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[Research Article]

DEVELOPMENT OF NEWTON'S LAW PHYSICS E-BOOK ON MOTION BASED ON TECHNOLOGICAL PEDAGOGICAL CONTENT KNOWLEDGE (TPACK)

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ABSTRAK

Pemanfaatan teknologi dalam pendidikan memungkinkan kegiatan pembelajaran menjadi lebih bervariasi, mudah dan menyenangkan sehingga dapat mempengaruhi pemahaman konsep siswa dalam pembelajaran fisika. Telah dilakukan penelitian yang bertujuan untuk mengembangkan e-book Hukum Gerak Fisika Newton berbasis Technological Pedagogical and Content Knowledge (TPACK) yang cocok untuk meningkatkan pemahaman konsep siswa telah dilakukan. Penelitian pengembangan ini menggunakan model ADDIE (Analysis, Design, Development, Implementation, dan Evaluation). Berdasarkan hasil analisis data validasi ahli diperoleh nilai persentase rata-rata sebesar 88% dengan kategori layak digunakan dalam proses pembelajaran. Hal ini didukung dengan hasil pemahaman siswa terhadap isi e-book sebesar 86,41 dengan kategori tinggi. Begitu pula respon siswa terhadap e-book yang dikembangkan menunjukkan bahwa e-book sangat baik digunakan dalam proses pembelajaran untuk meningkatkan pemahaman konsep siswa dan menciptakan pembelajaran yang menarik dan bermakna.

Kata kunci: e-book, hukum Newton, TPACK

ABSTRACT

The use of technology in education allows learning activities to be more varied, easy and enjoyable so that it can influence students' understanding of concepts in physics learning. Research which aims to develop an e-book on Physics of Newton's laws of motion based on Technological Pedagogical and Content Knowledge (TPACK) which is suitable for increasing students' understanding of the concept has been carried out. This development research uses the ADDIE (Analysis, Design, Development, Implementation, and Evaluation) model. Based on the results of expert validation data analysis, an average percentage value of 88% was obtained with the category suitable for use in the learning process. This is supported by the results of students' understanding of e-book's content, which was 86.41 in the high category. Likewise, students' responses of the e-book developed show that the e-book is very good for use in the learning process to increase students' understanding and create interesting and meaningful learning.

Keywords: e-book, Newton Laws, TPACK

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1. INTRODUCTION

The rapid development of science and technology in the 21st century has had a huge influence on various areas of life. One of them is in the field of education, where the use of technology, especially related to ICT, is very important as an effort to improve the quality of education in the 21st century. The application of technology in education has made various aspects of education easier, starting from educators, students, education system and educational facilities and infrastructure. The use of technology in education allows learning activities to be more varied, easy and enjoyable so that it can influence students' understanding of concepts in physics learning. Meanwhile, physics learning generally only uses physics textbooks in printed form, thereby not optimizing technology to suit the demands of the 21st century era (Jhangiani et al., 2018).

The physics learning process must begin by exposing students to real problems in everyday life and how to overcome these problems so that students' knowledge increases, and they understand physics more deeply (Haji, Safriana, & Safitri, 2015). Students' difficulties in learning physics are a lack of conceptual understanding and misconceptions experienced by students caused by daily experiences, books, and educators (Widiatmoko and Shimizu, 2018).

Educational problems still occur today as the results of observations in the field show that students' understanding of physics concepts, especially particle dynamics, is still not optimal. So efforts are needed to increase students' understanding of the concepts of physics teacher candidates, especially at Khairun University.

One solution that can be done to overcome the problems that occur is the use of learning media in the form of technology-based e-books which can represent physics concepts in various forms of representation so that they are more interesting and easier for students to understand. The use of e-books makes it possible to present electronic content in the form of sound, images, graphics, animation and video, making e-books seen as more attractive and interactive than printed books (Mohammed, 2015). Interactive e-books accompanied by animations and videos make it easier for students to grasp the contents of the reading material compared to ordinary e-books (Smeets & Bus, 2015). The use of e-books during the learning process has been proven to be able to increase understanding of concepts (Humairoh & Wasis, 2015).

This research aims to develop a physics e-book on Newton's laws of motion based on TPACK using a professional flip pdf application. This application has multimedia features such as audio, flash animation, hyperlinks, MP4, YouTube, quizzes, and videos which can help practice science learning skills, increase student learning motivation, and can enable students to learn independently (Rara et al., 2019). Apart from that, this application can be easily accessed by users using Android or smartphones.

The approach used to develop e-books to teach 21st century skills in physics learning is TPACK which integrates three basic knowledge, namely content knowledge, pedagogy, and technology (Mishra and Koehler, 2006). In this framework, learning material is packaged using a learning model that suits its characteristics and is combined with the technology used such as animation programs, simulations, and virtual laboratories as learning media and resources (Spector, Merrill, Elen, & Bishop, 2014). So, it is hoped that the e-book being developed can overcome problems that occur in the field. Therefore, it is important to carry out this research to improve the quality of education to answer the challenges of 21st century education.

2. METHOD

This research takes place at the physics education study program at FKIP Khairun

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University, and FPMIPA at Indonesian Education University and is planned for 6 months, starting from April – September 2023. The research will involve 30 prospective physics teacher students at the physics education study program at FKIP Khairun University (24 women , 6 men), and 40 prospective physics teacher students at FPMIPA UPI (30 women, 10 men). The instruments used in this research were, in the form of an e-book feasibility validation sheet, an instrument for understanding the content of the e-book, and a response questionnaire to the e-book.

This development research uses the ADDIE (Analyze, Design, Development, Implementation, Evaluation) model because in the product development steps, this model is considered more rational and more complete. This model can be used for various forms of product development in learning activities such as models, learning strategies, learning methods, media and teaching materials [Mulyatiningsih, 2016].

The research procedure for developing a Physics e-book based on Technological Pedagogical and Content Knowledge (TPACK) on the concept of Newton's law of motion carried out by the researcher can be seen in **Figure 1**.

Data from validation results from e-book quality testing experts are then converted into percentages and then interpreted based on the eligibility criteria for teaching materials as seen in table 1 [Sinaga etal., 2014].

Table 1. E-book Eligibility Criteria

Percentage (%)	Eligibility Criteria
91 < x ≤ 100	Excellent
76 < x ≤ 90	Good
61 < x ≤ 75	Feasible
x ≤ 60	Weak

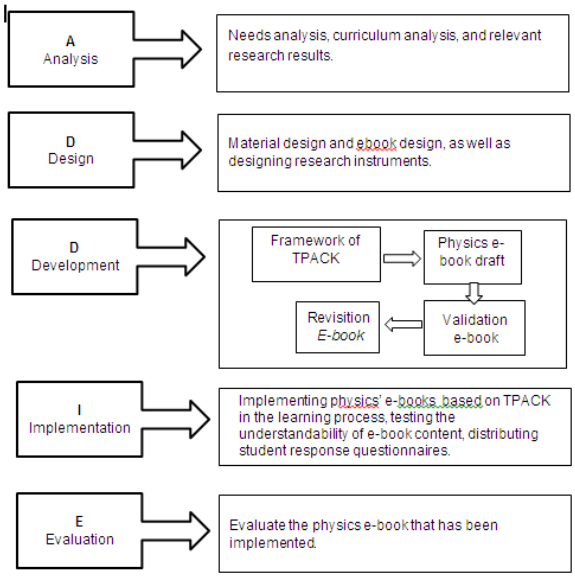

Figure 1. Research and development flow

Meanwhile, for the comprehensibility test, the data obtained is then converted into percentages and then interpreted based on the criteria according to Rakin & Culhane (1992).

Table 2. Comprehensibility Criteria

Percentage (%)	Criteria
0 < x ≤ 40	Low
40 < x ≤ 60	Medium
x > 60	High

Furthermore, data on student responses to the physics e-book obtained using the attitude scale questionnaire given after the implementation of the e-book needs to be converted into a quantitative scale and the scores obtained are then expressed in statement indicator criteria as interpreted in Table 3.

Table 3. Student Response Criteria (Sugiono, 2017)

Percentage (%)	Criteria
81% – 100%	Excellent
61% – 80%	Good
41% – 60%	Feasible
21 %– 40%	Weak
0% – 20%	Poor

3. RESULT AND DISCUSSION

The research results using the Research and Development (R & D) method with the ADDIEdevelopment model consisting of 5 stages, namely Analysis, Design, Development, Implementation, and Evaluation in the development of e-book based on TPACK, can be described as follows.

3.1 Analysis Stage

This stage begins with analyzing the need for product development. The development of a product can be initiated by a problem in an existing/implemented product. Problems can arise and occur because current or available products are no longer relevant to target needs, learning environments, technology, student characteristics and so on.

Based on the results of observations in the field, there are several problems that must be overcome, namely: First, the learning media used in the learning process is not supportive. Second, the available media is minimally developed. Third, the lack of response and activeness of students in the learning process. Fourth, students' lack of understanding of the material on Newton's laws of motion which is presented in ordinary printed books.

Based on the description of the problem above, the researcher developed e-book learning media with the hope of being able to make the learning process enjoyable and make it easier for educators and students in the online and face-to-face learning process later.
Design Stage

Next, at this design stage, the researcher carried out several plans regarding the media before the media was developed, namely: First, preparing the e-book design using the Flip PDF Professional application. The development of this e-book will contain a front cover, back cover, foreword, table of contents, learning objectives, material content, practicum, practice questions, answer key, project assignments, and bibliography. Second, planning the presentation of the material, namely determining the material that will be published in the media being developed, namely force, Newton's first law, Newton's second law, Newton's third law, and the application of Newton's law. The presentation of the e-book will also be adjusted to competency standards and the TPACK framework. Third, design an e-book feasibility instrument that will be filled in by material experts, pedagogical experts and media experts. Apart from that, an instrument was also designed in the form of multi-representation questions in the form of PG, and questions about understanding concepts in the form of essays which will then be validated by experts.

3.2 Development Stage

Next, the development stage is the stage of creating an e-book which is developed according to the design at the design stage. Below are some views of the physics e-book products produced.

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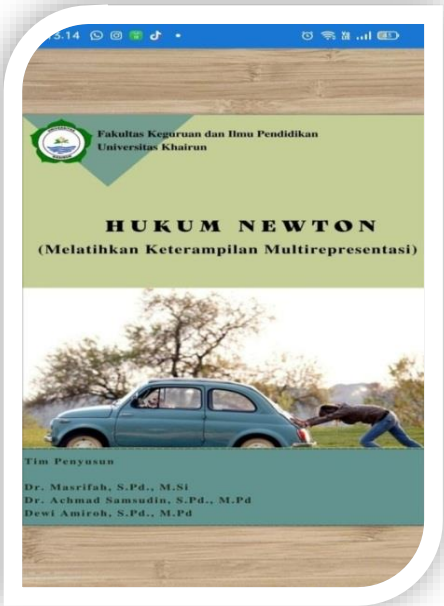

Figure 2.a. Cover e-book

Figure 2.b. Konten materi

Figure 2.c. Minilab activity

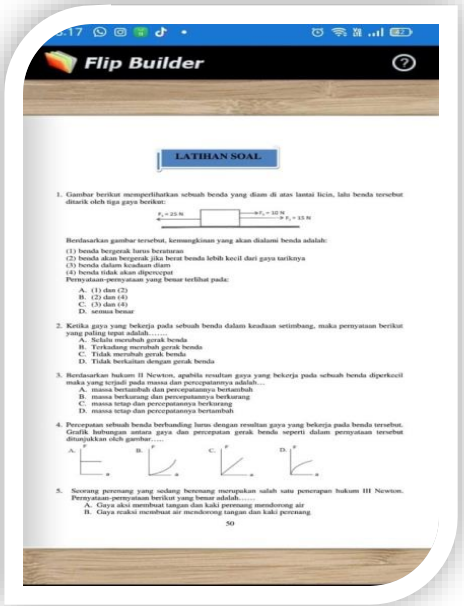

Figure 2.d. Exercise

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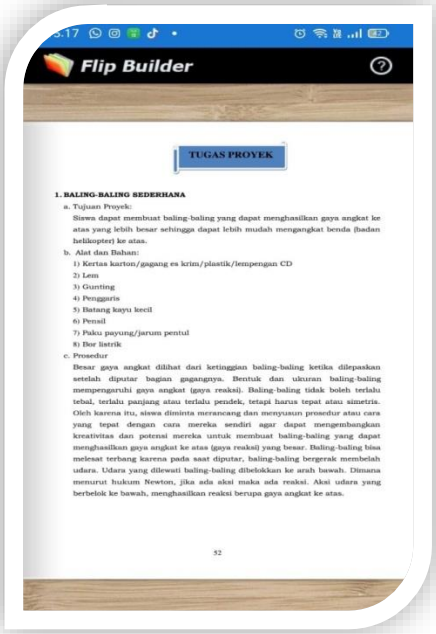

Figure 2.e. Project assignments

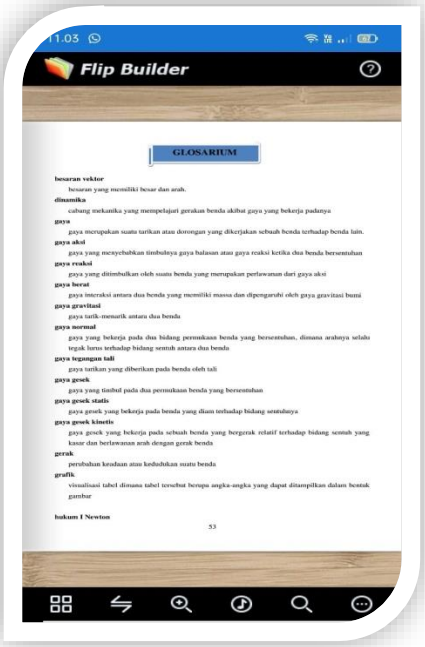

Figure 2.f. Glosarium

After the e-book has been developed, it is then validated by 3 material experts, pedagogical experts and media experts to test the feasibility of the product. If there are suggestions and input, a revision process will be carried out to produce a better e-book. The results of expert validation regarding the suitability of e-books can be seen in the following graph:

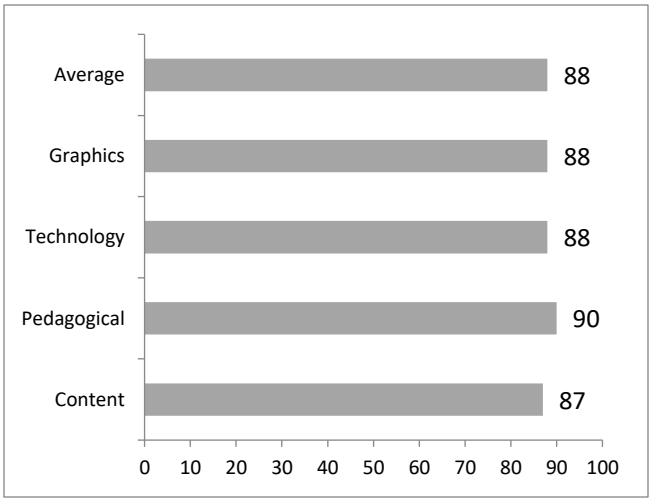

Figure 3. Feasibility level of the resulting E-book

Based on **Figure 3**, the highest level of feasibility is in the pedagogical component and the lowest is in the content component. However, all assessment components are in the feasible category. In general, judging from the total average value of the assessment components as seen in the graph above, it can be stated that the e-book developed has a feasibility percentage value of 88% which is classified as feasible, so the e-book can be implemented in the learning process even though there are still a few suggestions and input from the experts. After revisions have been made, the e-book is ready to be implemented in the learning process on a small scale first as a form of product testing.

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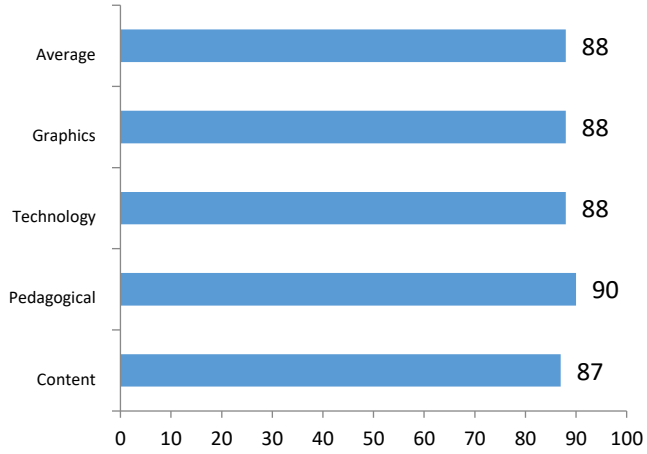

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3.3 Implementation Stage

At this implementation stage, the physics e-book that has been validated by experts and declared feasible, and has gone through the revision stage is then applied in the classroom learning process using a project-based learning model. E-books are distributed to students before the learning process takes place, and students can access them using an Android or smartphone. Next, the researcher carried out the learning process according to the plan that had been designed, where learning was carried out in groups using the e-book media that had been developed. After the learning process takes place, students are given a test to test their understanding of the content or contents of the e-book that they have studied. The results of the student comprehension test are as shown in Figure 4 below.

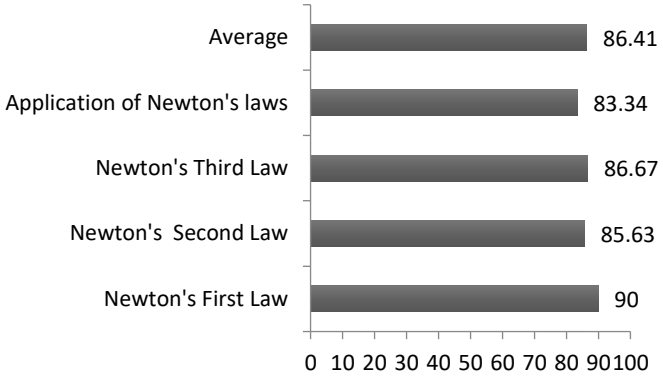

Figure 4. Physics students' understanding of e-book content

The results of the analysis show that in general the level of student understanding is 86.41 in the high category, where the sub-concept of Newton's 1st law reaches the highest score of 90. Meanwhile, the lowest achievement is in the sub-concept of applying Newton's law, however, it is still in the high category too. These results indicate that the resulting TPACK-based physics e-book content can be easily understood by students. A book is said to have a good level of comprehensibility if the book is easy for readers to understand. Comprehensibility is one of the main requirements for selecting verbal books

that can be used as learning resources (McNamara et al. 1996; Masrifah, 2021).

E-books are easy for students to understand because the content presentation uses a multi-representation approach where e-book content is presented in various forms of representation such as text, images, pictorial diagrams, tables, graphs and mathematical equations. This is important considering that to understand physics concepts, it is not enough just to memorize them because concepts in physics need to be explained in various kinds of representations. The display of various representations can help students understand the concepts they are studying.
The use of multiple representations is important in physics learning to facilitate students with different intelligence backgrounds in understanding physics concepts (Mardatila et al., 2019; Van Meter et al., 2020). This is related to the abilities possessed by each student, there are those whose verbal abilities are more prominent than their spatial and quantitative abilities, but there are also those who have the opposite. If a concept is presented in only one representation, it will only benefit some students [Suhandi, 2012].

3.4 Evaluation Stage

The evaluation stage is the final stage carried out to evaluate the overall stages that have been carried out. Evaluation is carried out to provide value for the development of teaching materials in learning. At this stage, researchers analyzed the data from students' response questionnaires to determine their responses to the physics e-book being developed.

If there are still deficiencies in the e-book learning media, it will be revised again. To obtain response data, at the end of the learning process students are given a questionnaire to determine their response to the e-book they have studied. The results of student responses to the TPACK-based physics e-book are presented in **table 4** below.

Table 4. Student Response Data

No.	Komponen	Persentase
1	Ease of use of e-books	87 %
2	The attractiveness of the e-book content/features	80 %
3	Assisted learning using e-books	88 %
Total Average		85 %

The results of the analysis of student responses on the ease of use component of the e-book obtained a percentage of 87% in the very good category, indicating that the physics e-book is easy to use/accessed by students in the learning process using Android/smartphone. In the attractiveness component, a percentage of 80% was obtained in the good category. Furthermore, in the learning assistance component using e-books, a percentage of 88% was obtained in the very good category, so it can be stated that the physics e-book that was developed really helps students understand the concepts presented and helps the learning process. Based on these results, it can be concluded that the TPACK-based Newton's laws of physics e-book is very good for use in the learning process to increase students' understanding of concepts and create interesting and meaningful learning.

This is supported by the results that shows as android-based Mobile Learning is suitable for learning physics at the time of Distance Learning (PJJ) today because its more efficient use can be used anywhere and anytime, so there is no need to be confused when you want to repeat lessons that have been studied previously (Aprilia, 2022).

4. CONCLUSION

The results of the research show that the physics e-book on Newton's laws of motion based on Technological Pedagogical Content Knowledge (TPACK) is in the feasible category after going through the development and expert validation

stages with a feasibility value of 88. This is supported by the results of the e-book content comprehensibility test which was obtained at 86.41 with high category. Likewise, the results of student responses regarding the ease and helpfulness of e-books in the learning process were 85% in the very good category. The resulting physics e-book can be used as a medium to improve students' multi-representational abilities and conceptual understanding because the content in the e-book is presented in various forms of representation so that it can facilitate all students with various learning styles and levels of cognitive ability.

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