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Developing STEM-Based Interactive E-Books to Improve Students' Science Literacy

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Abstract: The purpose of this research is to describe the feasibility of the developed STEM-based interactive e-book in improving students' scientific literacy to deal with independent learning policies of independent campuses. Furthermore, this study aims to determine the impact of the developed e-book and investigate students' interest in the e-book. This research employs the ADDIE development model as a type of R&D, including analysis, design, development, implementation, and evaluation. The findings indicate that the STEM-based interactive e-book increases students' scientific literacy skills, with an N-Gain score of 0.56 in the medium category. Based on the expert validation, the developed e-book obtained a percentage of 82.33 % from the material experts, 86.38 % from the media experts, 80.00 % from the IT experts, and 88.09 % from the scientific literacy test instrument experts. All categories belong to the highly feasible criteria. The percentage of students' responses toward the attractiveness of the e-book was 87.02 %. The developed STEM-based interactive e-book is appropriate for use in education. This study adds new knowledge and experience to developing STEM-based interactive e-books. Besides, providing electronic teaching material in the form of STEM-based interactive e-books can be used to support students' learning and trigger scientific literacy in the globalization era.

INTRODUCTION

Education is critical in developing excellent, intelligent, and competitive human resources (Afandi et al., 2019; Halim et al., 2018; Zefferman, 2018). This potential can be fully realized by implementing effective learning strategies and incorporating ICT into the learning process (Herianto & Wilujeng, 2020; Shraim & Khlaif, 2010). In the digital era, technology has become an effective and efficient medium for teaching and learning (Juhaňák et al., 2019). In the digital era, when ICT is developing rapidly, many people enjoy the convenience of technology. Educators and students must adapt to technological developments in the twenty-first century, particularly in the area of education, to generate excellent individuals who can compete globally (Emejulu & McGregor, 2019; Muhtia et al., 2019). Thus, allowing education to flourish (Muslihah et al., 2018).

STEM-based learning (Science, Technology, Engineering, and Mathematics) is alternative learning that has the potential to build students' skills in the 21st century (Indrasari et al., 2020), which encourages curiosity to explore

their knowledge (Rahmawati et al., 2020). The goal of STEM education for students is for them to have scientific literacy abilities as well as knowledge of ICT (Indrasari et al., 2020). Issues still plague the application of STEM-based learning in Indonesia, one of which is a lack of teaching resources that are integrated with technology, information, and communication (ICT) (Widayanti, 2019) (Kusumawati et al., 2020). When technology is used intelligently, it activates education that is more flexible, open, and available to anyone, resulting in more effective, efficient, extensive, wider, faster, and meaningful learning.

Increased scientific literacy is one of the focus points of the 21st-century learning trend (Amin, 2017; Parno et al., 2020; Sumanik et al., 2021). Scientific literacy is critical in global competition (Indrasari et al., 2020; Tias & Octaviani, 2018). According to the International Council of Associations for Science Education (ICASE), science education aims for students to have scientific literacy skills to live productively and have the best quality of life (Holbrook & Cavas, 2011; Kusumawati et al., 2020). Scientific literacy is the knowledge that students can use to address problems in their daily lives and make decisions based on scientific evidence (Hastuti et al., 2020).

According to PISA (Program for International Student Assessment) data, scientific literacy skills in Indonesia remain below the national average. According to The Organization for Economic Cooperation and Development (OECD) through PISA, "In 2009, Indonesia received 383 points and ranked 57th out of 65, 382 points (2012). Indonesia was ranked 64th out of a total of 65 countries. Furthermore, in 2015, Indonesia was ranked 64th out of 72 participating countries, with a score of 403 (OECD, 2018). poor levels of scientific literacy are caused by a lack of integrated learning in problem-solving in everyday life (Novitasari, 2018) and poor reading tradition and selection of textbooks (Fuadi et al., 2020).

Based on observations at three Lampung universities, the students claimed that they disliked reading activities, particularly reading books and that the selection of learning materials utilized so far still relied on textbooks or texts (textual). Furthermore, students' low reading interest is caused by monotony and the book's unappealing appearance (Mauludin et al., 2017). Students want books that have pictures, videos, and animations (Firdausy & Prasetyo, 2020). Less practical reasons also drive students to dislike reading culture; for example, the efficiency with which books are used influences someone's reading interest (Nurkayati, 2020; Sari & Sabardila, 2021). In the literature that not everyone can understand, the usage of loanwords is excessive (Kayigema & Mutasa, 2021). This is a significant difficulty for the Indonesian country in the 4.0 industrial era. The rapid advancement of information and technology has made it an essential component of education and learning (Ciffolilli & Muscio, 2018).

Besides educators, books are the most effective primary learning resource (Firdausy & Prasetyo, 2020). However, most educators' teaching resources are still textual (Hapsari et al., 2016) and have not been positively connected with student scientific literacy (Puspaningtyas et al., 2020). Furthermore, the learning process is incompatible with the idea of an independent learning policy (Sudaryanto et al., 2020).

Electronic books (e-books) are one of the educational materials based on technology, information, and communication to increase student scientific literacy (Herianto & Wilujeng, 2020) (Kusumawati et al., 2020). To make e-books more interactive, they can be merged with other computer media (Herianto & Wilujeng, 2020; Kusumawati et al., 2020). E-books include additional

interactive elements such as music, video, slideshows, and photographs (Mashfufah et al., 2019). Interactive learning that is attractively presented will almost surely have a positive impact on boosting educational quality (Latifah et al., 2020). Aside from that, e-books have the potential benefit of assisting students in improving their scientific literacy skills (Lestari et al., 2020) and launching an independent learning process following the concept of an independent learning policy.

Several research has demonstrated the importance of using teaching materials in learning activities to increase scientific literacy, according to research. Firdausy & Prasetyo, (2020) determined that interactive e-books can promote scientific literacy. The content of interactive e-books can assist educators in developing attitudes, determination, and material depth. Because students may learn individually, interactive e-books also give a learning experience. Expository learning can also help to increase scientific literacy (Aiman et al., 2020). Also, Indrasari et al., (2020) found that developing STEM-based teaching materials to improve students' scientific literacy skills can be accomplished by including components of scientific literacy indicators into learning. Finally, scientific literacy is linked to increased learning achievement (Jufrida et al., 2019).

Several previously described empirical studies indicate that the importance of innovation in constructing instructional materials is recommended to promote scientific literacy. This condition necessitates enhancements to science learning activities to realize learning integrated with problem-solving (Bahriah, 2015) in everyday life in the digital era on the attainment of aspects of scientific literacy (Fuadi et al., 2020). In this instance, it is vital to create interactive digital media to promote students' interest in reading culture to improve their scientific literacy (Fahyuni & Fauji, 2017). To address the aforementioned issue, one option is to create STEM-based interactive e-books. E-Books will be packed interactively, practically, and interestingly based on features of scientific literacy combined with STEM instruction and accessible via electronic devices such as mobile phones, tablets, and laptops/computers. This media development aims to investigate the impact of STEM-based interactive E-Books on components of student science literacy.

METHOD

This research employed the Research and Development method with the ADDIE development model (Branch, 2010). The research stages are divided into five categories: (1) analysis, (2) design, (3) development, (4) implementation, and (5) evaluation.

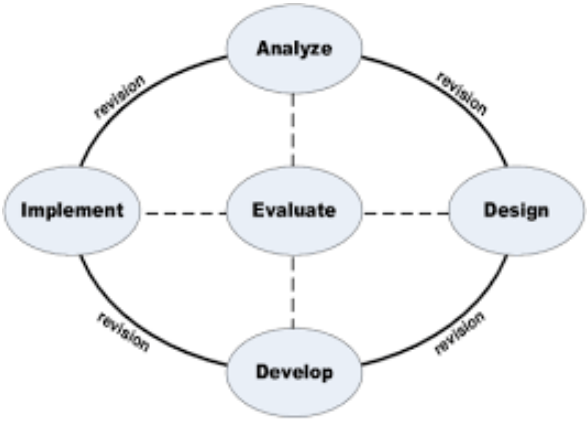

Figure 1. ADDIE research steps (Branch, 2010)

The implementation stages of the research include, first, problem analysis, requirements analysis, and material limit analysis developed using questionnaires distributed to Physics Education students batch 2020/2021 at three Lampung universities. Second, the researchers designed the product. Furthermore, the researchers provided product feasibility instruments for both validators and respondents (students). Third, expert validations of the generated product include material experts, media experts, information technology experts, and experts on scientific literacy test instruments. The product was then revised until it met the feasibility criteria. Fourth, the product was put into use or tested on students.

In this study, questionnaires were utilized to collect data, including product validation questionnaires, attractiveness response questionnaires, and scientific literacy test instrument data questionnaires. The product feasibility test by the validator is analyzed using 5 (five) answer choices; namely, (5) highly feasible, (4) feasible, (3) fairly feasible, (2) less feasible, and (1) not feasible.

Table 1. Expert Validation Feasibility Criteria

Average (%)	Validation Criteria
$80 \leq x \leq 100$	Highly Feasible
$60 \leq x < 80$	Feasible
$40 \leq x < 60$	Fairly Feasible
$20 \leq x < 40$	Less Feasible
$0 \leq x < 20$	Not Feasible

Furthermore, the average attractiveness response questionnaire analysis employs a Likert scale with five answer options with the following score interpretation (Asyhari & Silvia, 2016).

Table 2. Interpretation of Student Interest Questionnaire Score

Achievement (%)	Description
$80 \leq P \leq 100$	Very Interested
$60 \leq P < 80$	Interested
$40 \leq P < 60$	Fairly Interested
$20 \leq P < 40$	Less Interested
$0 \leq P < 20$	Uninterested

The scientific literacy test was administered as a multiple-choice test with 20 questions. The test data was examined, including numerous tests such as validity, reliability, discriminatory power, and difficulty level. Furthermore, a study of the growth in student scientific literacy was performed using the normalized average gain score based on the pre-test and post-test findings, with the following score categories (Majdi et al., 2018).

Table 3. Normalized Gain Score Category

Gain (g)	Category
$0.7 < g \leq 1.0$	High
$0.3 < g \leq 0.7$	Moderate
$g \geq 0.3$	Low

RESULT AND DISCUSSION

This research resulted in a STEM-based interactive e-book. The analysis phase aims to obtain information by examining the material's problems, needs, and constraints. Students were given questionnaires to complete as part of the analysis. According to the questionnaire's responses, students desired interactive instructional materials that may include fascinating writing, photos, videos, animations, and audio. This is because technology is rapidly evolving. Generations in the fourth industrial revolution have a fantastic potential to develop human resources with character, a broad perspective, and insight (Arif & Yuhdi, 2020; Johari et al., 2021; Miri et al., 2014). One of the linked problem-solving techniques, the STEM (Science, Technology, Engineering, and Mathematics) approach, can help solve these challenges (He et al., 2012; N. Hutchins et al., 2018; NM Hutchins et al., 2020). This method integrates five disciplines to enable students to use their expertise to solve difficulties in their daily lives. To enhance scientific literacy, universities in Lampung must develop STEM-based interactive e-books.

The goal of the design stage is to create a reference for creating the product. Compiling the framework of the structure of teaching materials, presenting a systematic presentation of material adapted to aspects of scientific literacy that correlate with STEM, collecting design objects such as material collection, evaluation questions, answers, pictures, videos, audio, and others are among the activities carried out.

The development stage's goal is to create a finished product. During the development stage, activities include creating interactive e-books using the Flip PDF Professional tool based on the design. A team of experts validated, tested, and assessed the product's feasibility. The material expert validation received an average percentage of 82.33 %. The media expert validation yielded an average percentage of 86.38 %. IT experts provided an average score of 80.00 %. Several ideas and inputs must be improved while validating the scientific literacy test instrument to be more suitable for measuring students' scientific literacy abilities. The validation received an average percentage value of 88.09 %, indicating that the criteria were feasible for research use.

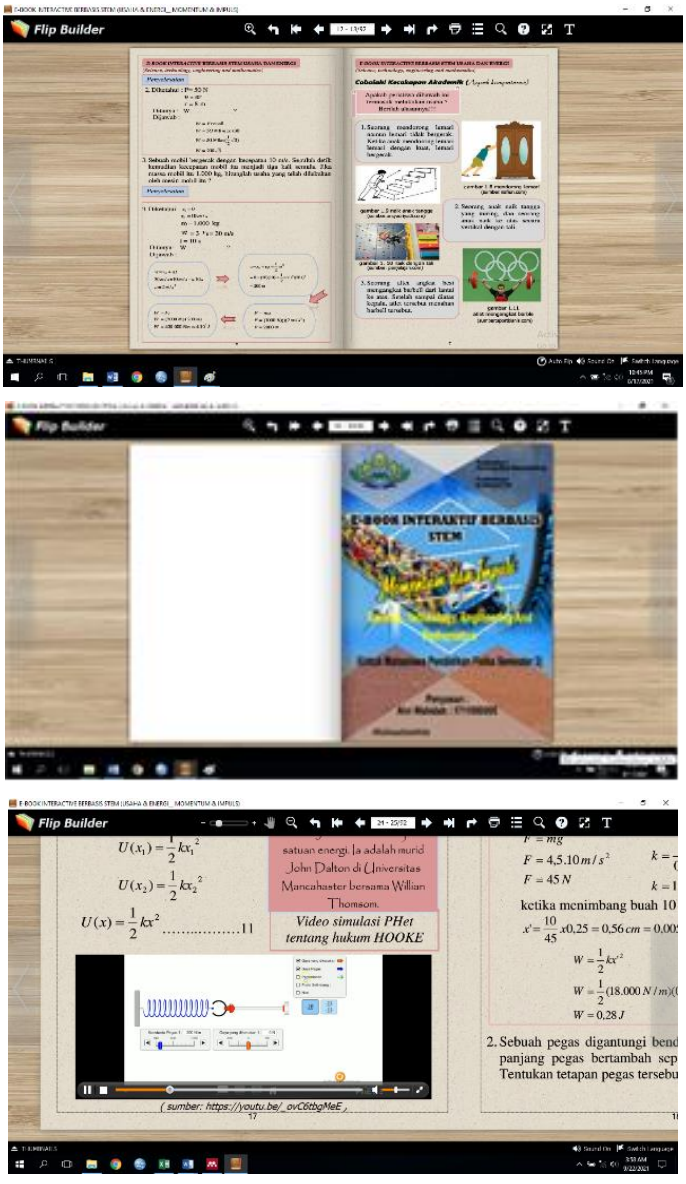

Figure 2. STEM-Based Interactive E-Book

The researchers then tested the product in a two-stage trial. The trials were small-scale and large-scale to assess the attractiveness and ability to increase students' scientific literacy skills. The small-scale trial involved 30 Physics Education Study Program students at UIN Raden Intan Lampung. The large-scale trial was carried out on 118 Physics Education Study Program students at three universities in Lampung: UIN Raden Intan Lampung, Universitas Lampung, and Universitas Muhammadiyah Metro.

In the small-scale trial, 30 students were given an attractiveness questionnaire comprising 15 questions with three assessed aspects: appearance, presentation of material, and benefits. The responses to the product's attractiveness in the small-scale trials are shown in Figure 3.

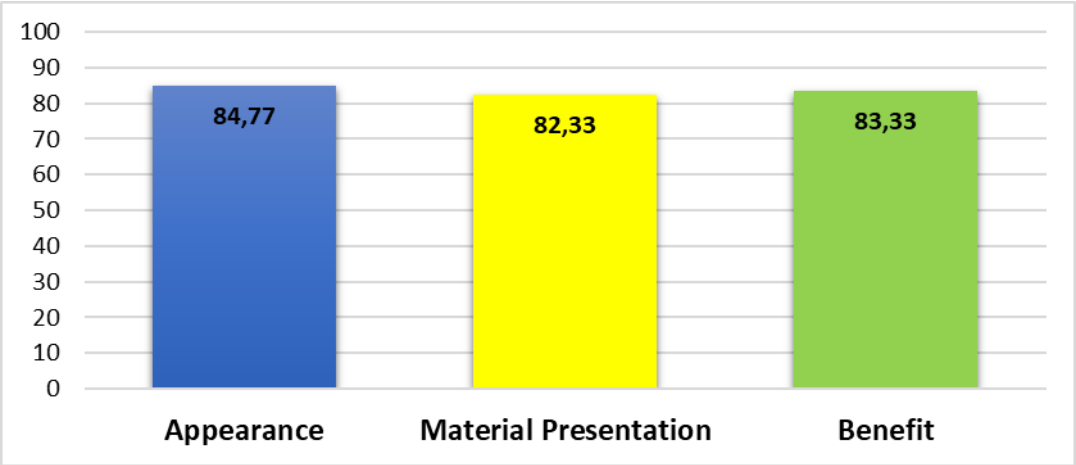

Figure 3. Small-Scale Trial Result

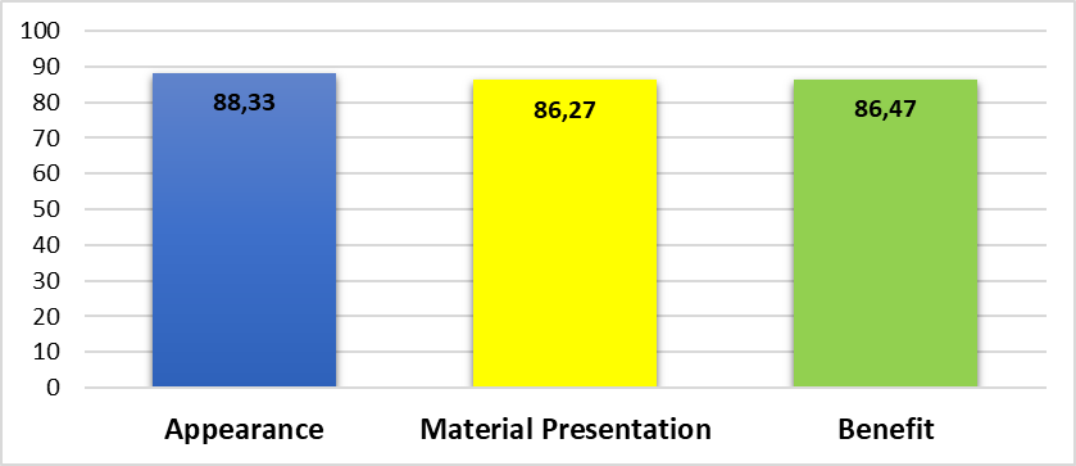

Figure 4. Large-Scale Trial Result

According to the findings of small-scale trials, the percentage of scores achieved is 84.77 % on the aspect of the display, 82.33 % on the element of content presentation, and 83.33 % on the aspect of benefits. The total of all aspects is 83.48 %. The STEM-based interactive e-book belongs to the attractive category.

Furthermore, according to the findings of the large-scale trial done by three universities in Lampung, the display element received an average score of

88.33 %. The material presentation aspect received an average score of 86.27 %. The benefits aspect received an average score of 86.47 %. Therefore, the overall average percentage was 87.02 % within the highly feasible category.

One of the purposes of this research is to see if STEM-based interactive digital e-books could improve students' scientific literacy skills. The changes in the pretest and post-test scores indicated a gain in scientific literacy. The starting capacity of scientific literacy in the large-scale trial on 118 students from three universities in Lampung was inadequate, as evidenced by the average pretest result of 44.3. As a result, the STEM-based interactive e-book was implemented. Students' scientific literacy improved after being exposed to the developed learning media. The average posttest score of 76 demonstrated the improvement. This improvement was also reflected in the average N-Gain score, which is 0.56 in the moderate category.

Meanwhile, UIN Raden Intan Lampung attained the average pretest value of 44 in the small-scale trial comprising 30 students from the Physics Education Study Program. After implementing the developed media, students' scientific literacy grew to 76.3. The average value of the N-Gain score was 0.57 in the moderate category. These findings suggest that the STEM-based interactive digital e-book increased scientific literacy skills. The STEM-based teaching media can boost scientific literacy (Afriana et al., 2016; Indrasari et al., 2020).

The benefits and drawbacks of this STEM-based interactive e-book include that it is easily accessible by students via electronic devices such as computers/laptops, mobile phones, or tablets connected to the internet network (HTML5 extension) and can be used anywhere and at any time. The widespread usage of the internet can be a tremendous asset in the development of learning with an online system (He et al., 2012; Yuberti, 2015; Yusop & Sumari, 2013). The extension (exe) can be accessed offline using a computer/laptop that can be copied and pasted between computers/laptops. STEM-based interactive e-books are digital teaching resources that assist students in understanding learning information that is not boring because it contains images, audio, and video that can enhance learning activities (Fennell et al., 2019).

The final step was evaluation. At this step, the researcher evaluated to collect data at each stage, aiming to improve or revise the product. After being revised, the STEM-based interactive e-book was designed and tested for feasibility, attractiveness, and scientific literacy ability. As a result, the STEM-based interactive e-book is extremely feasible, entertaining, and capable of boosting students' scientific literacy. Thus, it can be employed in teaching and learning activities.

The STEM-based interactive e-book can be utilized to enhance student learning and can stimulate the improvement of scientific literacy in the era of globalization. It is highly important as an effort to increase students' scientific literacy. It can expand sources of information on the growth of interactive e-book media development (Dunleavy et al., 2009; Herawati & Muhtadi, 2018). This finding is certainly relevant to previous research by Firdausy & Prasetyo, (2020) on STEM-based interactive teaching materials (Indrasari et al., 2020). The product developed is packaged interactively, attractively, and practically in a series of digital books containing images, videos, animations, etc. The material is presented based on aspects of scientific literacy (context, knowledge, competence, and attitude) integrated with STEM (Science, Technology, Engineering, and Mathematics) learning that can be accessed easily through electronic devices.

As a result, this research has the potential to be employed as a supporting medium in basic physics courses, particularly in the areas of work and energy and momentum and impulse. The researchers develop STEM-based interactive e-books using new knowledge and expertise. Furthermore, offering educational materials that can be used improves students' scientific literacy in the globalization era (Afandi et al., 2019).

CONCLUSION

Based on the findings, it is possible to conclude that STEM-based interactive digital e-books can improve students' scientific literacy skills. The STEM-based interactive e-book is highly feasible. Based on the expert validation, the developed e-book obtained a percentage of 82.33% from the material experts, 86.38% from the media experts, 80.00% from the IT experts, and 88.09% from the scientific literacy test instrument experts. All categories belong to the highly feasible criteria. The students claimed that the STEM-based interactive e-book is attractive.

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