# TIK-61 The Development of Electronic Book Contained Scientific Literacy in Learning Physics to Enhance Students' Academic Achievement

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# The Development of Electronic Book Contained Scientific Literacy in Learning Physics to Enhance Students' Academic Achievement

**Muhammad Arifuddin, Andi Ichsan Mahardika*, Fauzia Dwi Sasmita, Saiyidah Mahtari**

Lambung Mangkurat University, Jl. Brigjen H. Hasan Basry, Banjarmasin, Indonesia.

*Email: ichsan_pfis@ulm.ac.id.

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**Abstract.** Technology-based teaching materials enriched with scientific literacy are not yet available, notably regarding the topic of Newton's law of gravity. This study aims to develop e-booster and describe its validity, practicality, and effectiveness. This study uses ADDIE development model with the research subjects consisting of 38 students of X MIPA at a public high school in Banjarmasin. The data collection technique is implemented through interview, observation, questionnaires, and tests. The data analysis is carried out by examining the percentages of the validity test, the average scores obtained from the survey results, as well as the results of the N-gain test and t-test on students' academic achievements. The results indicated that: (1) the validity test result of e-booster obtained 88.71% which was categorized as very high (2) the practicality result of e-booster obtained 75.39% which was categorized as practical, and (3) the effectiveness of e-booster in improving student's learning achievement obtained 0.57 which was categorized as moderate and significant at the level α=0.05. It is then concluded that e-booster is valid, practical, and effective, and thus, suitable to be integrated within learning physics to enhance students' academic achievement.
**Keywords:** E-booster, electronic book, scientific literacy, physics learning.

## Introduction

The advancements of 21st-century technology has become a new paradigm for human beings and has had a significant influence on various sectors in life, specifically on education (Benešová & Tupa, 2017). The presence of technology is expected to play the role as a powerful, intellectual tool in education, particularly in supporting the construction of one's knowledge. Accordingly, the integration of adaptive technology can elevate the quality of education (Huda, et al., 2018). Adaptive technology, in this case, refers to the use of mobile computing devices such as smartphones, tablets, and e-readers in the teaching and learning process (Grant, 2019). Internet-based learning, such as mobile learning, can provide endless, diverse multimedia contents which promote feasibility in the interactions between teachers and students. Features in mobile learning, for instance, audio, video, and audiovisual ones, are new alternatives used for delivering teaching materials and concepts which are difficult to contextualize. Likewise, the majority of the concepts taught in physics education is still difficult to visualize nowadays (Anshari, et al., 2017).

In order to encounter the challenges of the 21st century, students need to be equipped with skills qualified enough to show their competitiveness in the globalization era. The integration of 21st-century skills which consist of digital literacy, inventive thinking, effective communication, and high productivity becomes crucial in education. One of the subdomains needed to support these four domains is scientific literacy (Ariesteidou & Christothea, 2020; Turiman, et al., 2012). Scientific literacy plays an important role in broadening learners' knowledge, investigation of natural science, as well as oral and written vocabulary needed to understand science, the relationship between science, technology, and society (Hernandez, et al., 2015).

Up to this point, many studies related to mobile learning have been carried out, many of which implemented mobile phone applications such as Tong (Tong, 2016), Jeger (Sulistyo & Kurniawan, 2020), and Projo Bale (Sayono, et al., 2020). However, the above-mentioned platforms are only accessible for Android device users, thus excluding non-android device users. In addition, various research related to scientific literacy within several science subjects' learning process had been carried out, such as biology (Wei & Xia, 2016), chemistry (Seftari, et al., 2018), and physics (Rusilowati, et al., 2016), all of which integrated scientific literacy within the textbooks, forcing the whole "offline" learning method for these subjects. This is contradictory to the fact that our education system must follow the advances made in the modern era and integrate latest technology and digital contents within learning and teaching, such as using more multimedia resources in presentations and the use of digital materials within the learning process (Grynyuk, et al., 2022; Engbrecht, 2018).

Focusing in the teaching of physics, there is no research found related to scientific literacy integrated with technology which discusses Newton's law of gravity. This is unfortunate as it contains a lot of scientific literacy indicators as described by Wilkinson (Wilkinson, 1999) which include: (a) science as a body of knowledge, (b) science as a way of investigating (c) science as a way of thinking, and (d) the interaction between science, technology, and society. Serving the role as "basic knowledge and skills" required in each individual (Turgut, 2007), scientific literacy can be considered as a new demand in promoting education in terms of sustainability throughout students' future career and academic achievements (Correia, et al., 2010). Scientific literacy in Newton's law of gravity does not only involve basic concepts, but also the scientific theories and hypotheses substance, as well as understanding for problems and problem solving that calls for a scientific investigation. Scientific literacy is important as it provides context to overcome social problems (Mourtzis, et al., 2022). A scientifically literate generation can solve these problems better, make well-thought decisions that will affect the individuals' quality lives, and become lifelong learners (Zen, 1990). Therefore, the process of acquiring knowledge through scientific literacy places more emphasis on the skills integrated within the indicators. These skills are important for students, especially regarding problem-solving and decision making (Gucluer & Kesercioglu, 2012).

Although numerous studies have examined the enhancements on students' academic achievement through several innovations, namely literacy (O'Toole & Kannass, 2018; See & Gorard, 2020), scientific literacy (Wen, et al., 2020), mobile learning through laptops enriched with literacy content (Bando, et al., 2017), mobile learning through tablets enriched with literacy content (Mang, et al., 2017), and mobile learning through electronic books enriched with literacy content (Ihmeideh, 2014), but so far there is no research on mobile learning using electronic books enriched with scientific literacy content. Therefore, this research is carried out to enhance mobile learning by developing e-booster (electronic books contained scientific literacy) with the topic of Newton's law of gravity, accessible through various types of online-based computers and smartphones. This study aims to develop e-booster and describe its validity, practicality, and effectiveness.

## Methods

This research uses research and development (R&D) method with ADDIE model which consists of analysis, design, development, implementation, and evaluation (Branch, 2009). The steps carried out are executed as follows: the analysis stage is carried out to investigate the problems and solutions; the design stage is carried out by designing e-booster; the development stage is done by increasing the accessibility of e-booster; the implementation stage is implemented by testing e-booster on 38 students of X MIPA, and the evaluation stage is carried out by correcting or revising e-booster if deemed necessary. The details of these steps are described in Table 1.

**Table 1.** Details of product development stages using ADDIE model

| Step | Activity | Result |
|---|---|---|
| Analyze | Analyzing the problems found in the research subject's class. | Physics books used are monotonous and rigid, not proven to have enhanced learners' knowledge, curiosity of natural science, oral and written vocabulary. 63% of the students are Android users whereas 37% of students are iPhone users. |
| | Analyzing on the standard competencies and basic competencies | The planets' motion in the solar system based on Newton's laws is analyzed. |
| | Analyzing the characteristics of the materials taught in Newton's law of gravity | Sub-materials are placed in order of the meetings taught. The force of gravity is delivered in the first meeting, followed by the strengths of gravitational field in the second meeting, as well as Kepler's Laws and satellite motion. |
| | Analyzing on students' characteristics | Students actively ask questions, tend to have high level of curiosity, and promote positive learning competitions with each other. |
| | Analyzing on possible resources that indicate problem-solving. | A trial is conducted to produce electronic books on various mobile applications or computer software. Based on the trial, it is decided that electronic book using professional flip PDF application is chosen, so it can be accessed online. |
| Design | Creating books using Microsoft Word | The cover, layouts, templates, color combinations, font types, and font sizes are determined. |
| | Adding designed concepts using Flip PDF Professional software | Some features, such as links, videos, GIFs, hyperlinks are created, as well as making the final evaluation exam (multiple choice questions). File extension is formatted as HTML. |
| Development | Integrating contents with supporting media to make it accessible in any smartphone device | Hosting to website.<br><br>Validity data is also performed by the validator and given suggestions for improvements. |
| Implementation | Implementing the treatment of e-booster on 38 students | This treatment was given for two meetings. |
| Evaluation | Giving Formative and summative evaluation | E-booster's effectiveness and results are evaluated, revisions are also conducted if necessary |

E-booster's quality is indicated by its validity, practicality, and effectiveness. Validity refers to product testing, similar to formative evaluation, used to produce a product that conforms to a predetermined specification plan through the identification of the product's strengths and weaknesses during the process (Rusdi, 2018). In this study, e-booster validity was tested by three validators and determined by the criteria in Table 2 (Akbar, 2016). E-booster is considered as valid if the category reached is at least medium.

**Table 2.** E-booster validity criteria

| No. | Percentage of Validity | Category |
|---|---|---|
| 1 | 80.01 - 100.00 | Very high |
| 2 | 60.01 - 80.00 | High |
| 3 | 40.01 - 60.00 | Medium |
| 4 | 20.01 - 40.00 | Low |
| 5 | 01.00 - 20.00 | Very low |

The practicality of E-booster is to measure the convenience of E-booster which is carried out by distributing questionnaires for the students (Aminah, 2016). In this research, the practicality e-booster is determined based on the criteria in Table 3 (Akbar, 2016). E-booster is considered as practical if the category reached is at least sufficient.

**Table 3.** E-booster practicality criteria

| No. | Average Score | Category |
|---|---|---|
| 1 | 80.01 - 100.00 | Very practical |
| 2 | 60.01 - 80.00 | Practical |
| 3 | 40.01 - 60.00 | Sufficient |
| 4 | 20.01 - 40.00 | Less practical |
| 5 | 01.00 - 20.00 | Very impractical |

Effectiveness refers to the achievement of predetermined goals (Rohmawati, 2015). The effectiveness of e-booster is determined based on the criteria in Table 4 (Hake, 1998). E-booster is considered effective if the category reached is at least medium.

**Table 4.** E-booster effectiveness criteria

| No. | Gain Score | Category |
|---|---|---|
| 1. | $(\langle g \rangle) \geq 0.7$ | High |
| 2. | $0.7 > (\langle g \rangle) \geq 0.3$ | Medium |
| 3. | $(\langle g \rangle) < 0.3$ | Low |

To determine the significant effect of e-booster in improving students' academic achievement, t-test was carried out. The data obtained from the results of the pre-test and post-test which are normally distributed meet the requirements of the t-test with the hypothesis that there is an effect of using e-booster in learning physics in improving students' academic achievement if the t value is > t table (Sarwono, 2015).

## Results and Discussion

Internet of things become a modern educational orientation as it can easily be accessed by everyone (Kurniawan, et al., 2019). Learning using the internet becomes the reason why e-booster is designed online, to make it accessible by all device users, be it computers, iPads, iPhones, or Androids for free. There is no time limit nor working hours on e-booster. The following figures present the displays of the products being developed.

The development of e-booster becomes a reference and alternative to improve students' learning experience, specifically on Newton's Law of gravity which is closely related to the scientific literacy indicators. The components in e-booster include:

a. Learning activities are designed according to students' needs. Digital books are accessed just like using textbooks in general; students turn each page of the book accompanied by the audio file respectively. The availability of material exposure is supported with colorful images, moving animation, and educational videos, complete with sample questions to help the process of integrating materials being taught, practice questions to increase students' understandings about the concepts, and answer keys for self-assessment.


**Figure 1.** The Developed E-Booster

b. Scientific literacy content is presented through the four indicators, namely science as a body of knowledge, science as a way of investigating, science as a way of thinking, and the interaction between science, technology, as well as society that is presented as accordingly with the subtopics taught.


**Figure 2.** Science as a body of knowledge (presenting theory)

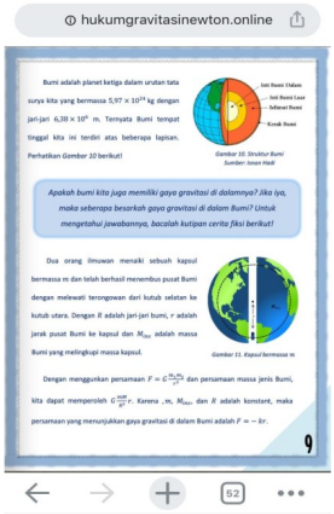


**Figure 3.** Science as a way to investigate (explaining the answer)


**Figure 4.** Science as a way of thinking (causal relationship)


**Figure 5.** The interaction of science, technology, and society (future career)

**Validity test results**

Based on the assessment obtained from validator, the e-booster validity results obtained an average score of 88.71, which was categorized as very high. These results were obtained from 3 validity indicators covering content validity, appearance validity, and scientific literacy validity. Content validity indicator received an assessment of 85.56 and the validator gave suggestions to provide subtitles on the educational videos to ease students in understanding the information and knowledge delivered. Improvements and revisions were made by adding Indonesian subtitles to all educational videos in e-booster.

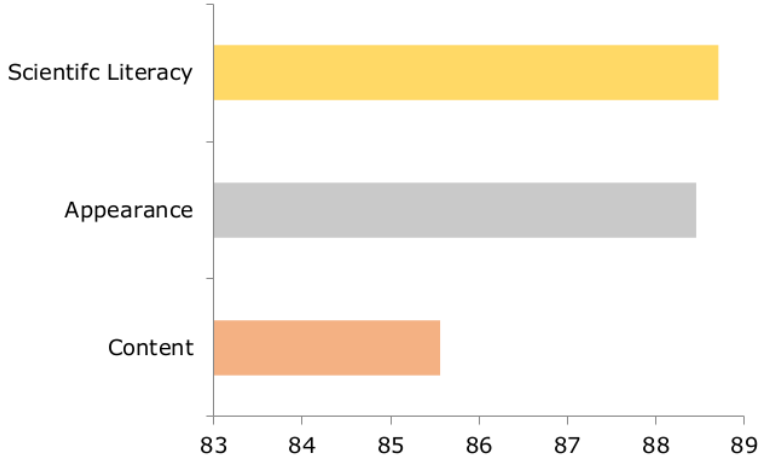


**Figure 6.** E-booster Validity Test

The reason behind e-booster being accessed through a website page is to avoid cache overload and storage usage that can cause troubles due to the large RAM usage and smartphone memory capacity (Kim, et al., 2012). The materials in this electronic book is arranged systematically to make it easier to convey the desired materials to students (Ivey, 2010). E-booster uses communicative language and there are foreign terms used such as goldilocks, the pale blue dot, and retrograde that play a very important role in students' literacy development (Lee, et al., 2019).

Color selection is also important concerning cognition and students' behavior (Sa'aleek, 2018). E-booster is dominated with the colour of Lazuardi (sky blue) because it can stimulate learners' motivation, creativity, and imagination (Mehta & Zhu, 2009). E-booster uses two types of fonts which belonged to the sans serif group, namely calibri (body) and just another hand. These fonts are selected to adjust with students' readability when displayed on either a computer screen or a smartphone screen (Hojjati & Muniandy, 2014). The use of images in E-booster are also intended to increase students' motivation and imagination to study on the text presented. Most of the pictures are presented in the form of illustrations to gain students' attention and encourage more detailed, textual data processing, as well as help creating non-verbal codes with the purpose to ease students in comprehending the materials (Kasmaienezhadfard, et al., 2015).

E-booster emphasizes reading activities as the strategy to improve scientific literacy in the classroom (Grant, et al., 2015). Reading activities will direct students to engage in thinking activities. Through thinking activities, not only will they be triggered with a high curiosity level towards nature, but also to carefully make calculations and find answers to their curiosity. Other than the materials presented, Matthews stated that reading activities

which are given through science history are aimed to develop students' reasoning and thinking skills, as well as fostering their interest in science and humanitarian attitudes (Cansiz & Universitesi, 2017). Therefore, the identification of topics in the learning process must be relevant (Grant, et al., 2015) and meaningful in life as to increase students' motivation to learn.

**Practicality test results**

Based on the assessment obtained from the 38 students, the practicality of e-booster obtained an average score of 75.39% and was categorized as practical. These results were obtained from the three practicality indicators, namely benefits, efficiency, and convenience.

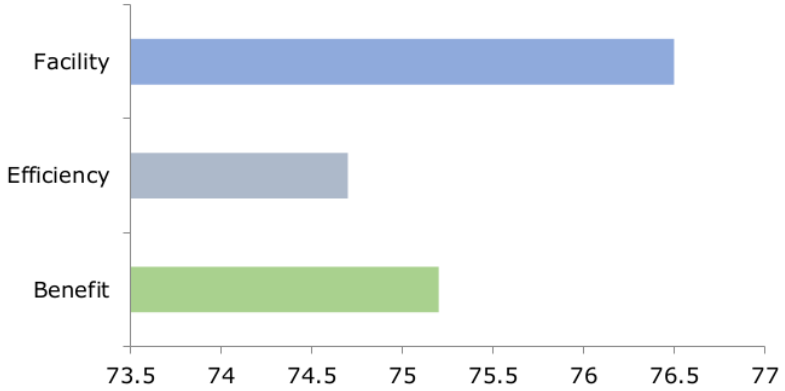


**Figure 7.** E-booster Practicality Test

The convenience criterion tested on e-booster emphasizes on how much effort is spent in the usage of e-booster. Meanwhile, the efficiency criterion relates to the use of cellular data and resources (device battery), and the benefit criterion relates to the feedback received from students during and after using e-booster. One of the indicators on the benefit criterion is related to knowledge and information received. E-booster enabled 92% of students acquire new knowledge and information, such as goldilocks, geocentric, heliocentric, light years, and retrograde. The new knowledge and information obtained showed a significant impact on students' interest in studying astronomy in 77%, followed by students' interest in pursuing career in science and technology, which increased by 58%. E-booster adheres to multimedia learning cognitive theory, which suggests to provide educational videos and moving animations to ease the integration of new information into cognitive structures, which can improve learning process (Brame, 2016). The increase in learning process, according to the multimedia learning cognitive theory, has an impact on student's convenience to understand the material. Students' convenience in comprehending the material also depends on classroom conditions and circumstances.

E-booster presents the history of science and scientists, as well as an analysis of countries with the latest technology and good economic prosperity. This topic opens up numerous discussions between teachers and students, thus building a good learning within the environment. A conducive environment plays an important role in building the participation and activeness of students in the classroom (Susak, 2016), with the hope that it can encourage students' participation through discussions related to scientific literacy

and economic welfare (Ogunkola, 2014). This was also admitted by 92% of students who stated that learning physics using e-booster promotes a positive and enjoyable learning atmosphere in the classroom. This is also supported by the display on the device screen. E-booster uses 14-size font with double spacing between lines. This is in line with Darroch, et al. (2005) who stated that the font size displayed on a handheld computer (smartphone) must be adjusted to the target reader. Large font sizes (more than 12) are preferred by readers. However, the number of words or texts presented on each page must be considered. The shapes and sizes of the letters legible enough also vary, depends on the spacing between letters or spacing between lines. Spaces are intended to help the eyes recognize blocks of text as a group and help students to easily catch the start of each line. Dyson states that the spacing between lines of text impacts the readers' screen reading speed, thus double spacing is highly recommended (Dyson, 2004).

E-booster's practicality through the efficiency aspect is also supported by hyperlinks that allow students to move pages quickly and ease access on various websites related to learning materials. This finding contradicts the study conducted by Fitzsimmons, et al. (2019) which states that hyperlink effect causes color changing on the text, and change the focus of the readers on sentences that contain hyperlinks instead of the entire text. They believe that it obstructs reading and harms the reader's ability to comprehend the text. However, the hyperlinks in e-booster do not change color, and thus this problem is solved. E-booster also anticipates the number of hyperlinks in the text by replacing them through the magic box feature which is directly linked to the website. Using 3G (third-generation technology) data network, e-booster can be opened in less than ten seconds. The battery power usage of this electronic book is also quite efficient. 87% of students stated that their smartphone battery power remained stable and did not decrease significantly during the use of e-booster. The effectiveness, in terms of battery drainage, is also in line with the requirements which stated that the essence of effective and efficient energy management is represented by the amount of how much energy is consumed by the system (Carroll, 2010).

**Effectiveness Test Results**

Based on the N-gain score, e-booster's effectiveness result is categorized in the medium rank as the score obtained was 19.804 for t value with 1.68709 for t table and the significance of 2 parties obtained a score of 0.000. Based on the significance, it is smaller than 0.05, so the hypothesis that stated that there is an effect on the use of e-booster on learning physics in enhancing students' academic achievement is acceptable.

The role of e-booster in the effectiveness and improvements in students' academic achievement is performed through the activity called "let's see" which contains sample questions, "let's try" and "let's fight", which contain practice questions as well as formative tests integrated through scientific literacy content (specifically for example questions) and equipped with solutions and answer keys that help students to learn and practice independently. Example questions, practice questions, and formative tests are aimed to guide students in facing final tests.

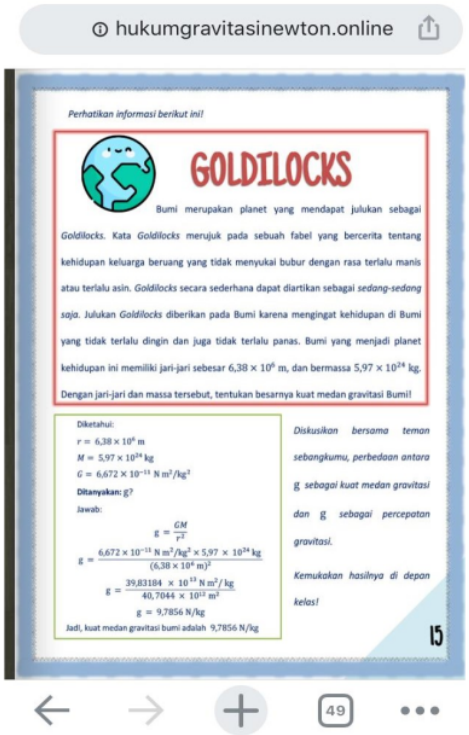


**Figure 8.** Example problems with scientific literacy content

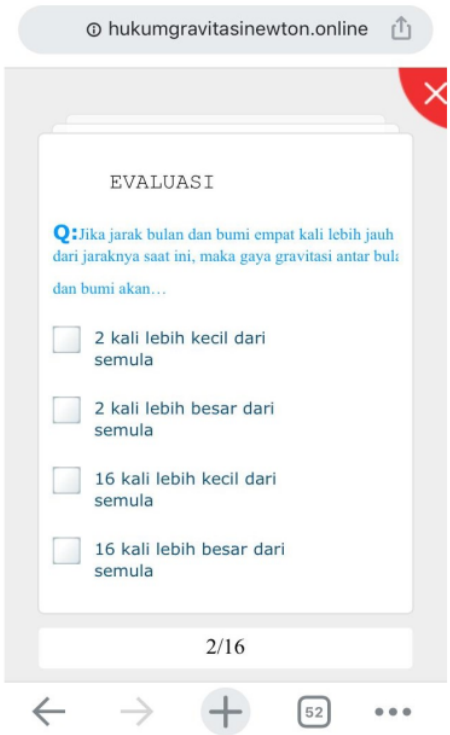


**Figure 9.** A formative test with scientific literacy content

Scientific literacy application in science learning, especially in physics, is an important component in science education itself (Baram-Tsabari & Yarden, 2005; Knain, 2006). Scientific literacy application in e-booster not only focuses on knowledge transfer, but also facilitates students to gain knowledge through activities which encourage reading and thinking about science and technology. Science and techology are intended so that the knowledge gained from those activities can increase students' interest and help them in solving problems related to learning and life in society (Gucluer & Kesercioglu, 2012).

Reading activities as well as introducing scientific vocabulary activities to students help them assimilate the meaning of vocabulary, which impacted significantly on enhancing their academic achievement (Itza-Ortiz, et al., 2003). Scientific literacy application in e-booster is also effective in increasing academic achievement with the effectiveness results as obtained in Table 2. Kristina states that the use of scientific reading texts in science learning affects students' understanding of scientific concepts more effectively (Gucluer & Kesercioglu, 2012). This is also in line with Güçlüer & Kesercioğlu (2012) which states that the development of scientific literacy in science teaching is a more effective method in increasing academic success.

However, it is necessary to pay more attention to the evaluation used to determine students' learning achievement. Based on the results of learning achievement tests' analysis of multiple-choice questions, it is concluded that multiple-choice questions tend to make respondents emphasize on their memory strengths more and encourage respondents to make guesses (Walstad & Becker, 1994). Meanwhile, based on the analysis of the

students' learning outcomes test on essay questions, it was found that some students still had difficulties in numerical skills. Some students still have difficulty in the completion stage of the square root and cube root. There are still students who wrongly completed the comparison equation of √4: √1 and 36.84% of students immediately removed the root sign in the comparison equation, so that students get √4:√1 = 4:1. Even though numerical skill is as a part of calculating operations in mathematics are needed to solve physics problems (Reddy & Panacharoensawad 2017). Therefore, it is hoped that their numerical skills are further trained to support students' academic achievement.

## Conclusion

Based on the results of the development and discussion, it is concluded that the validity of e-booster obtained a score of 88.71%, which was categorized as very high. In addition, the practicality obtained 75.39%, which was categorized as practical. Last but not least, the effectiveness from the N-gain score obtained a score of 0.57 which was categorized as medium and significant at α=0,05 which means there is an influence on the use the elekronic book on physics learning to enhance students' academic achievement.

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