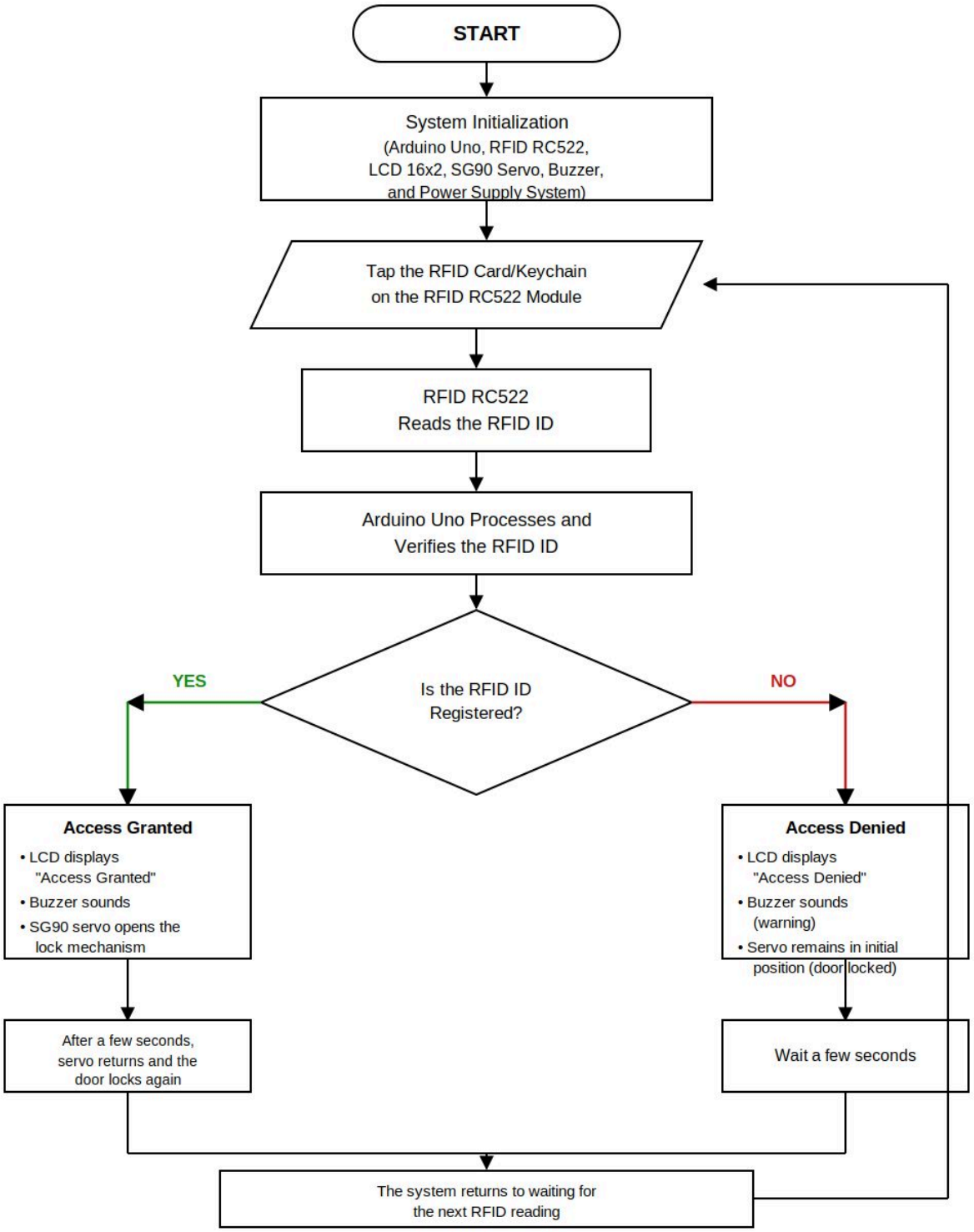


Figure 3. Flowchart of RFID verification and access control

If the UID does not match the registered value, the program calls the access-denied routine. The LCD reports the rejection, and the buzzer provides an audible warning. The servo is not moved to the opening position; therefore, the simulated door remains locked. The process demonstrates the essential logic of an access-control system without requiring a full-scale physical door.

4.3 Functional Test Results

Table 2. Functional behavior of the prototype

No	Condition	RFID reading	LCD	Servo	Buzzer
1	Registered card	Detected	Access granted / door open	Opens, then closes	No rejection warning
2	Unregistered card	Detected	Access denied	Remains locked	Warning indication
3	System startup	Reader initialized	System ready / standby	Closed	Off

As shown in Table 2, the functional test indicates that the prototype performs the intended access-control sequence. A registered card is recognized and produces the expected output chain, whereas an unregistered card does not activate the door-opening mechanism. Therefore, the test supports the basic functional requirement that the authentication results control the actuator state.

The results in Table 2 are important for the educational purpose of the prototype because each authentication state has visible and audible consequences. Visitors can directly observe that the same reader can produce two different system decisions depending on the stored fingerprints. The LCD makes the decision explicit, the servo converts the decision into physical movement, and the buzzer adds an additional feedback channel to the system.

The testing approach was intentionally limited. The research did not claim a quantitative accuracy percentage because the available evidence in the TA is descriptive and functional rather than a statistically designed repeated-trial dataset. Accordingly, the article reports observed functional outcomes rather than inventing numerical performance measures.

4.4 Physical Design as Learning Media

As shown in Figure 4, the 3D-printed smart home structure serves both as housing and as a visual teaching aid. The door became the central object of the demonstration, while the RFID reader was positioned at the point where a user would normally interact with an access-control system. This arrangement helps connect the electronic components with a familiar real-world context (Fitriani, Rizkyudin, & Pradhana, 2022; Muzaki, Amal, & AlFarisi, 2024; Pasaribu & Setiawan, 2021).

The internal placement of the Arduino, power module, and wiring keeps the external presentation orderly. Simultaneously, the visible LCD, RFID reader, and door mechanism expose the important stages of the process. Therefore, the design balances technical protection with educational visibility. The prototype is also consistent with the learning environment at UPTD Graha Teknologi Sriwijaya, where visitors are encouraged to learn through direct interactions. The study documentation describes the institution as using practical and interactive demonstrations in science, technology, and mathematics. The Smart Door Lock extends this approach to the area of digital security and embedded systems.

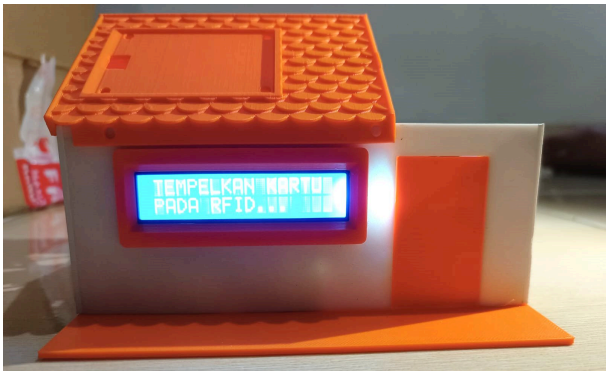


Figure 4. Prototype viewed as a 3D Smart Home educational model

4.5 Discussion in Relation to Previous Research

The prototype is technically aligned with earlier RFID door-lock studies in using a reader, microcontroller, authentication logic, and actuator. Research on Arduino-based door locks has shown that RFID can be used to distinguish authorized and unauthorized access, while other studies have extended such systems through IoT, smartphone control, logging, or additional authentication factors.

The present study differs primarily in terms of its educational objectives. Instead of optimizing a permanent access control installation, it translates the access control principle into an interactive exhibit. This emphasis is consistent with research showing that Arduino and RFID can be incorporated into learning media and training. Therefore, the value of the prototype is not limited to whether the door opens; it lies in making the underlying process observable and explainable.

The prototype also supports experiential learning because visitors can perform authentication actions themselves. A visitor presents a card, observes the reader's response, sees the verification message, and then sees the door actuator respond. This short feedback loop can make concepts such as RFID identification, UID matching, microcontroller processing, and actuator control easier to communicate than a static explanation.

4.6 Validation and Suitability at the Research Site

Before being treated as the final result, the prototype and its design were discussed with personnel at UPTD Graha Teknologi Sriwijaya, particularly those responsible for science and technology demonstrations and educational services. The discussion considered system functionality, physical appearance, ease of use, safety, alignment with educational missions, and possible future development. The research documentation states that the relevant UPTD personnel agreed on the prototype as an educational aid. This supports the practical suitability of the prototype in the study setting. Nevertheless, the validation described in the TA is qualitative and site-based; it should not be interpreted as a standardized psychometric validation or a statistically generalizable evaluation of learning effectiveness.

4.7 Educational Interpretation and Practical Implications

The prototype can be interpreted as a small-scale embedded learning system because it combines identification, processing, actuation, and feedback into one observable sequence. From the visitor's perspective, the interaction begins with a simple action—placing a registered or unregistered card near the reader. The RC522 converts the radio interaction into an identifier, the Arduino processes the identifier, and the output devices translate the decision into visual, auditory, and mechanical responses. This chain is useful for explaining that an automated security system is not a single component but a coordinated set of hardware and software functions.

An important practical implication is the possibility of explaining the system logic without exposing the visitor to complex source code. The LCD messages provide a user-level representation of the program states: standby, checking, access granted, and access denied. The servo provides a physical

representation of the access decision. The buzzer provides a second channel of feedback. These outputs can be explained individually and then connected to the overall system architecture. Such an approach is appropriate for a science-center environment because visitors may have different levels of prior knowledge about electronics and programming.

The prototype also demonstrates the educational value of modular hardware. The RFID reader can be discussed as an input device, the Arduino as the processing unit, and the servo, LCD, and buzzer as outputs. The battery, charger, and switch illustrate the importance of power management. The 3D-printed smart home model then connects these technical elements to a familiar application. This modular explanation can help educators demonstrate basic embedded-system concepts before introducing more advanced topics, such as networking, databases, or multi-factor authentication.

From a system-development perspective, the use of an evolutionary prototype method is consistent with the need to adjust a physical teaching aid through repeated observation and evaluation. Hardware placement, display visibility, user interaction, and mechanical movement are easier to assess after an initial physical model exists. Therefore, the method supports iterative improvement rather than requiring every design detail to be finalized before the first working model is assembled.

Nevertheless, the practical scope of the prototype should be clearly communicated to users. The system demonstrates the principle of RFID authentication but should not be considered a production-grade security solution. The registered UID is handled within the Arduino program, the RFID reading distance is limited, and the prototype does not include centralized logging or advanced cryptographic authentication. Presenting these boundaries as part of the educational material can be beneficial because visitors can learn that engineering systems involve trade-offs between simplicity, cost, usability, security, and scalability.

At the institutional level, the prototype adds a digital security theme to an existing collection of practical teaching aids. The research site already uses direct interaction and demonstrations to support the learning process. The Smart Door Lock can extend this model by allowing visitors to experience a contemporary application of RFID and microcontroller technology. It can also serve as a starting point for future exhibits involving IoT, access logs, wireless communication, fingerprint authentication, or other smart home technologies.

Finally, the study suggests that educational contributions should be assessed more systematically in future work. The present study establishes functional suitability and qualitative agreement from relevant personnel, but it does not quantify changes in visitor knowledge. A subsequent study could compare understanding before and after interaction with the prototype, examine ease of use across visitor groups, and measure the consistency of system responses over repeated trials. These additions would strengthen the evidence concerning both technical reliability and educational effectiveness.

5. Conclusions

5.1 Conclusion

This study successfully designed and implemented an RFID-based smart door lock prototype using Arduino Uno as an interactive learning medium at UPTD Graha Teknologi Sriwijaya. The system integrates RFID RC522, RFID card/keychain, Arduino Uno, LCD 16×2, SG90 servo, buzzer, and an independent battery-based power supply in a 3D-printed smart home model. Functional testing confirmed the intended input-process-output sequence: a registered RFID identifier is detected and verified, the servo opens the simulated door, the LCD and buzzer provide feedback, and the door subsequently returns to the locked state; an unregistered identifier is rejected, and the door remains locked.

Functionally, the prototype demonstrates the complete sequence of RFID identification, UID verification, access decision, actuator control, visual feedback, audio feedback, and automatic

relocking. Registered cards are granted access and cause the servo to open the simulated door, whereas unregistered cards are rejected and cause the door to remain locked. These results support the feasibility of presenting the authentication chain as a directly observable learning interaction.

The main contribution and novelty of this study are the context-specific integration and presentation of established RFID-Arduino technology as a public educational exhibit. Unlike a conventional smart lock that prioritizes operational security, this prototype is deliberately designed so that visitors can observe and interact with each stage of the access-control process within a compact 3D-printed smart home model. The combination of standalone power, RFID identification, Arduino decision logic, servo actuation, LCD messages, buzzer feedback, and automatic relocking creates a self-contained demonstrator that connects embedded-system concepts with a familiar smart-home scenario. Thus, this study contributes a practical design model for science-center educational media rather than claiming a new authentication algorithm.

5.2 Research Limitations

This study was limited to a prototype and educational demonstration. It does not assess the long-term component durability, large-scale deployment, resistance to deliberate attacks, database-based access logging, or comprehensive environmental testing. The learning impact on visitors was not measured using a controlled quantitative learning-outcome instrument.

5.3 Suggestions and Directions for Future Research

Future development can add Wi-Fi or Bluetooth to introduce Internet of Things concepts, while a database or memory card can be used to record access history. Alternative actuators and authentication methods, such as fingerprint sensors, keypads, and facial recognition, can broaden the educational content. The 3D smart home model can also be refined to provide a more realistic representation of a residential smart-security system.

Future studies should additionally evaluate learning effectiveness using pretest and posttest instruments, usability questionnaires, repeated functional trials, and systematic reliability measurements. Such work would complement the present functional prototype study and provide stronger evidence of educational impact.

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Author Contributions

RHA contributed to research conceptualization, system design, prototype development, functional testing, and preparation of the original manuscript. YA contributed to methodology development, research supervision, evaluation of the prototype, and critical manuscript review. NKO contributed to data collection, documentation, interpretation of findings, and manuscript editing. All authors reviewed and approved the final manuscript and agreed to be accountable for the integrity of the work.

References

Arasid, W., Zakaria, D., & Abdullah, C. U. (2025). An IoT-based smart home prototype: Enhancing energy efficiency, water conservation, and sustainability education. *Journal of Environment and Sustainability Education*, *3*(3), 454-463. https://doi.org/10.62672/joease.v3i3.148

Aretha, S. D., Rachmah, A. A., Sholikhah, B., Afifah, R. N., & Radianto, D. O. (2024). Smart door key otomatis dengan Sensor RFID menggunakan mikrokontroler arduino uno. *KOLONI*, *3*(2), 129-136. https://doi.org/10.31004/koloni.v3i2.629

Firmansyah, R., Bachtiar, A. M., & Syahputra, R. (2024). Simulasi Prototype Smart Door Lock RFID terintegrasi dengan sistem informasi manajemen akses berbasis IoT. *Jurnal Teknologi dan Sistem Komputer*, *12*(2), 78-89. https://doi.org/10.14710/jtsiskom.2024.18234

Fitriani, I. M., Rizkyudin, M. S., & Pradhana, C. (2022). Smart doorlock otomatis berbasis mikrokontroller arduino. *Metrotech (Journal of Mechanical and Electrical Technology)*, *1*(1), 31-36. https://doi.org/10.33379/metrotech.v1i1.1029

Hermawanto, F., Habibi, H. J., & Hasyim, N. C. (2022). Rancang bangun sistem pengunci pintu berbasis RFID dan arduino pada laboratorium komputer jurusan teknik informatika. *Jurnal Pengelolaan Laboratorium Pendidikan*, *4*(1), 26-35. https://doi.org/10.14710/jplp.4.1.26-35

Hidayatullah, B. A., Hadary, F., & Marindani, E. D. (2024). Arduino-based robot with RFID Utilization as an educational media for Indonesian traditional folk song and Pancasila. *Journal of Electrical Engineering, Energy, and Information Technology (J3EIT)*, *12*(1), 193-204. https://doi.org/10.26418/j3eit.v24.1234

Ilham, M. M., Ihsan, M. K., Yofinaldi, S., & Paduloh. (2024). Design using RFID Sensor Based on Arduino Uno. *Scientica: Jurnal Ilmiah Sains dan Teknologi*, *2*(2), 16-22. https://doi.org/10.572349/scientica.v2i2.875

Jenaro, D. F. P., Sulistyo, E., Santosa, A. B., & Widodo, A. (2021). Pengembangan media trainer pintu otomatis dengan sensor ultrasonik, RFID, dan PIR berbasis arduino pada mata pelajaran mikroprosessor dan mikrokontroler kelas X di SMKN 1 Driyorejo. *Jurnal Pendidikan Teknik Elektro*, *10*(3), 11-18. https://doi.org/10.26740/jpte.v10n03.p11-18

Kusuma, A. W., & Ardianto, R. (2024). Optimasi penggunaan pin Arduino menggunakan ekspander I2C pada sistem smart home. *Jurnal Rekayasa Elektrika*, *20*(1), 22-30. https://doi.org/10.17529/jre.v20i1.3456

Leo, A., Azis, A., & Emidiana. (2021). Perancangan sistem kunci pintu otomatis mengunakan RFID Arduino Uno. *Jurnal Ampere*, *6*(1), 43-48. https://doi.org/10.31851/ampere.v6i1.5242

Muzaki, I., Amal, M. I., & AlFarisi, M. (2024). Smart lock door berbasis digital menggunakan RFID RC522 dan microcontroller arduino nano. *Transient: Jurnal Ilmiah Teknik Elektro*, *13*(2), 75-81. https://doi.org/10.14710/transient.v13i2.75-81

Nasution, H., & Fahri, M. (2024). Sistem kendali akses ruangan berbasis RFID dengan RTC DS3231 untuk pencatatan waktu aktivitas pengguna. *Jurnal Teknik Informatika*, *16*(2), 101-112. https://doi.org/10.15408/jti.v16i2.5678

Nugroho, A. H., Ladjamudin, A.-B. B., & Bariroh, S. (2020). Prototipe pengontrol kunci pintu berbasis arduino uno menggunakan RFID studi pada SMKS Kesehatan Utama Insani. *Jurnal Teknik Informatika UNIS*, *7*(2), 100-108. https://doi.org/10.33592/jutis.v7i2.390

Nugroho, A. P., Prasetya, B. A., & Dewi, C. (2024). Analisis performa sistem embedded berbasis Arduino pada aplikasi kendali akses Real-time. *Jurnal Infotel*, *16*(1), 45-54. https://doi.org/10.20895/infotel.v16i1.9012

Pamungkas, R. W. P., Haryanto, B. D., Saputra, I. E., Alfaridzy, M. D., & Hafidz, R. (2024). Implementasi Teknologi RFID dalam rancang bangun sistem absensi mahasiswa dengan database MySQL: Optimalisasi efisiensi dan keakuratan. *Scientica: Jurnal Ilmiah Sains dan Teknologi*, *2*(7), 388-398. https://doi.org/10.572349/scientica.v2i7.1936

Pardani, N. P., & Yulianti, B. (2026). Perancangan sistem absensi otomatis mahasiswa berbasis RFID terintegrasi google spreadsheet dan smart door lock. *Jurnal Teknologi Industri*, *15*(1), 15-25. https://doi.org/10.35968/jti.v15i1.1926

Pasaribu, A., & Setiawan, A. E. (2021). Penerapan auto lock door berbasis arduino uno dan RFID. *Jurnal Sistem Informasi dan Teknologi (SINTEK)*, *1*(1), 27-32. https://doi.org/10.56995/sintekl Sistem Informasi dan Teknologi (SINTEK), 1(1), 27-32. doi:10.56995/sintek.v1i1.25

Putra, I. M. D., & Lestari, N. K. (2023). Implementasi sistem kendali akses pintu otomatis berbasis RFID RC522 dan Arduino Uno. *Jurnal Teknik Elektro Undip*, *15*(2), 88-97. https://doi.org/10.14710/transmisi.15.2.88-97

Raharjo, S., & Prasetyo, D. (2023). Karakterisasi solenoid door lock pada sistem kendali akses otomatis berbasis mikrokontroler. *Jurnal Fisika dan Aplikasinya*, *19*(2), 72-79. https://doi.org/10.12962/j24604682.v19i2.1234

Rahmi, L. (2021). Pengembangan kunci pintu pintar berbasis Radio Frequency Identification (RFID). *JAMIK: Jurnal Aplikasi Manajemen Informatika Komputer*, *1*(2), 68-77.

Rifal, K. Z., Kusmantoro, A., & Harjanto, I. (2024). Studi analisa penggunaan baterai li-ion dan li-po pada sistem IoT hidroponik. *JETI (Jurnal Elektro dan Teknologi Informasi)*, *3*(1), 1-5. https://doi.org/10.26877/jeti.v1i1.580

Rizal, M. H., Diharjo, F. E., & Ridwan, M. (2025). Perancangan Alat Absensi Berbasis RFID dan ESP32. *JuTEkS (Jurnal Teknik Elektro dan Sains)*, *12*(1), 261-265. https://doi.org/10.32832/juteks.v12i1.21582

Sari, I. P., Sulaiman, O. K., & Apdilah, D. (2025). Implementasi RFID dalam perancangan sistem absensi karyawan. *Jurnal Minfo Polgan*, *14*(1), 107-112. https://doi.org/10.33395/jmp.v14i1.14646

Septian, D. D., & Andrasto, T. (2020). Pengaman pintu rumah menggunakan otentifikasi dua faktor berbasis arduino uno. *Edu Elektrika Journal*, *9*(2), 24-30. https://doi.org/10.15294/eej.v9i2.42774

Setiawan, B. H. (2023). Integrasi LCD I2C pada sistem embedded berbasis Arduino untuk antarmuka pengguna yang efisien. *Jurnal Informatika Upgris*, *9*(1), 33-41. https://doi.org/10.26877/jiu.v9i1.5678

Sianturi, F. A., & Sitio, A. S. (2025). Implementasi IoT dalam sistem absensi siswa berbasis RFID dan cloud computing. *Jurnal Media Informatika*, *6*(2), 1192-1196. https://doi.org/10.55338/jumin.v7i1.5647

Suherman, A., & Kurniawan, D. (2023). Teknologi RFID dan implementasinya pada sistem keamanan modern. *Jurnal Teknik dan Informatika*, *10*(1), 14-23. https://doi.org/10.37025/jtiust.v10i1.2345

Suryono, S., Supriyati, S., Dadi, D., Kusumastuti, S., & Khambali, M. (2025). Rancang bangun pengontrol lampu listrik dengan saklar tanpa sentuh, remote dan IoT. *Orbith: Majalah Ilmiah Pengembangan Rekayasa dan Sosial*, *21*(2), 175-188. https://doi.org/10.32497/orbith.v21i2.6763

Villanueva-Loredo, J. A., Ortiz-Lopez, M. G., Leyva-Ramos, J., & Diaz-Saldierna, L. H. (2023). Switching regulator based on a non-inverting step-down/up DC–DC converter for lithium-ion battery applications. *Micromachines*, *14*(6), 1144. https://doi.org/10.3390/mi14061144

Zafitri, S. N. A., Satra, R., & Alwi, E. I. (2025). Rancang bangun alat smart lock pada laci meja menggunakan sensor RFID berbasis Arduino. *LINIER: Literatur Informatika dan Komputer*, *2*(1), 115-121. https://doi.org/10.33096/linier.v2i1.2793