The development of electronic teaching materials on linear impulse and linear momentum to improve students’ scientific literacy

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Abstract. Students’ low scientific literacy competence and the unavailability of electronic teaching materials that match scientific literacy indicators that can be used in online learning encourage researchers to develop electronic teaching materials to improve students’ scientific literacy. This research aims to produce and describe the appropriateness of electronic teaching materials used in the learning process to enhance scientific literacy. The electronic teaching materials developed are based on scientific literacy indicators, namely explaining scientific phenomena, interpreting data and providing scientific evidence, designing and evaluating scientific investigations. The type of research used is research and development of the ADDIE model. The appropriateness of electronic teaching materials in terms of validity, practicality, and effectiveness. Research data was obtained from validation sheets given to three validators, student response questionnaires and learning outcomes tests. The data were analyzed by validity test, practicality test, and effectiveness test using N-gain score. The results showed that: 1) the validity of teaching materials obtained a score of 3.52 in the very high category, 2) the practicality of electronic teaching materials based on student response questionnaires obtained a percentage of 80.81% in the practical category, 3) the effectiveness of electronic teaching materials obtained a score of 0.44 in the medium category and the students’ scientific literacy ability 44.11% in the medium category. Based on the results of the study, impulse and linear momentum electronic teaching materials have been produced to improve students’ scientific literacy that is appropriate for use in the learning process. This research has implications, namely increasing students’ scientific literacy, especially on impulse and linear momentum material.

1. Introduction
The 21st century is marked by the development of science and technology in the field of life in society, especially information and communication technology which is very rapid, where everything can be regulated by technology [1]. The development of science and technology will bring education to face increasingly severe challenges, one of which is that education is expected to produce human resources who have good abilities in facing various challenges in life in the era of globalization [2]. In the 21st century, the development of the world is becoming increasingly rapid and complex. A paradigm shift in the education system is needed to provide the 21st-century skills that learners need to face the era of globalization [3].
Based on the results of the needs analysis, resulting in the development of teaching materials on the internet and assignments in the form of questions and assignments. The learning carried out does not refer to scientific literacy indicators but only to the competencies possessed by students.

Literacy skills have an essential role in the success of the younger generation. The younger generation with good literacy skills will easily understand information verbally and in writing. The competencies possessed in life can be supported by the ability of the younger generation to master literacy. The competencies possessed can become more potent if the younger generation masters literacy, namely being able to sort out information that can support the success of their lives.

Scientific literacy can be defined as scientific skills and knowledge to identify questions, acquire new knowledge, explain scientific phenomena, draw conclusions based on facts, understand the characteristics of science, have an awareness of how science and technology can shape a natural, intellectual, and cultural environment, and desire to participate in and care about issues related to science.

Globalization makes the world seem borderless, resulting in comparisons between schools in the form of curricula, assessment methods, and student achievements on an international scale. It makes schools urged to be excellent and be competitive. International programs to compare student achievement, such as Trends in International Mathematical and Science Study (TIMMS), started in 1995 and is carried out every four years. Programmes for International Student Assessment (PISA), which began in 2000, are carried out regularly every three years. The year is an example of an international student comparison program, especially in science and mathematics.

Based on a survey conducted by PISA in 2018, released on December 9, 2019, Indonesia was ranked 70th out of 78 with a score of 396. The causes of the low level of scientific literacy of students in Indonesia related to the ongoing education process include the applied education system, the selection of models, approaches, methods and learning strategies, selection of learning resources, student learning styles, and learning infrastructure. Based on the results of pre-research in class X of SMAN 1 Gambut which was distributed using Google Form, it showed that students’ scientific literacy skills were still low; 92.31% of students were still unable to explain scientific phenomena, 86.23% of students were still unable to evaluate and design scientific investigations, and 96.15% of students were not able to interpret data and provide scientific evidence.

Based on an interview with one of the teachers at SMAN 1 Gambut, the learning used during the Covid-19 pandemic uses Google Classroom which is intended not to spend a lot of students’ internet quota. The teaching materials are in the form of files in .docx or .pdf formats downloaded via the internet, and assignments in the form of questions in the students’ worksheets are then distributed to students. It is due to teachers who do not master the technology that supports the creation of online learning materials. The learning carried out does not refer to scientific literacy indicators but only follows teaching materials on the internet and students worksheets. Based on the results of the needs
analysis conducted by researchers, it is necessary to use teaching materials to support online learning. The teaching materials are expected to be able to train students’ scientific literacy.

One solution to train scientific literacy at SMAN 1 Gambut is with learning media. Learning media can convey messages from the teacher to students in learning so that it can stimulate the thoughts, feelings, and attention of students to achieve learning objectives [15]. One solution to train scientific literacy at SMAN 1 Gambut is with learning media. Learning media can convey messages from the teacher to students in learning so that it can stimulate the thoughts, feelings, and attention of students to achieve learning objectives [16].

Learning media that can be developed to train literacy are digital teaching materials. Digital teaching materials are all materials that teachers must prepare to support the learning process in non-printed form, namely digital [17]. Digital teaching materials can be created using flipbook software. Flipbook has the advantage that it can convert pdf files in an interactive form in which images, audio, video, animation and hyperlinks can be inserted [18]. A similar study conducted by Firdaus, Pursitasari, Permana, & Suhardi shows that scientific literacy electronic teaching materials are suitable for use as teaching materials [19]. The electronic teaching materials used can improve students’ scientific literacy competence. Likewise, Sumantri & Khaliq concluded that the 3D Page Flip-based science literacy E-Book is suitable for use as a medium to improve students’ scientific literacy [20]. The electronic teaching materials developed are different from previous research, namely all local cultures and virtual practicums integrated with learning materials. Teach electronically without having to install additional applications, and use the hyperlink feature to go to practice questions and move pages quickly.

Based on the background of the study, the researchers developed impulse and linear momentum electronic teaching materials to improve students’ scientific literacy. This research aims to produce and describe the appropriateness of electronic teaching materials used in the learning process to improve students’ scientific literacy.

2. Method
The development model used for this research is the ADDIE (Analysis, Design, Development, Implementation and Evaluation) model [21]. ADDIE has the following steps:

| Step           | Explanation                                                                 |
|----------------|-----------------------------------------------------------------------------|
| Analysis       | Curriculum analysis, needs analysis, student characteristics analysis and teaching material analysis. |
| Design         | Designing electronic teaching materials starts from documents, converting them into pdf form and saving them on the Flip PDF Professional. |
| Development    | Develop electronic teaching materials and upload them so that they can be accessed online by students. |
| Implementation | The application of teaching materials that have been made in class X MIPA 1 SMAN 1 Gambut was carried out for three meetings where each meeting discusses one sub-chapter. |
| Evaluation     | A formative evaluation was carried out to collect data at each stage used to improve the developed teaching materials, and a summative evaluation was carried out at the end of the study to determine the effectiveness of electronic teaching materials to improve students’ scientific literacy. |

The research subject is linear momentum impulse electronics teaching materials. The research object is the appropriateness of impulse and linear momentum electronic teaching materials to improve students’ scientific literacy in terms of validity, practicality, and effectiveness. Data collection techniques were carried out with validation sheets, student response questionnaires and learning outcomes tests. Before the research was conducted, the researcher conducted a preliminary study by interviewing and giving
questions with scientific literacy indicators to find out the problems in SMAN 1 Gambut and the scientific literacy competence of students.

Student response questionnaires were given through a google form containing 18 statements. The response questionnaire given to students had nine positive statements and nine negative statements with options, namely strongly agree, agree, disagree, and strongly disagree. The response questionnaire given is the basis of the practicality assessment of the developed electronic teaching materials. Learning outcomes test is provided through Google Form to students. The questions in the learning outcomes test refer to the scientific literacy competency indicators by the OECD (Organization for Economics Cooperation and Development) in the form of essays. Eligibility of electronic teaching materials is stated from the results of the validation sheet assessment with a minimum category of good [22], for the practicality of electronic teaching materials based on a response questionnaire with a minimal practical category [23], and the minimal effectiveness of the moderate category based on the N-Gain obtained from the results of the pre-test and posttest [24].

3. Result and Conclusion

The developed electronic teaching materials are to improve students’ scientific literacy on impulse and linear momentum materials. Electronic teaching materials were developed using Flip PDF Professional software on linear impulse and momentum materials that can be accessed online via Android iOS-based smartphone devices, laptops, and computers. The following is an example of the display of electronic teaching materials accessed on computers in figure 1.

![Figure 1. Cover Display of Electronic Teaching Materials Accessed Through Computers](image1)

Display of electronic teaching materials accessed on smartphone Android and iOS shown in Figure 2.

![Figure 2. Initial Display of Electronic Teaching Materials Accessed Through Android Smartphones (left) and iOS Smartphones (right)](image2)
Electronic teaching materials were validated by three validators consisting of two academics and one practitioner. The results of the validation of electronic teaching materials by validators are shown in Table 2.

| No | Indicator            | Assessment Aspect                  | Average | Category     |
|----|----------------------|-----------------------------------|---------|--------------|
|    | Content Aspect       | 1. Software Engineering          | 3.49    | Very Good    |
|    |                      | 2. Content Quality               |         |              |
|    |                      | 3. Organization                  |         |              |
|    |                      | 4. Language                      |         |              |
|    |                      | 5. Evaluation                    |         |              |
|    | Display Aspect       | 1. Visual Communication          | 3.56    | Very Good    |
|    |                      | 2. Format                        |         |              |
|    |                      | 3. Attractiveness                |         |              |
|    |                      | 4. Font Shape and Size           |         |              |
|    | Validity             |                                   | 3.52    | Very Good    |
|    | Reliability          |                                   | 0.97    | Very High    |

Based on the table above, the results of the validator’s assessment for the validity of electronic teaching materials are categorized as very good with a score of 3.52 and very high reliability, namely 0.97. It shows that the developed electronic teaching materials can be tested on students of class X MIPA 1 SMAN 1 Gambut.

The validation of electronic teaching materials on the content aspect is in the very good category. Assessment on the content aspect includes aspects of software engineering, content quality, language, organization, and evaluation. The electronic teaching materials developed have clear instructions for use. The use of RAM based on the Device Info application is 38 MB on the Google Chrome browser; this means that there is not too much RAM usage because the devices owned by students have RAM capacities ranging from 2 GB to 8 GB. The software used in the manufacture of electronic teaching materials, namely Flip PDF Professional, is also considered appropriate in manufacturing electronic teaching materials. The output of this application is in the form of HTML, which can be appropriately run using a browser without using additional applications. Electronic teaching materials developed with the Flip PDF Professional application also do not experience errors when accessed.

The electronic teaching materials developed are adjusted to the learning indicators to be achieved as well as scientific literacy indicators by the OECD. Electronic teaching materials are also equipped with pictures, videos and links that aim to attract students' interest. The material in electronic teaching materials is systematically arranged which is divided into three subchapters. The language used in these electronic teaching materials is systematic, simple and easy to understand by students. It is in line with Prastowo, which states that electronic teaching materials must be arranged systematically using language that students easily understand according to students' level of knowledge [25].

Another part of this electronic teaching material is evaluation. Evaluation aims to find out whether students have met the standards or not. The standards are determined based on the learning objectives to be achieved. The evaluations made are also adjusted to the OECD scientific literacy indicators [26].

The appearance of electronic teaching materials depends on visual communication, format, attractiveness, and the shape and size of the letters. The layout and color of electronic teaching materials are consistent in each sub-chapter. Further, the layout of electronic teaching materials is dominated by blue. Blue is often associated with nature, such as the sky and the sea, which gives a relaxed and calm impression. Hideako Chijiwa, in his book entitled “Color Harmony”, classifies blue as a cool color. Cool colors tend to make it more comfortable to look at [27]. It makes it possible to make access to electronic teaching materials feel comfortable viewing the display of them being accessed.

The column format used in electronic teaching materials is a double-column that divides the page into two columns. Daryanto suggests that to produce good and attractive electronic teaching materials, it is necessary to design and develop them by considering the appropriate format, attractiveness, and
font size. The column format used must be proportional to both the single-column format and the double-column format. The use of multiple columns must have a proportional ratio of the distance between columns [28].

One of the attractiveness of electronic teaching materials is on the cover page. The front cover combines various colors, images and appropriate font sizes. The colors used on the cover page are black and blue. The images used are Newton’s Swings and billiards balls, which definitely, are closely related to the material of impulse and linear momentum. The white color is used as the title of the electronic teaching material because the writing background is black. The experimental results of Fonda stated that white writing on a black background and white writing on a red background has a high level of clarity with almost the same value [29].

The contents of the electronic teaching materials that are made contain pictures and illustrations that are presented attractively and the right bold and italics as an emphasis on certain words. The fonts used in this electronic teaching material are Sans Serif fonts, namely Comic Sans MS and Pineapple Grass. Sans Serif fonts were chosen because they are easier to read than Serif fonts. It is supported by Dogusoy, Cicek and Cagiltay, who state that reading electronic text in Serif and Sans Serif typography when compared is generally found that the reading of Sans Serif typefaces is faster and more accurate than the Serif type [30]. The use of the Sans Serif typeface is also supported by Fittrialny & Ardoni. Sans Serif letters have the characteristics of not having hooks, only stems and stems, simple and easy to read, suitable for websites, e-books, databases, and display monitor base. Sans Serif fonts look more straightforward and easier to read in a variety of sizes [31].

The practicality of electronic teaching materials developed based on student response questionnaires distributed through a google form, as shown in Table 3.

| No. | Indicator              | Percentage | Category   |
|-----|------------------------|------------|------------|
| 1   | Benefit Aspect         | 84.31%     | Very Practical |
| 2   | Efficiency Aspect      | 71.16%     | Very Practical |
| 3   | Convenience Aspect     | 85.95%     | Very Practical |
| Average |                       | 80.81%     | Very Practical |

On the aspect of benefits, 94.4% of students stated that electronic teaching materials helped students learn physics. 72.2% of students stated that the electronic teaching materials made the learning atmosphere fun and not boring. A pleasant learning atmosphere can make students have interest and motivation in learning [32]. It is in accordance with the results of the response questionnaire which stated that 88.9% of students were motivated to study the material of impulse and linear momentum. Electronic teaching materials can help students learn independently because they have a communicative and two-way language, making it easier to learn. 83.3% of students stated that electronic teaching materials helped students in learning independently. 83.3% of students stated that electronic teaching materials made it easier to understand learning materials. The benefits aspect obtained a percentage of 84.31%, which is included in the very practical category [33].

The practicality of electronic teaching materials is also assessed based on the aspect of efficiency. Learning using electronic teaching materials is assessed on time by 72.2% of students. This time efficiency is because students can use hyperlinks to move to the desired subchapter or page quickly. The hyperlink feature also allows students to access other content on electronic teaching materials simultaneously. Video features that can be accessed without having to leave electronic teaching materials also make time more efficient. Based on the website speed test via tools.pingdom.com, the first page loading time is 2.24 s, and the time it takes to switch pages is 1.2 s. During the use of electronic teaching materials, 94.4% of students stated that electronic teaching materials were not wasteful in the use of power, and 61.1% of students stated that electronic teaching materials did not consume a lot of internet quota. In the aspect of efficiency, the percentage obtained is 71.16% in the practical category.
The last aspect of the practicality assessment is the aspect of convenience. The language used in electronic teaching materials is considered easy to understand by 94.4% of students. 100% of students stated that the size of the letters in electronic teaching materials did not complicate the learning process. It is due to the use of Sans Serif fonts which are quite easy to read, and the size is 14 so that the size is appropriate for use in the developed electronic teaching materials. Electronic teaching materials that are made can be accessed easily on various networks according to 94.4% of students.

Based on the discussion of the three practical aspects of electronic teaching materials, the overall practicality of electronic teaching materials through student response questionnaires obtained an average of 80.81%, so it can be concluded that electronic teaching materials are practically used in learning. The practical electronic teaching materials can help students understand learning materials.

The effectiveness of electronic teaching materials is obtained by calculating the N-gain score obtained based on the pretest and posttest to students of class X MIPA 1 SMAN 1 Gambut. The following are the results of the calculation of the N-gain score.

| Table 4. The Result N-Gain Score |
|----------------------------------|
| Pre-test Average | Post-test Average | h | Category |
| 0.00 | 44.11 | 0 | 0.44 | Medium |

The average of scientific literacy competence is shown in table 5.

| Table 5. The Result N-Gain Score |
|----------------------------------|
| Pre-test Average | Category | h | Post-test Average | Category |
| 0.00 | Low | 0 | 44.11 | Medium |

The developed electronic teaching materials train students to be able to solve problems on the Learning Outcomes Test. The Learning Outcome Test is given in the form of 7 essay questions. The level of questions on The Learning Outcome Test ranges from C2 to C5. Table 4 shows the average score of the students’ pre-test for scientific literacy competence is 0.00%. During the pre-test, none of the students met the Minimum Completeness of Criteria at school, which was 75. The average posttest score for scientific literacy competence showed an increase to 44.11%. Based on the N-gain score, the effectiveness of electronic teaching materials is found in the medium category.

The indicator explaining scientific phenomena gets 52.94%, receiving the highest percentage compared to other indicators. The scientific phenomenon indicator gets the most elevated rate because the questions used are at the lowest level compared to other scientific literacy indicators. It is in accordance with Nabilah & Sahala findings on the material of linear impulse and momentum stating that the lower the level of the question, the higher the percentage of students’ cognitive abilities. Indicators interpreting data and scientific evidence get a percentage of 50%. The lowest percentage was obtained on the indicators of designing and evaluating scientific investigations, namely the percentage was only 29.41%. It is similar to Setiawan’s research which shows that the ability to design and evaluate scientific investigations has the lowest increase compared to other scientific literacy competencies. It happens because students are doing practical activities for the first time, so they are not used to designing scientific investigations.

The results obtained are in accordance with the behavioristic learning theory. Behavioristic learning theory holds that learning is a change in student behavior due to the learning process itself. The learning process is a stimulus that the teacher can control to obtain the expected student response. Based on the three indicators of scientific literacy, it has been found that students' behaviour who initially had low scientific literacy skills turned into a medium category of scientific literacy skills after the teaching materials were applied.

Overall, the developed electronic teaching materials can improve student learning outcomes. It is in line with the results of Lestari’s research which states that using electronic teaching materials is proven
to be significantly effective in improving student learning outcomes [37]. It shows that electronic teaching materials have been developed to be an excellent online learning tool during the current Covid-19 pandemic.

The previous description shows that the electronic teaching materials developed can be said to be effective because they are in accordance with the expected goals, namely to increase students’ scientific literacy. It is in line with Tegeh opinion that the effectiveness of a product is related to the extent to which the product can achieve certain goals [38].

The developed electronic teaching materials are declared appropriate to be used in the learning process to improve students’ scientific literacy. It is based on the validity of the very good category, the practicality of the very practical category, and the effectiveness and competence of scientific literacy in the medium category. The drawbacks contained in the developed electronic teaching materials are not knowing whether students access the electronic teaching materials provided or not. This research has implications, namely increasing students’ scientific literacy, especially on impulse and linear momentum material. The limitation in this research is that it has not included all the sub-indicators of scientific literacy in the learning outcome test; further researchers are expected to include all the sub-indicators of scientific literacy in the learning outcome test.

4. Conclusion
Based on the results of the study, electronic teaching materials are suitable for use in the learning process to improve students’ scientific literacy. It is based on a) the validity of electronic teaching materials in the very high category, b) the practicality of electronic teaching materials as seen from the questionnaire responses of students included in the very practical category, c) the effectiveness of electronic teaching materials seen from the N-gain score is in the medium category, and the scientific literacy competence of students is in the medium category so that it can be used in the learning process to improve students’ scientific literacy. This research has implications, namely increasing students’ scientific literacy, especially on impulse and linear momentum material. Based on the shortcomings in the developed electronic teaching materials, it is hoped that similar research can find out whether students have access to electronic teaching materials.

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