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Design of Smart Door Lock as A Teaching Aid for Magnetic Field Material in High School

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Abstract. This research aims to 1) produce a product in the form of a smart door lock teaching aid based on the RFID RC522 sensor and Arduino Uno as a teaching aid for magnetic field material in high school, 2) determine the suitability of the teaching aid that has been created and developed, and 3) to determine students' responses to props developed. This type of research is research and development (Research and Development, R&D), by applying the ADDIE development model, namely Analysis, Design, Development, Implementation, Evaluation. The tool that has been developed is then validated by three validators using an expert validation sheet instrument. The assessment of the product being developed consists of aspects of tool efficiency, tool relationship with learning, educational value, tool durability, aesthetics, technical and safety. The results of expert validation obtained an average validation percentage value of 80.55% with a very feasible category. Student responses to teaching aids were measured using a student response questionnaire. The results of student responses obtained an average response percentage of 84.19% in the good category. It can be concluded that the smart door lock based on the RFID RC522 sensor and Arduino Uno as a teaching tool for magnetic field material can be used in studying magnetic fields in high school.

Keywords: arduino uno, smart door lock, teaching aids

1. Introduction

Physics is the study of the physical properties of an object, including its characteristics, changes in shape, and observable conditions. Many physics concepts are abstract, making them difficult for students to understand. To help students understand these ideas more effectively, it is important to make them more concrete and relevant. One way to achieve this is through the use of teaching aids. Teaching aids in physics learning, especially in delivering explanations on magnetic field material, have an important role. This tool is designed to help students understand the concept of magnetic fields in solenoids in a more interactive and interesting way [1]. This approach enables students to gain a deeper understanding, generate accurate and engaging data, and improve their ability to interpret results. Additionally, incorporating learning media in the educational process aids in summarizing information more efficiently. Compared to students who only listen to lectures, those who use learning media typically show greater interest and engagement in the learning process [2].

Students often struggle with learning physics, particularly when it comes to understanding the concept of magnetic fields. This challenge is further compounded by the limited opportunities for hands-on activities that could reinforce their understanding [3]. When the learning process relies solely on lectures without practical experiments, students have difficulty developing a clear understanding of abstract physical phenomena, such as magnetic fields [4]. A survey indicates that 71% of students perceive physics as a difficult subject, primarily due to the large number of formulas that need to be memorized, while another 25% find the concepts themselves difficult to grasp. This suggests that ineffective teaching methods and a lack of practical laboratory experience contribute significantly to the difficulties students face in understanding physics [5].

Teaching aids play a crucial role in physics education by increasing students' interest and motivation, while also broadening their overall knowledge [6]. The primary function of physics teaching aids is to help students visualize concepts, working principles, phenomena, or natural laws that are difficult or even impossible to observe directly [7]. These simple yet engaging learning tools effectively present information in an inspiring manner, providing students with an optimal learning experience. One example of a physics phenomenon that can be explored using teaching aids is the magnetic field, which is the region around a magnetic object or an electrified conductor where magnetic forces can be detected [8].

The needs questionnaire is an instrument used to collect data about the needs and challenges experienced by students in learning activities. In the world of education, this questionnaire aims to analyze student needs related to the learning process and the use of teaching aids on magnetic field material [9]. This needs analysis questionnaire was conducted at SMA Negeri Jayaloka which is located in the province of South Sumatra, in the district of Musi Rawas, Lubuklinggau city. The needs analysis carried out includes several statements, including, the teacher teaches physics material using the discussion method, the teacher still uses the lecture method in the learning process, the teacher has used teaching aids in explaining physics material, the lack of availability of teaching aids in the school laboratory, using teaching aids as a learning resource makes it easier to understand the material, students are enthusiastic if there are teaching aids in learning, teaching aids available at school are still manual, teaching aids available at school are still minimal, agree if the magnetic field teaching aids are made and developed.

The analysis revealed that 91.25% of students reported that physics lessons are predominantly delivered through the discussion method, demonstrating a preference for active interaction that fosters better comprehension. However, 63.75% noted that the lecture method is still employed, which may be less effective in maintaining their attention. Furthermore, while 95% of students acknowledged the use of teaching aids by their teachers, 97.5% identified issues with laboratory equipment, indicating shortcomings in the quality and availability of these resources. A high percentage of students 96.25% expressed a strong desire for user-friendly teaching aids on magnetic fields, and 95% stated that their enthusiasm for learning would increase with the use of such aids. This underscores the vital role teaching aids play in boosting learning motivation. However, 76.25% of students reported that the current teaching aids are manual, which may hinder their creativity. Additionally, 68.75% recognized a lack of teaching aids for magnetic fields in their school, and 93.75% believed that learning would improve with the integration of teaching aids. On average, 88.12% of students strongly agreed on the necessity of developing teaching aids for magnetic field topics, reflecting their awareness of the critical role such tools play in enhancing the quality of physics education at school.

Ampere's law states that an electric current flowing through a wire generates a magnetic field around it. This principle is fundamental to understanding the operation of an RFID (Radio Frequency Identification) door lock system. When an RFID card is brought near the reader in this system, an electric current passes through the reader's coil, producing a magnetic field that interacts with electromagnetic components such as solenoids. Solenoid based door locks function on the principle of electromagnetism, which explains that a magnetic field is created when electric current flows through a coil of copper wire. The solenoid coil generates a magnetic field capable of pushing or pulling metal components (commonly including a plunger), thereby enabling the door to lock or unlock when current is applied [10]. This mechanism relies on the magnetic field to operate, allowing the door to open and close automatically. By leveraging Ampere's law, such systems enhance both security and convenience by demonstrating how an electric current can create a magnetic field to activate a door lock [11].

Research [12] on the development of physics teaching aids in the form of magnetic cranes demonstrated highly positive results regarding their feasibility in the learning process. The tool achieved a media validation score of 81.5% and a material validation score of 91.65%. Limited trials with students also yielded favorable responses, with a satisfaction rate of 96.7%. These findings suggest that the tool effectively enhances student motivation and interaction when learning about magnetic fields. However, several limitations were identified. The teaching aid cannot yet measure the magnetic field (B) and magnetic force (F) precisely and lacks a user manual, which could extend its lifespan. Additionally, the tool's durability received a relatively low rating of 55.6%, highlighting the need for improvement in this area. Another study by [13] found that students perceived the device as helpful in understanding magnetic field concepts more practically and interactively. The positive feedback underscores the tool's potential to support the learning process effectively. During experiments, students displayed high levels of interest and participation, indicating the tool's effectiveness in improving material comprehension. Nonetheless, certain weaknesses remain, such as reliance on analog sensors, which often have low resolution and can result in data collection errors. Similarly, research by [14] demonstrated that the magnetic field measuring instrument is well-suited for physics education. Students reported that it facilitated their understanding of magnetic field concepts and boosted their motivation and engagement during experiments, ultimately contributing to their cognitive development. However, issues such as inconsistent sensor sensitivity under specific conditions and limited measurement range need to be addressed, as they may impact the accuracy of results.

In this context, teaching aids have been designed to demonstrate smart door locks related to the phenomenon of magnetic fields in solenoids. This teaching aid will undergo expert validation to ensure its suitability before being tested on students. Testing has been conducted at SMA Negeri Jayalaloka to evaluate how effective the RC522 RFID sensor and Arduino Uno-based smart door lock function as teaching aids for the concept of magnetic fields.

2. Methods

This study employed the Research and Development (R&D) methodological framework. Within this approach, development research is conceptualized as "educational design research," a systematic process focused on creating, developing, and implementing educational programs, processes, and products. As elaborated in [15] educational design research encompasses a comprehensive investigation into the planning, development, and evaluation of educational practices and innovations.

The R&D methodology involves a sequence of procedures aimed at producing new products or enhancing existing ones [12]. It is specifically designed to generate innovative solutions and assess their effectiveness [16]. This study utilized the ADDIE development model, which comprises five stages: Analysis, Design, Development, Implementation, and Evaluation [17]. The ADDIE model was chosen because it provides a systematic framework for designing, developing and evaluating learning programs effectively, thus ensuring learning objectives are achieved optimally [18]. By emphasizing individual learning and integrating both short- and long-term objectives, ADDIE provides a well-structured framework for understanding knowledge acquisition and human learning processes. A schematic of the ADDIE model as a learning system design is shown in Figure 1.

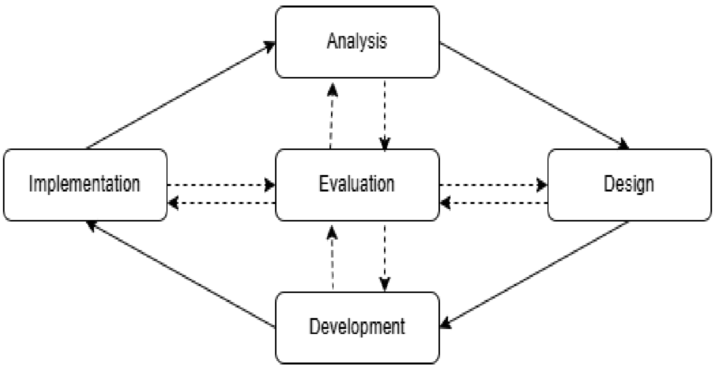

Figure 1. Research phase.

2.1. *Analysis Stage*

The analysis stage is the stage of collecting information that can be used as a basis for making products and developing products. The purpose of this analysis is to identify the main problems that arise in the learning process, especially in terms of problem solving. In solving these problems, the main focus is on the development of the magnetic field props used. The information needed for this analysis will be obtained through a questionnaire that assesses the needs. In the analysis stage, researchers identified the problems and needs that exist in learning magnetic field material in high school. The analysis process begins by assessing the current learning methods applied, as well as identifying obstacles faced by students in understanding the concept of magnetic fields, such as the limited teaching aids available.

2.2. *Design Stage*

At the design stage in the research of designing smart door locks as teaching aids on magnetic field material based on RFID RC522 and Arduino Uno sensors in high school, designing the props system in detail, starting from the selection of components to the preparation of the tool's working scheme. The design begins with the selection of the RC522 RFID sensor as the main component that functions to detect RFID tags and Arduino Uno as the system controller. Then design how the RFID sensor will be integrated with Arduino to read the RFID tag, which then generates a signal that will activate the solenoid to open or lock the door as an illustration of the magnetic field that can be measured using the sensor. In addition, programming design was also done to determine how the Arduino would process the data from the RFID sensor and control the door locking mechanism. All of these elements are designed to ensure the trainer functions properly, is effective in explaining the concept of magnetic field, and is easy to use by students in classroom learning.

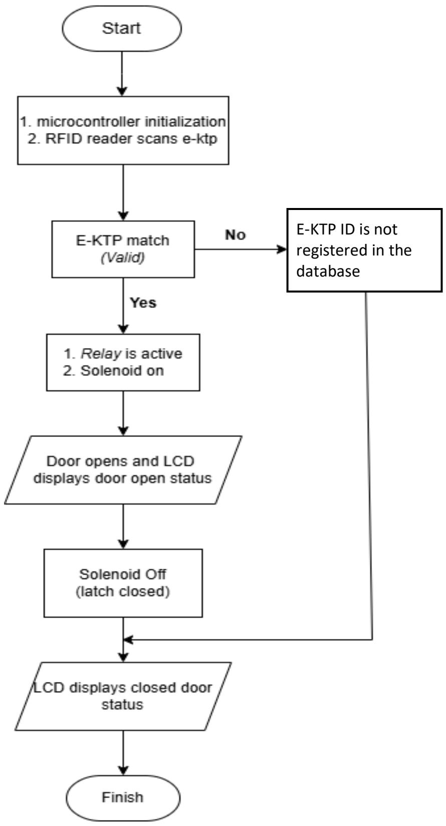

Figure 2. *Flowchart of a smart door lock*

Hardware and software are two essential components in the tool design phase for the magnetic field topic, specifically for intelligent door locks. The hardware component includes the smart door lock mechanism, while the Arduino IDE serves as the software platform. Sketch refer to drawings or preliminary designs that illustrate the structure or concept of a system or product, often used in the design of electronic systems or hardware. In the research of designing smart door locks based on RFID sensors and Arduino, sketches are generally circuit diagrams that show how each component (such as RFID sensors, Arduino, and solenoids) is connected and functions together. Meanwhile, software refers to the software used to design, test, and program the system. In the design of smart door locks, the software used includes software for writing programming code (such as the Arduino IDE), which allows writing and uploading code to the Arduino board to set up RFID sensors and solenoids. Meanwhile, C programming is the process of writing code or instructions in the C programming language to create computer programs. The C language is an intermediate-level programming language that was first developed in the 1970s and is still widely used today due to its efficiency, flexibility, and ability to access memory directly [19]. The operational mechanism of the smart door lock trainer is illustrated in Figure 2.

In the flowchart, microcontroller initialization is the first step that is done before the microcontroller starts carrying out its main tasks, such as reading sensors or controlling other devices. This initialization step is very important to ensure that all components and devices connected to the microcontroller are ready and can operate properly. The smart door lock illustrates the working sequence of the system that incorporates key components such as the Arduino Uno, RC522 RFID sensor, and solenoids. The process starts when the user brings the RFID card closer to the sensor, which then reads the information from the card. If the detected data matches the data registered in the system, the Arduino will send a signal to activate the solenoid, which allows the door to open. Conversely, if the data is invalid, the system will deny access and the door will remain locked. This flowchart facilitates the understanding of the interactions between components and ensures that each stage in the door locking and opening process runs smoothly and according to the desired functionality. The smart door lock system comprises several components, including an Arduino Uno, RC522 RFID sensor, door lock solenoid, 16×2 LCD display, E-KTP, single-channel relay, 12V adapter, jumper cables, and a breadboard. These components are assembled and configured according to the design specifications using a circuit board.

2.3. *Development Stage*

At the development stage, the first step is to make a smart door lock props product based on the planned design. This process includes assembling physical components such as the RC522 RFID sensor, Arduino Uno, solenoids, and other components to compile a system that can function as a whole. After the physical product is completed, it is followed by testing the hardware and software to ensure that the system operates properly, such as verifying RFID data reading, solenoid operation, and communication between components. Furthermore, to ensure the quality and suitability of the design, validation by experts is carried out, which involves assessment from professionals in the field of electronics or education to evaluate the effectiveness of this teaching aid in supporting the learning process.

2.4. *Implementation Stage*

At the implementation stage, start testing smart door lock props based on RFID sensors and Arduino Uno by involving students as the main users. Students are given the opportunity to use props in learning magnetic field material, where they can interact directly with the system, such as bringing the RFID card closer to the sensor to open or lock the door. During the use of the tool, it is observed how students interact with the props and whether they can understand the concepts taught more easily and clearly. After the implementation process, a response questionnaire was distributed to the students to gather feedback regarding their experience using the tool. The results of this response questionnaire are used to evaluate the extent to which the teaching aids successfully support the learning process.

2.5. *Evaluation Stage*

The last stage in this process is the evaluation stage. Evaluation is a process to assess whether the smart door lock props that are being developed are successful and in accordance with the development objectives that have been set previously. Actually, evaluation can be done at the end of each stage of the four phases mentioned. The evaluation carried out at each stage is known as formative evaluation, which aims to make immediate improvements. Therefore, the evaluation stage is the final step in the ADDIE model [20].

The participants in this study are 12th-grade students from SMA Negeri Jayalaloka. The research instruments include a needs analysis questionnaire, a validation sheet for media experts, and a student response questionnaire. The calculation of the Likert scale for the needs analysis is presented in Table 1 [21].

Table 1. Likert scale calculation.

Score	Criteria
4	Strongly Agree
3	Agree
2	Disagree
1	Strongly Disagree

The percentage of responses for each statement is then calculated using the following equation [22].

$$\%X_{in} = \frac{\sum s}{S_{maks}} \times 100\% \quad (1)$$

Let $\%X_{in}$ = represent the percentage of the score optained, $\sum_S$ = indicate the total number of scores, and S_{maks} = refer to the maximum score. The criteria for assessing the needs questionnaire are outlined in Table 2 [23].

Table 2. Criteria for the needs questionnaire.

Percentage	Criteria
76% - 100%	Strongly Agree
51% - 75%	Agree
26% - 50%	Disagree
0% - 25%	Strongly Disagree

The design of the smart door lock, which uses magnetic field material based on the RC522 RFID sensor and Arduino Uno, is considered feasible or very feasible if it achieves a percentage of ≥ 52% and ≥ 76%, respectively. The media validation criteria are in Table 3 [24].

Table 3. Media validation criteria.

Percentage	Criteria
76% - 100%	Very Feasible
51% - 75%	Feasible
26% - 50%	Not Feasible
0% - 25%	Very Not Feasible

According to the Likert scale, the percentage of responses from student questionnaires can also be categorized into score interpretation criteria, as shown in Table 4 [25]. Student response questionnaires are considered good or very good if the results are ≥ 71%.

Tabel 4. Student response percentage criteria.

Percentage	Criteria
85% - 100%	Very Good
70% - 85%	Good
50% - 70%	Not Good
0% - 50%	Very Not Good

3. Results and Discussion

The outcome of designing the smart door lock as a teaching tool for magnetic field concepts, utilizing the RC522 RFID sensor and Arduino Uno, is presented. The research process for designing this teaching aid is described through the five stages of the ADDIE development model: Analysis, Design, Development, Implementation, and Evaluation. Below is a detailed explanation of each stage involved in the design of the teaching aid.

3.1. *Analysis*

The results of the student needs analysis can be seen in Table 5.

Table 5. Results of the student needs questionnaire.

Statement	Percentage	category
The teacher has utilized teaching aids in explaining physics material.	95%	Strongly Agree
Students want teaching aids related to magnetic field material to be developed	96.25%	Strongly Agree
Students are enthusiastic about learning about magnetic fields with the use of teaching aids	95%	Strongly Agree
The teaching aids available at school are still manual	76.25%	Strongly Agree
The magnetic field teaching aids available in schools are still minimal	68.75%	Agree
When learning about magnetic fields, using teaching aids will be better.	93.75%	Strongly Agree
Average	88.12%	Strongly Agree

A needs analysis of teaching aids was conducted at SMA Negeri Jayaloka, involving 22 students. The results from the questionnaire revealed a positive response towards the use of teaching aids, with 95% of students acknowledging that their teacher had used teaching aids to explain physics concepts. However, 97.5% of the students reported encountering issues with the laboratory equipment. This suggests that while teaching aids are being utilized, there are still concerns regarding the quality and availability of the tools that require attention. Additionally, 96.25% of the students expressed a desire for more accessible teaching aids related to magnetic field topics, and 95% of the students showed enthusiasm about the availability of such aids. These findings suggest that teaching aids can enhance student motivation and comprehension in physics learning. However, 76.25% of students noted that the current practicum tools remain manual, which can restrict their creativity. Moreover, 68.75% of the students indicated a lack of teaching aids for magnetic field topics at the school. An overwhelming 93.75% of students agreed that learning would be more effective with the use of teaching aids. With an average of 88.12% of students strongly agreeing on the need to develop teaching aids for magnetic field material, this highlights the importance of innovation in providing resources to foster more effective learning. Evaluation at this stage can include an assessment of the clarity and relevance of questions in the questionnaire, the level of respondent participation, and the suitability of the analysis results with the learning objectives to be achieved.

Based on the needs analysis explanation, students need smart door lock teaching aids because of the need for more interactive and modern tools in physics learning, especially in magnetic field material. This reflects students' desire to switch to more innovative teaching aids, such as smart door locks, which can create a more enjoyable and effective learning experience. Technology-based teaching aids, such as smart door locks, which integrate magnetic field concepts with practical applications, have the potential to attract students' attention and improve their motivation and understanding of physics materials. Therefore, this data suggests that smart door lock teaching aids are needed by students to support more interactive and thorough learning. E-KTP is related to magnetic electricity through the use of chip technology integrated in it. The chip in the E-KTP is usually based on RFID technology. When the E-KTP is brought close to an RFID reader the electromagnetic energy from the reader will induce a small electric current within the E-KTP chip allowing the chip to transmit the stored data in the form of an electromagnetic signal back to the reader. This technology utilizes the magnetic field generated by an RFID reader to read data without direct contact between the card and the device. Thus, E-KTP applies the basic principle of magnetic electricity to facilitate identity recognition and data transfer.

3.2. *Design*

In the design phase, a smart door lock is created using a solenoid as the primary component to secure the door. The solenoid acts as an electromechanical actuator that generates a magnetic field when energized, allowing it to attract or move parts of the locking mechanism. This process relies on electromagnetic induction, which enables linear motion in the solenoid plunger. The solenoid is triggered by a control system linked to the RFID module. When an RFID-enabled e-KTP (electronic

Identity Card) is placed near the RFID reader, the system verifies the user's identity by checking the UID (Unique Identifier) on the chip. If the UID matches an entry in the database, the microcontroller sends an electric current to the solenoid, producing a magnetic field strong enough to move the plunger and release the lock. This design ensures that the generated magnetic field is stable and efficient, considering the need for low power consumption to preserve device performance and prevent solenoid overheating during operation. At the design stage of the smart door lock device, testing is carried out to ensure that the system can detect valid and invalid e-KTPs according to the data registered in the database. When an unregistered e-KTP is used, the system must accurately recognize the discrepancy. The LCD on the device is designed to display an "Invalid" status or a similar message that clearly informs the user that access is denied.

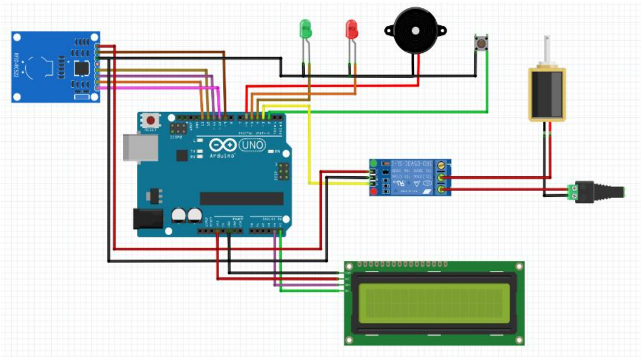

Figure 3. Smart door lock circuit scheme.

3.3. *Development*

At the development stage, the process of making props is carried out in accordance with the planned design.

Figure 4. Smart door lock props on magnetic field material based on RC522 RFID sensor and Arduino Uno.

A solenoid is a coil of wire that generates a magnetic field when an electric current flows through it. When current is applied to a solenoid, the resulting magnetic field will be focused inside the coil and produce an attractive or push force on the object inside, such as an iron core [26]. This force allows the solenoid to move the object linearly, for example to open or close a lock. In the context of RFID, this technology is used to activate the solenoid by sending data that is read by an RFID reader. When an RFID tag that stores certain data is brought close to the reader, the reader creates a magnetic field that induces an electric current in the RFID chip. The data from the RFID tag is then sent to a microcontroller (such as an Arduino) that processes the information and sends a signal to the solenoid. The signal is an electric current that activates the solenoid to generate a magnetic field that can move the solenoid core, opening or closing a door, for example. Thus, RFID is used to control the solenoid by reading wireless data that triggers mechanical action on the solenoid based on electromagnetic principles.

In designing a solenoid for a smart door lock, the magnetic field plays a crucial role in determining the performance of the locking mechanism. Tests are conducted to ensure that the generated magnetic field is strong enough to quickly attract or release the locking pin. Additionally, the efficiency of the magnetic field is enhanced by selecting a solenoid core material with high magnetic permeability, such as steel or ferrite, to optimize the magnetic flux. The research also focuses on minimizing the residual magnetic field to prevent the lock from jamming after the solenoid is activated. In a smart door lock, the RFID system serves as the authentication method, using radio waves to read data from RFID tags. The research also focuses on the integration of the RFID module with the solenoid to ensure proper synchronization between the two. When the RFID tag is detected, the system sends a signal to the solenoid, prompting it to generate a magnetic field that activates the locking mechanism. Functional testing includes simulating various usage scenarios, such as the RFID reading distance, solenoid response time, and the system's resistance to electromagnetic interference. Additionally, tests are performed to ensure the magnetic field can be emitted under low power conditions, allowing the device to operate with minimal energy consumption.

The main components of the system include the Arduino Uno microcontroller, a solenoid as the primary actuator, and magnetic sensors such as reed switches to detect magnetic fields. Additional components like keypads, RFID modules, and relays support the system's operation. The Arduino Uno oversees the entire system, processing inputs from the magnetic sensor or authentication module and controlling the solenoid actuator for the magnetic field. The system is designed to enhance the security and efficiency of door locks by utilizing magnetic field technology, enabling automatic locking and unlocking.

Additionally, a media feasibility test was conducted by three media expert validators. This test evaluated various aspects, including the efficiency of the tool, its relevance to the learning process, its educational value, durability, aesthetics, technical functionality, and safety. The results of the feasibility test, as assessed by the three media expert validators, are presented in Table 6.

Table 6. Media validation results for the smart door lock magnetic field prop.

Aspect	Precentage	Category
Tool efficiency	75%	Very Feasible
Relevance of the tool learning	83.33%	Very Feasible
Contains educational value	83.33%	Very Feasible
Tool durability	79.16%	Very Feasible
Aesthetics	83.33%	Very Feasible
Technical	76.38%	Very Feasible
Safety	83.33%	Very Feasible
Total	80.55%	Very Feasible

The media validation results indicate that the smart door lock used as an instructional tool for teaching magnetic field concepts in high school, received an average score of 80.55%. This score places it in the "very feasible" category, confirming that the tool meets various important criteria for effective learning support. In the validation evaluation stage of the tool, it was found that the reading of e-KTP by the RFID module sometimes failed. This is likely caused by factors such as improper card position, electromagnetic interference, or less than optimal sensitivity of the RFID module. To overcome this problem, several improvements are recommended, such as adjusting the optimal distance between the RFID module and the card.

3.4. *Implementation*

After validating the media on the smart door lock as a teaching aid for magnetic field material, the next step is to test it at SMA Negeri Jayalaloka. The purpose of this trial was to determine the students' response to the developed tool. Student responses were measured using an instrument consisting of 4 questions, namely 1) learning motivation, 2) operation of teaching aids, and 3) quality of teaching aids. The trial will be carried out with students from the twelfth grade. The results of the students' responses are summarized in Table 7.

Table 7. Results of the student response questionnaire data analysis.

Aspect	Percentage	Category
Learning motivation	85.55%	Very Good
Operation of teaching aid	84.09%	Good
Quality of teaching aid	82.95%	Good
Average	84.19%	Good

The data analysis from the student response questionnaire reveals that the use of smart door lock teaching aids in teaching magnetic field concepts at Jayaloka State High School is highly effective, with an average student response of 84.19%, falling within the good category. Because this shows that props not only help in understanding the material, but also make the learning process more interesting. This percentage indicates that the teaching aids successfully enhanced students' learning motivation, reflected by a motivation score of 85.55%, suggesting that students became more engaged and enthusiastic about the learning process through direct interaction with the tool. The tool's ease of use, with a score of 84.09%, ensures that students can focus on understanding the magnetic field concept without being hindered by technical difficulties. Furthermore, the quality of the teaching aid, rated at 82.95%, demonstrates that the tool not only meets high-quality standards but also fosters an effective learning environment. The overall positive responses from students regarding these various aspects affirm that the teaching aids are well-received as innovative learning tools. In conclusion, the smart door lock teaching aids offer a positive learning experience, enhance comprehension, and motivate students in their study of magnetic fields. Meanwhile, according to [27], the students' responses to the teaching aids were very positive, with 81.03% of students from three schools in Bengkulu agreeing that this tool should be developed. The average student perception score was 78.43%, categorized as good in terms of motivation, performance, and tool quality. Students were enthusiastic about learning with this tool, despite the limited facilities at their schools. Furthermore, the teaching aids proved effective in enhancing students' understanding of physics concepts in a visual and interactive manner. The trial demonstrated an improvement in students' average scores after using the tool, confirming its effectiveness in explaining challenging material [28]. Evaluation of student response questionnaires involving aspects of learning motivation, operation of teaching aids, and quality of teaching aids aims to measure the effectiveness of the use of teaching aids in supporting the learning process. Data obtained from the questionnaire were then analyzed to identify the strengths and weaknesses of teaching aids, as well as provide recommendations for improvement to increase the effectiveness of their use in learning.

3.5. *Evaluation*

The evaluation stage is the final step in the ADDIE model development process. Evaluation activities are carried out based on the results of validation, student responses, as well as opinions and input from experts. This evaluation is divided into two types, namely formative evaluation and summative evaluation. This development prioritizes formative evaluation carried out at each stage or phase of ADDIE. Formative evaluation is carried out based on the results of observation analysis and needs questionnaire. From the observation results, it was found that there were still shortcomings in teaching materials and some learning places had not utilized teaching materials to help students understand the concept of magnetic fields. Therefore, the development of role tools is needed to help students in learning physics. Based on the needs share, 88.12% of students agree with the importance of developing teaching aids for magnetic field materials. Evaluation at the design stage includes the initial design concept, while at the development stage includes improving the ability to read RFID. The results of tool validation by validators show evaluation in terms of efficiency, relevance to learning, educational value, tool durability, aesthetics, technical, and safety. With an average percentage of 80.55%, this tool is considered very feasible to use. The implementation stage was carried out through questionnaires accompanied by student responses. Based on questionnaires and student responses, all students gave positive responses to smart door lock props, with an average percentage of 84.19%, which is included in the good category. According to [29], the evaluation results indicate that teaching aids for electric field learning received excellent ratings from various validators. Validation by material experts reached 80%, media experts 77.5%, and learning experts 82%, all categorized as highly feasible. Trials with physics teachers showed an average validity of 94%, with effectiveness and efficiency aspects achieving 100%. Students rated the teaching aids with an average score of 83.2% across material, design, and interest aspects. Overall, the product was deemed effective and efficient for electric field learning. Additionally, a pretest-posttest assessment conducted on a single group of students revealed improved scores after using the teaching aids, demonstrating the media's effectiveness in enhancing students' understanding and physics learning outcomes [30].

4. Conclusion

This research led to the development of a smart door lock, designed as a teaching aid for magnetic field concepts, utilizing RFID RC522 and Arduino Uno technology. The tool was created to support physics education at the secondary school level. Results from the needs analysis indicated that 88.12% of students strongly supported the development of this tool. Using the Research and Development (R&D) methodology along with the ADDIE model (Analysis, Design, Development, Implementation, Evaluation), the tool underwent a thorough process to ensure its feasibility and effectiveness in an educational setting. The evaluation revealed that the tool received an average feasibility rating of 80.55%, which was classified as "very feasible" for use in the learning process. Furthermore, students expressed highly positive responses, with motivation levels reaching 85.55%. These results suggest that the tool is not only effective in simplifying complex physics concepts but also enhances student engagement and interest in learning. In conclusion, this research emphasizes the significance of developing practical and interactive teaching aids to improve students' understanding. This study contributes significantly to the advancement of teaching aids in physics and science education, while also paving the way for future research focused on creating even more engaging and effective teaching tools for students.

Acknowledgments

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