

The effectiveness of the ring electromagnetic accelerator on students' understanding of the Lorentz force concept based on prophecy

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Abstract

This study aims to evaluate the effectiveness of using the Ring Electromagnetic Accelerator (REA) tool in improving understanding of the Lorentz force concept and developing students' prophetic attitudes. The research method used is mixed method with sequential explanatory design. The research subjects were 10 students of the Physics Education Study Program in the 6th and 8th semesters who had taken the Electromagnetic Field course. The research instruments included Lorentz force concept understanding test, prophetic attitude questionnaire, and observation sheet. Quantitative data analysis used N-gain calculation, while qualitative data were analyzed descriptively. The results showed a significant increase in understanding the concept of Lorentz force with an N-gain of 0.44 (medium category). Evaluation of the Student Worksheet shows that 80% of students can describe the theoretical basis of the tool and its relation to the concept of Lorentz force well. Observation of prophetic attitudes showed an increase in the aspects of shiddiq (N-gain 0.60) and *fathonah* (N-gain 0.75). Qualitative analysis revealed that the use of props helped visualize abstract concepts and increase awareness of the importance of honesty in the scientific process. This study concludes that the use of REA is effective in improving understanding of the Lorentz force concept and contributes positively to the development of students' prophetic attitudes. The implication of this research is the importance of integrating character development in physics learning, especially at the university level.

Keywords: Lorentz force Concept · Prophetic · Props · Ring Electromagnetic Accelerator

INTRODUCTION

People sometimes misunderstand that learning physics or studying physics is difficult to understand. On the contrary, physics is a science that is very close to the activities in our lives. According to researchers (Fajrin et al., 2021) one of the physics materials that is very close to the activities in our lives is in the material of electromagnetic fields, objects that are often used in our daily lives are very much in line with this material.

There are various ways offered to support good learning. However, we must first understand what learning models and methods are suitable for each type of learning. One of them is that we can use teaching aids or learning media. These teaching aids aim to make it easier for us to understand the theory in its original form, so that learning objectives will be achieved properly. Moreover, when we study physics, it is certainly inseparable from observation, experimentation, or practicum activities. According to Fitriani (2023), through

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these activities we can prove physical phenomena in real and direct ways and we can relate them to existing theories.

Teaching aids as one of the tools to help educators measure student learning outcomes, especially in understanding the concept of the material that has been taught. With these teaching aids, it can also be an interactive learning medium that can also help someone understand or improve their perception in learning (Fadillah & Safitri, 2022).

In learning that occurs at universities, teaching aids are still very much needed as media that can make it easier for students to understand the theoretical concepts taught by lecturers. In a study conducted by (Yunita & Ilyas, 2019) discussed learning that uses electromagnetic induction teaching aids to make students more active in the learning process so that students' critical thinking skills increase. However, in his research did not include what kind of teaching aids were used in student learning as a measuring tool in this study.

In addition, from the results of research conducted by Mariyani (2023), the results obtained in the form of a REA teaching aid can be a media aid in learning and teaching activities in lectures as a demonstration. Respondents or users of this tool also said that the use of teaching aids can increase student interest during lectures. In research conducted by (Fitrian et al., 2023) regarding designing teaching aids, the results obtained from the study were that teaching aids that had been made and developed on the Lorentz force material could be used as learning media in the teaching and learning process of physics both practically and contextually. Research conducted by (Jhoni et al., 2024), stated that the size of the magnet used for the experiment greatly influenced the aluminum used to prove the Lorentz force of the three-finger rule. However, this study only focuses on proving the concept of the Lorentz force theory and does not focus on the use of tools that can help the process of understanding the concept.

In a study conducted by Mubarok (2023) entitled "Prophetic Education; Implementation Review in 21st Century Islamic Education" explains that prophetic education, especially in the 21st century, is very much needed. The existence of prophetic education that is applied with various approaches has been proven to be able to organize the morality of students and good and correct ways of thinking to live their lives in this era. Furthermore, according to Arifuddin (2019), prophetic education is a learning model inspired by the nature of the Prophet Muhammad., with this model it is hoped that someone can contribute to the birth of knowledge that will continue to develop from year to year and can be applied in their daily lives. In addition, according to Adriyani et al. (2024) in his research also stated that classroom learning applied to Senior High School (SMA) students using prophetic education is very relevant to the form of learning methods, especially in the material of light waves and electromagnetics. By using this prophetic education, it can be measured that students have prophetic characters or traits, namely *Shiddiq*, *Amanah*, *Fathonah*, and *Tabligh*.

From several researchers who have conducted research on the use of teaching aids as learning media both at school and university levels as well as research on prophetic education, it can be concluded that to support better learning, teaching aids or media are needed. Moreover, in studying physics in order to understand it more clearly. In addition, from the learning process using these teaching aids, it can be used as a benchmark regarding the relationship between the learning process and the prophetic nature found in students or students. Therefore, researchers want to conduct research in the form of the effectiveness of a REA tool on the concept of learning Lorentz force material based on the properties of Rasulullah SAW (prophetic).

From this study, it will be seen how effective a teaching aid is that is developed for students who have been given material on the Lorentz force. With this teaching aid, can students better understand the concept of the material that has been studied? In addition, from this study, it can also be seen how much the learning applied is related to the prophetic properties that are measured.

Lorentz force

The Lorentz force, also known as the magnetic force, is a force that occurs when an electric current flows through a conductor in a magnetic field. According to Jhoni (2024), the Lorentz force is a force that appears when an object experiences a relative movement to a magnet, this movement produces a current that flows electricity. This shows an intrinsic nature and interaction between electric current and magnetic field which is the basis for various electromagnetic phenomena that we observe in our daily lives. The grand formula for the Lorentz force is provided in Equation 1.

$$\mathbf{F} = \pm q\mathbf{v} \times \mathbf{B} = \pm qvB \sin \theta \tag{1}$$

A wire carrying a current I can produce a magnetic field. One example of the application of the Lorentz force with the concept of a circular magnetic field that will be raised in this study is a solenoid. Inside a solenoid, there is a very-very strong magnetic field. This is because the magnetic fields of each coil combine to form a long spiral shape. Meanwhile, at the outermost point of the solenoid the magnetic field is relatively small because the magnetic field by a wire segment is weakened by the wire segment across from it.

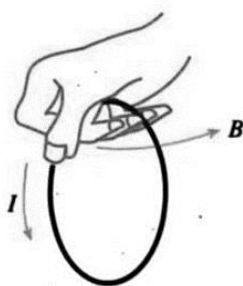


Figure 1. The direction of the magnetic field by the coil and the circular wire carrying electric current

The magnetic field strength due to the solenoid is calculated by drawing a longitudinal section of the solenoid. The path parallel to the magnetic field is only the path CD with length L . According to Ampere's Law:

$$BI = \mu_0 I = \mu_0 nIl \tag{2}$$

$$BI = \mu_0 In \tag{3}$$

Meanwhile, the calculation for the magnetic field by the toroid is

$$BI = \mu_0 In = \frac{\mu_0 IN}{2\pi a} \tag{4}$$

In a circular conductor wire, using Ampere's Law, the magnitude of the magnetic field at point P is obtained as follows:

$$B = \frac{\mu_0}{2} \frac{R^2}{(R^2 + x^2)^{3/2}} \quad (5)$$

METHODS

This study adopted a mixed-method approach with a sequential explanatory design to evaluate the effectiveness of the REA teaching aid on students' understanding of the Lorentz force concept and the development of prophetic attitudes. The subjects of the study consisted of 10 students of the Physics Education Study Program in semesters 6 and 8 who had taken the electromagnetic field course, selected through a purposive sampling technique based on these criteria.

The research instruments used include a test of understanding the concept of Lorentz force (pre-test and post-test), a prophetic attitude questionnaire using a Likert scale, and an observation sheet for the use of teaching aids. The research procedure begins with a pre-test, understanding the concept and prophetic attitude, implementation of learning using teaching aids, and ends with a Post-Test to obtain the results of student development.

Quantitative data analysis involves calculating N-gain to determine the effectiveness of the teaching aids. Meanwhile, qualitative analysis uses descriptive methods to describe the quantitative data obtained. The N-gain formula used:

$$\langle g \rangle = \frac{(\text{post-tests score}) - (\text{pre-tests score})}{(\text{max score}) - (\text{pre-tests score})} \quad (6)$$

The results of the N-gain calculation are categorized into three criteria, namely, high (N-gain > 0.7); medium ($0.3 \leq \text{N-gain} \leq 0.7$); and low (N-gain < 0.3).

The use of Likert scale and N-gain analysis allows researchers to measure students' prophetic attitudes quantitatively and analyze the extent to which students' understanding of the Lorentz force concept and prophetic attitudes have increased after using the REA tool.

RESULTS AND DISCUSSION

Results

This study aims to evaluate the effectiveness of the use of the REA teaching aid in helping students understand the concept of Lorentz force and its application in real life. In addition, this study also observes changes in students' prophetic attitudes, especially in the aspects of *shiddiq* (honest) and *fathonah* (intelligent), before and after the learning activities take place.

This study involved 10 students of Physics Education Study Program semester 6 and 8 Muhammadiyah University Prof. Dr. HAMKA as research subjects. The students had previously received Lorentz force material in the Electromagnetic Field lecture. At the beginning of the study, students were given a brief explanation of the working principle and components of the REA tool. Then, students conducted experiments according to the guidelines provided. The data obtained were in the form of charged particle trajectories influenced by the

magnetic field of the REA. Based on the research that has been conducted, the data obtained were provided in Table 1.

Table 1. REA Research Data

No	(C)	(m/s)	(A)	(T)	Tracks
1		2×10^6	0.4	0.2	
2		3×10^6	0.2	0.2	
3	5×10^9	4×10^6	0.2	0.2	Curved
4		2×10^6	0.4	0.4	
5		3×10^6	0.2	0.4	

From Table 1, it can be seen that the greater the particle speed and the stronger the magnetic field used, the more curved the particle trajectory will be. This is in accordance with the concept of Lorentz force, where charged particles moving in a magnetic field will experience a force perpendicular to the direction of motion and the direction of the magnetic field. This data was taken after students had been given the concept of material in the form of Lorentz force in the form of pre-test and post-test. Afterwards, students took data samples from the REA tool as a form of observation of the use of teaching aids. This data was taken by the students as respondents/subjects in this study.

Table 2. Evaluation of Lorentz Force Learning Outcomes

N	Pre-Test	Post-Test
10	640	820
Average	64	80
<g>	0,44	

From table 2, the average value of the pre-test and post-test can be determined in the form of conceptual understanding of the Lorentz force. The student learning outcomes are respectively: 64 and 80, so the N-gain obtained from both is 0.44 with a moderate category. To be clearer regarding the evaluation of student learning outcomes on the Lorentz force material, it can be described in the Figure 2.

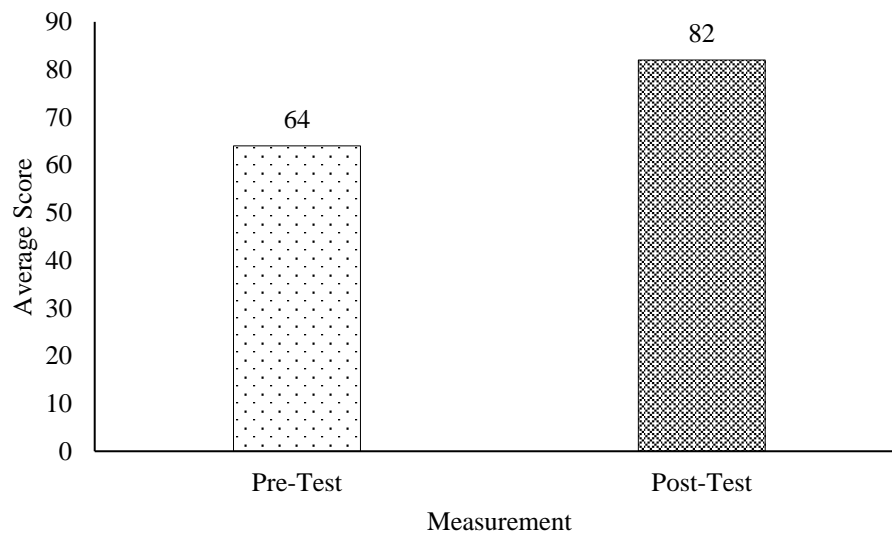


Figure 2. Lorentz Force Learning Outcomes

From the graph above, it can be seen that the students' scores vary between 50 and 70. The students who obtained the lowest pre-test score were 50, while the highest pre-test score was 70. Overall, the students' pre-test scores varied quite a bit, with most students obtaining scores in the range of 60-70. The average score of students in completing the Pre-Test questions was 64.

After the learning activities were carried out, there was a significant increase in the Post-Test scores. A total of 6 students obtained the same Post-Test score, namely 80. This shows that they have successfully mastered the material given well. Meanwhile, 2 other students obtained low Post-Test scores, namely 70. The average score of students in completing the Post-Test questions was 80.

Thus, from the results of this study, it can be said that there is an increase in the understanding of the Lorentz force concept from students, this can be seen from the results of the pre-test and post-test which have increased. The average value of the students' pre-test showed a figure of 64, while the average value of the students' post-test showed a figure of 80.

Table 3. Prophetic Aspect of *Shiddiq*

N	Prophetic <i>Shiddiq</i> pre-test	<i>Fathonah</i> pre-test	<i>Shiddiq</i> post-test	<i>Fathonah</i> post-test
10	31	29	39	36
Average	3.1	2.9	3.9	3.6
Total	6		7.5	
<g>	0.60		0.75	

Based on the table above, the average results of the Pre-Test *shiddiq* were 3.1 and *fathonah* were 2.9 and the average results of the Post-Test *shiddiq* were 3.9 and *fathonah* were 3.6. With the N-gain obtained on the Pre-Test score of 0.60, it is classified as a moderate category. While on the Post-Test score, the N-gain obtained was 0.75, classified as a high category.

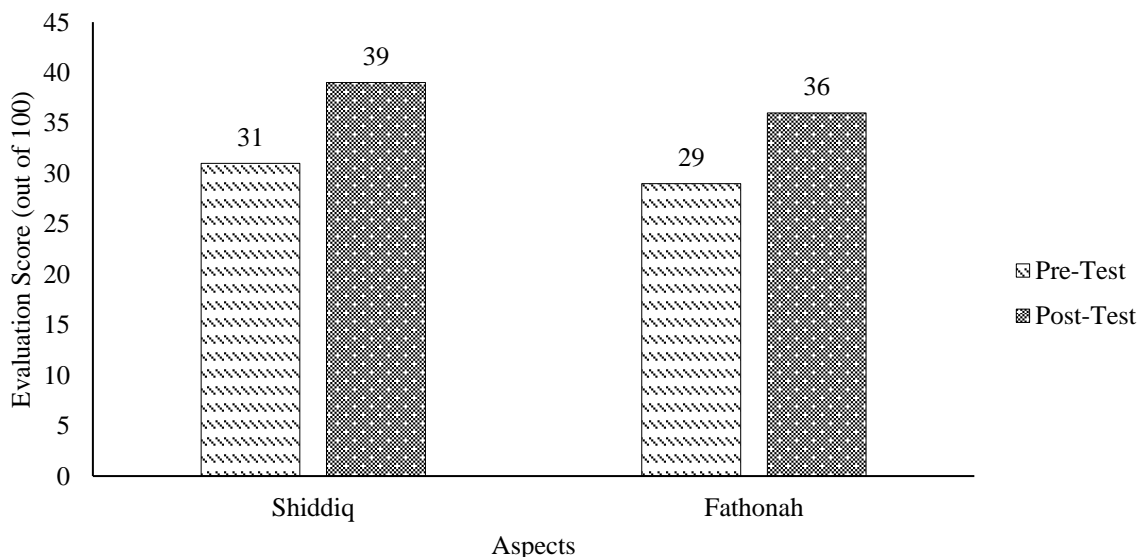


Figure 3. Prophetic Graph During Pre-Test and Post-Test

From the graph above, it can be seen that the students' pre-test scores for the *shiddiq* (honesty) aspect vary. For the *shiddiq* aspect, the students' scores are spread from level 1 (very

poor) to 5 (very good). A total of 4 students are at a sufficient level (score 3), 3 students at a good level (score 4), 1 student at a very good level (score 5), and 1 student each at a poor level (score 2) and very poor (score 1). This shows that most students have a fair to good honest attitude before the learning activity.

In the post-test value, it can be seen that after the learning activities were carried out there was an increase in students' prophetic attitudes in both aspects assessed. For the *shiddiq* (honest) aspect, as many as 6 students showed an honest attitude at a good level (value 4), and 2 students at a very good level (value 5). Only 1 student was at a poor level (value 2), and 1 student at a sufficient level (value 3). This indicates that the learning activities are quite effective in improving students' honest attitudes.

In the Pre-Test value of students for the *fathonah* (intelligent) aspect, most students are at a sufficient level (value 3) as many as 5 people. There are 2 students at a good level (value 4), 2 students at a less level (value 2), and 1 student at a very good level (value 5). There are no students at a very less level for this aspect. In general, the intelligent attitude of students before learning activities still needs to be improved.

Meanwhile, the *fathonah* (intelligent) aspect after the learning activities were carried out (post-test), there was a significant increase with 6 students at a good level (score 4), 1 student at a very good level (score 5), and 3 students at a sufficient level (score 3). There were no more students at a low level for this aspect. This shows that the learning activities have succeeded in improving the overall intelligent attitude of students. From this study, the results showed that the use of REA teaching aids in learning the Lorentz force material effectively helped students understand the concept of the material. With the teaching aids that have been improved, testing the material through pre-tests and post-tests, as well as filling out prophetic questionnaires and using REA teaching aids. This study is practically useful because the teaching aids developed are based on renewable technology. And from the learning activities carried out, the prophetic nature of each student who is included in it can be measured.

Discussion

Based on the results of the Student Worksheet (LKM) evaluation, it can be seen that most students, as many as 80%, can describe the theoretical basis of REA and its relationship to the concept of Lorentz force well. However, there are still 20% of students who are incomplete in explaining the working principle of the tool. In other aspects such as describing the purpose of using the tool, the tools and materials used, and writing down the course of the experiment, most students, 90%, can do it correctly. Meanwhile, in presenting data and processing research data, 70% of students managed to do it well, while 60% of students were able to provide appropriate conclusions based on the results of their research. In the calculation aspect related to Lorentz Force, centripetal force, and determining the direction of Lorentz Force, 70% of students were able to do it correctly, while 30% of students had difficulty in doing the calculations.

Meanwhile, for the prophetic concept on the aspect of *shiddiq* or honesty, the results of the pre-test showed that most students were at a sufficient to good level. After the learning activity (giving the post-test), there was a significant increase where most students showed honesty at a good to very good level. However, there was still 1 student who was at a low level for this aspect. On the other hand, for the aspect of *fathonah* or intelligence, the results of the Pre-Test

showed that most students were at a sufficient to low level. Then after the learning activity (giving the post-test), there was a significant increase with most students at a good to very good level. There were no more students at a low level for this aspect.

From the data of the pre-test and post-test results in this study, the results obtained were in the form of N-gain in the pre-test *shiddiq* and *fathonah* of 0.60 which is included in the medium category, and the post-test *shiddiq* and *fathonah* of 0.75 which is included in the high category. Overall, the learning activities carried out were quite effective in improving students' understanding and mastery of the material, as well as developing their prophetic attitudes, especially in the aspects of *shiddiq* (honest) and *fathonah* (intelligent). However, there are still some students who need further attention and guidance to optimize their learning outcomes and prophetic attitudes.

CONCLUSION

Based on the results of the research that has been conducted, it can be concluded that the REA tool is effective in learning the Lorentz force material. The use of this tool has been proven to improve students' conceptual understanding well. The majority of students are able to describe the theoretical basis of REA, its relation to the Lorentz force concept, the purpose of using the tool, and write down the course of the experiment correctly. The results of the study showed a significant increase between the pre-test and post-test scores. Before using the REA tool, students' understanding of the Lorentz force concept was still limited. After conducting an experiment with the tool, there was an increase in understanding as seen from students' ability to explain concepts, analyze data, and complete calculations related to the Lorentz force. In terms of prophetic attitudes, there was a positive development from the Pre-Test to the Post-Test. In terms of *shiddiq* (honesty), there was an increase from the level of good enough to good-very good. Meanwhile, in terms of *fathonah* (intelligence), there was an increase from the level of good-less to good-very good. This shows that the use of the REA tool not only improves conceptual understanding, but also contributes positively to the development of students' prophetic attitudes.

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