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Didaktika: Jurnal Kependidikan Vol. 13 No. 4 Nopember 2024

Development of TPACK-Based Electronic Magazine Physics Teaching Materials to Enhance Technology Literacy of High School Students

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Abstrak

This study aims to design Physics teaching materials in the form of an electronic magazine based on TPACK to enhance technological literacy among high school students (SMA/MA) in Banda Aceh. The materials are intended to be feasible, valid, and practical. The study employs Research & Development methodology using the Alessi and Trollip development model. The subjects of the electronic magazine trial were 30 eleventh-grade students from SMA/MA in Banda Aceh. The feasibility assessment instrument for the electronic magazine was validated by six media expert validators and six content expert validators. The practicality assessment instruments consisted of teacher response questionnaires and student response questionnaires. This development research was completed through several stages of product revision, ensuring that the developed magazine is valid and practical for use in teaching. The feasibility of the electronic magazine was determined to be in the "very feasible" category, based on an average score of 4.42 or 88.56% from the media expert validators, and an average score of 4.41 or 88.27% from the content expert validators. This is supported by the results of the teacher response analysis, which was very positive with a score of 90.56%, and further confirmed by an average positive student response score of 87.35%. This indicates that the development of the Physics teaching materials in the form of an electronic magazine based on TPACK to improve technological literacy among high school students in Banda Aceh is feasible and practical for use in teaching.

Key word: Teaching Materials, Electronic Magazine, TPACK, Technological Literacy, Feasibility Test, Practicality Test

Introduction

Technological literacy has become a trending topic in the education world in the era of Artificial Intelligence in 2023. It is crucial for students to have technological literacy competence and understanding as basic knowledge to face the digital transformation era(Kurniadi et al. 2023). According to an OECD (Organization for Economic Co-operation and Development) survey, the average literacy level of Indonesian students ranked 72nd out of 74 countries between 2019 and 2023. This indicates a very concerning literacy level among students (Hidayah, 2017; Fauji, 2023).

Education in the digital transformation era demands that students acquire new competencies to navigate a rapidly evolving world (Kadıoğlu-Akbulut et al. 2023). Students are required to be selective in independently implementing technology integrally, analyzing information and knowledge, using software, and being responsive in problem-solving while upholding the values of digital ethics (Ramdhayani 2023). On the other hand, teachers must be able to develop multi-interactive and technology-integrated teaching materials, enhance pedagogical knowledge, and deepen content in every teaching material. Therefore, the

development of teaching materials based on Technological Pedagogical Content Knowledge (TPACK) to improve students' technological literacy is essential **(**Helsa, Yullys et al, 2023).

TPACK-based teaching materials can be developed by emphasizing teaching activities that provide access to technological knowledge as a tool to enhance students' (Eloho Ifinedo 2021) technological literacy through interactive multimedia software, educational video links, and other supporting resources. The teaching materials can be packaged in a way that attracts students' interest, one of which is by using electronic magazines (Utomo et al, 2022). The use of electronic magazine-based teaching materials can improve students' learning outcomes(Siska, Juliani 2022). Electronic magazines contain content and images packaged in an attractive, simple format, providing educational information that broadens students' knowledge (Jariati dan Yenti 2020).

Recent literature reviews indicate that one of the continually evolving fields in education is physics. Physics, which examines abstract phenomena and facts found in nature, requires supportive tools for learning (Perdana Fengki Adie, Zakariah, Alasmari, dan Rassy 2023). Historically, students have understood physics primarily through formulas without grasping the basic concepts of physics (Darmaji et al. 2022). Students still have the mindset of studying physics based on formulas(Bellová, Melicherčíková, dan Tomčík 2018). Physics education involves mathematical operations such as algorithms, fractions, linear expansions, and derivatives, which students often find challenging when solving mathematical problems (Awaliyah, 2019).

This is evidenced by an initial survey on Physics education among several high school students in Banda Aceh, who reported difficulties in understanding learning materials that rely heavily on complex formulas. Students showed a lack of interest in learning physics, which they perceived as abstract, and the theories studied were mainly based on the provided textbooks. The success of physics education can be influenced by students' abilities to find solutions, analyze information, and utilize technology. Additionally, the success of teachers in developing teaching materials that engage students and improve technological literacy through applied teaching materials is crucial. The development of TPACK-based electronic magazine physics teaching materials is one alternative solution.

The objectives of this study are (1) To design TPACK-based electronic magazine physics teaching materials to improve technological literacy among high school students (SMA/MA) in Banda Aceh. (2) To assess the feasibility of TPACK-based electronic magazine physics teaching materials for improving technological literacy among high school students (SMA/MA) in Banda Aceh. (3) To test the practicality of TPACK-based electronic magazine physics teaching materials for improving technological literacy among high school students in Banda Aceh.

Method

This study employs Research and Development (R&D) based on the development model created by Alessi and Trollip. The model includes three primary stages: Planning, Design, and Development. These stages are integrated into a single teaching material, emphasizing the use of technological knowledge as a tool to aid in the understanding of abstract Physics concepts. This is achieved through interactive multimedia software, educational video links, and virtual laboratories, all packaged in line with student trends to enhance technological literacy skills.

The data collection instruments in this study consist of expert validation sheets for Media and Content, as well as teacher and student response questionnaires used during the trial

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process. The subjects of the electronic magazine trial were 30 eleventh-grade students from SMA/MA in Banda Aceh. The feasibility assessment instrument for the electronic magazine was validated by six media expert validators and six content expert validators. The practicality assessment instruments included teacher and student response questionnaires. The criteria for feasibility and practicality can be found in Tables 1 and 2.

Table 1. The Eligibility Criteria for Learning Media

Percentage	Value scale	Interpretation
81% ≤ Skor ≤ 100%	5	Very feasible
61% ≤ Skor ≤ 80%	4	feasible
41% ≤ Skor ≤ 60%	3	Quite feasible
21% ≤ Skor ≤ 40%	2	Not feasible
0% ≤ Skor ≤ 20%	1	infessible

(Sugiyono, 2014)

Tabel 2. Criteria for the Practicality of Learning Media

Percentage	Interpretation
85,00% ≤ Vp ≤ 100%	Veery practical
70% ≤ Vp ≤ 85%	practical
50% ≤ Vp ≤ 70%	Less practical
01% ≤ Vp ≤ 50%	Not practical

(Sugiyono, 2014)

Results

Design of TPACK-Based Electronic Magazine Physics Teaching Materials to Enhance Technological Literacy Among High School Students (SMA/MA) in Banda Aceh

The design of the teaching materials in this study is based on the development model created by Alessi and Trollip, which is limited to the following three stages:

1. Needs Analysis and Scope Determination

The needs analysis was conducted based on the results of initial observations and interviews regarding the challenges and difficulties in understanding certain abstract Physics concepts, as well as the level of technological literacy among high school students (SMA/MA) in Banda Aceh. This was done to determine the scope of the teaching materials to be developed and to analyze the appropriate content. This stage also involved analyzing the students' issues, characteristics, and the teaching methods used by teachers to enhance technological literacy during the learning process.

The following are some of the findings that form the basis for developing TPACK-based electronic magazine Physics teaching materials to enhance technological literacy among high school students in Banda Aceh.

Table 3. Stages of Needs Analysis

Determining the Scope	Identifying Learners	Material Analysis	Brainstorming with Subject Teachers
a. Targeting Eleventh-Grade High School Students (SMA/MA) b. Teachers' proficiency with technology varies. c. Teachers are required	a. Students are not enthusiastic about Physics learning. b. Students face difficulties with abstract Physics concepts,	a. There is a need for the development of teaching materials integrated with technological access, aligned with students' interests	TPACK-integrated learning media is needed to enhance students' technological literacy.

to have the ability to design and develop more interactive materials integrated with technology, in line with advancements in the field of education.	necessitating the use of visualization tools and virtual understanding, such as virtual labs, educational videos, and other artificial media.	and trends in digital media usage, as a cohesive and integral part of the curriculum. Learning should not be limited to textbooks, which can sometimes be monotonous.
d. There is a lack of teaching materials and the use of technology-integrated learning media in schools.	c. Technological literacy and students' understanding of social media ethics vary.	b. The use of teaching materials integrated with social media platforms makes it more engaging for students to understand difficult concepts.
e. With the advent of Artificial Intelligence in education, there needs to be a balance between understanding technological literacy and developing students' character and digital ethics in the use of technology through technology-based learning media.	d. The use of ChatGPT, Bing AI, ChatSonic, You.Com, Perplexity, etc., by students to complete assignments has not been accompanied by an increased understanding of the ethical implications and issues of plagiarism.	c. A TPACK-integrated electronic magazine serves as a teaching material that includes content, images, audio, video, and social media links, all presented in an appealing format that facilitates students' understanding of concepts.
f. Teachers are increasingly limiting and reducing the amount of content material.	e. Technological literacy impacts students' accuracy in accessing learning resources.	

Based on the needs analysis, several findings have formed the basis for developing Physics teaching materials in the form of an electronic magazine to enhance technological literacy among high school students (SMA/MA) in Banda Aceh. The era of Artificial Intelligence has brought significant changes to the education sector, making it a focus for educators seeking various solutions. Education should not only concentrate on improving technological skills but must also be accompanied by digital ethics in every learning material, especially in Physics

2. Design and Development

In this stage, the developer creates the conceptual framework for the magazine, prepares teaching materials, and sources content from various available resources. This stage also involves designing the layout, including font selection, color schemes, image placement, educational video links, and creating a storyboard by designing appropriate templates. The developer then proceeds with the development of the electronic magazine based on the drafted design. The components and elements are designed using Canva and compressed into a PDF format to produce the anticipated prototype of the Physics electronic magazine. Below are some examples of the developed electronic magazine:

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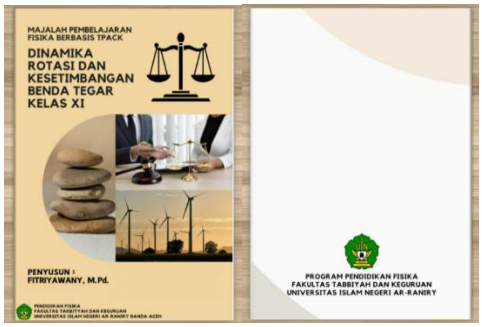


Figure 1. Front Cover and Back Cover



Figure 2. Magazine Description Page and Usage Instructions

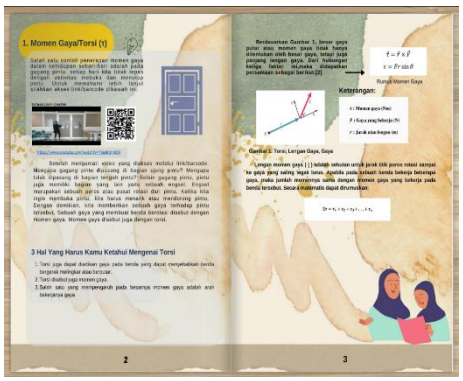


Figure 3. Material Page Layout

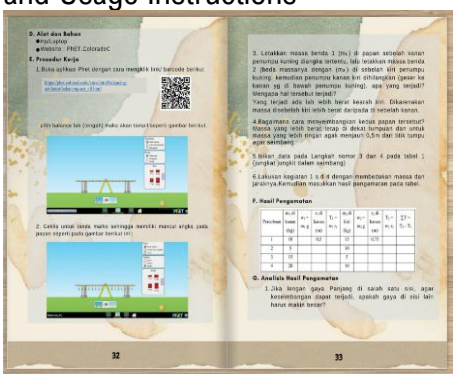


Figure 4. Student Worksheet Layout

Product Feasibility Assessment of TPACK-Based Electronic Magazine Physics Teaching Materials to Enhance Technological Literacy Among High School Students (SMA/MA) in Banda Aceh

The feasibility of the teaching materials in this study is determined based on the assessments of expert validators. The validators include 6 media experts and 6 content experts. These experts completed validation forms and evaluated the prototype of the electronic magazine that had been developed. The feasibility assessment aims to obtain feasibility scores, validity levels, and suggestions and feedback from the validators.

The validation process occurs in several stages. First, the validators assess the product from both media and content perspectives. Second, during the validation process, revisions are made based on the suggestions and feedback provided by the validators. Third, a trial phase is conducted with several students and teachers. During this trial, additional suggestions and feedback from students and teachers are collected, and the developer revises the product accordingly. The developer makes iterative improvements until the product is deemed feasible and valid for use in teaching. The results of the feasibility assessment of the TPACK-based electronic magazine Physics teaching materials for enhancing technological literacy among high school students (SMA/MA) in Banda Aceh can be analyzed as follows.

a. Feasibility of TPACK-Based Electronic Magazine Physics Teaching Materials for Enhancing Technological Literacy Among High School Students (SMA/MA) as Assessed by Media Experts.

Evaluation by media experts was reviewed in terms of the electronic magazine's design, including its visual appearance and programming aspects. There are seven (7) evaluation criteria for the visual appearance: design, text/typography, images, animation, video, and packaging. For the programming aspect, there are two (2) criteria: usability and navigation.

Six (6) media validators were involved, consisting of four (4) lecturers from the Physics Education Program, Faculty of Tarbiyah and Teacher Training, UIN Ar-Raniry Banda Aceh, and two (2) high school Physics teachers in Banda Aceh.

The evaluation process was conducted based on a weighted scale on the evaluation items by marking a checklist on the corresponding scale column in the attached instrument. After assigning the evaluation weights, the validators provided feedback and suggestions on the developed electronic magazine product. The researcher converted the data into percentage values and calculated the average score of the validation results. The data were analyzed using descriptive qualitative analysis techniques. The following is the media expert evaluation instrument presented in Table 4.

Table 4. Feasibility Validation Data by Media Expert Validators

Aspek Penilaian	**Prosentase Kelayakan**	**Kriteria Penialain**
Display aspects	89,33	Very veasible
Programming aspects	87,78	Very veasible
average score	**88,56**	Very veasible

(Data processed in 2024)

Based on the media expert validation data in Table 4., the media's feasibility is classified as very feasible (88.56%) with the average score from all six validators referring to the feasibility criteria in Table 1. Thus, the TPACK-based electronic magazine for enhancing technology literacy among high school students is deemed suitable for use as a Physics teaching medium in schools. The highest feasibility assessment percentage is in the visual appearance aspect, at (89.33%) with a 'very feasible' rating

b. Feasibility of the TPACK-Based Electronic Magazine and PhET Simulation on Rotational Dynamics and Rigid Body Balance as Evaluated by Subject Matter Experts

Evaluation by subject matter experts is based on the content of the developed electronic magazine. This assessment aims to determine whether the electronic magazine is developed according to the completeness of the material's substance, the currency of the content, the accuracy of data and facts, adherence to proper language and linguistic norms, and alignment with valid literature, making it suitable for use as teaching material. There are six (6) subject matter validators, consisting of four (4) lecturers from the Physics Program and two (2) high school Physics teachers in Banda Aceh. The following is the subject matter evaluation instrument presented in Table 5.

Table. 5. Subject Matter Expert Validation Data

Assessment Aspect	**Feasibility Percentage**	**Assessment Criteria**
content feasibility aspects	90,37	Very veasible
Display feasibility aspects	87,78	Very veasible
Language Aspects.	86,67	Very veasible
Average Score	**88,27**	Very veasible

(Data processed in 2024)

Based on the validation data from media experts in Table 5., the material's feasibility is classified as very feasible (88.27%), with the average score from all three validators referring to the feasibility criteria in Table 1. This indicates that the TPACK-based electronic magazine for enhancing technology literacy among high school students is suitable for use as a Physics teaching medium in schools. The highest feasibility assessment percentage is in the Material Presentation aspect, at 90.37%, with a 'very feasible' rating. This is followed by the Feasibility

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of Presentation aspect, which also received a 'very feasible' rating (87.78%), and finally, the Linguistic Accuracy aspect of the material, which received a 'very feasible' rating (86.67%)

The results of this study are consistent with the research conducted by (Srikandi et al. 2019), (Handika et al, 2022), Prasetyaningsekti et al, 2022), and (Nabila et al. 2024) with the results of the research on the development of the electronic magazine obtaining a feasibility score from subject matter experts with a valid rating.

c. Suggestions and Feedback from the Validators

There are several suggestions from the validators that have been implemented in the development of the TPACK-based electronic magazine Physics teaching materials to enhance technology literacy among high school students in Banda Aceh. Comments and criticisms were also received from the validators as input for revisions, particularly regarding grammatical errors and the misuse of foreign terms, increasing the number of images by enlarging them with an attractive layout, and adding links to learning resources.

The analysis results for the media aspect, starting with the layout/design, include two indicators: the appropriateness of the background selection for the cover material and the accuracy of the layout proportion. The evaluation by media experts for this indicator falls into the category of suitable for use without revision. The second aspect, text/typography, includes three indicators: the appropriateness of font selection for readability, the suitability of font usage, and the correctness of color usage. For the second indicator, it is recommended to choose more appealing fonts, especially in terms of font size selection. When selecting font colors, avoid overly contrasting colors or those that cause discomfort to the eyes. The third aspect, images, includes three indicators: image composition, image size, and image quality. Suggestions from the validators for this third indicator include ensuring good image quality with clear resolution, using more images that align with the content, selecting images that are easy for students to understand, revisiting image layout, and adding image captions. The fourth aspect is the use of video, which consists of two evaluation indicators: the appropriateness of video selection and content. The sixth criterion is packaging, which includes the attractiveness of the cover and the alignment of the title with the magazine cover. The evaluation by media experts for this indicator also falls into the category of suitable for use without revision.

The programming aspect consists of two components: usability and navigation. The usability aspect includes four evaluation indicators: user suitability, the ability to be used independently, completeness of technology usage instructions, and the appearance of usage instructions. Navigation and interactive links consist of two evaluation indicators: the appropriateness of navigation button usage and the effectiveness of interactive links. The evaluation results from the six validators indicate that the programming aspect is suitable for use in enhancing students' technology literacy.

For the material aspect analysis, the first suggestion from the validators is to increase the amount of material included in the electronic magazine by adding case study examples that can be applied in everyday life. This is done to make it easier for students to understand abstract concepts. Each piece of material presented should be accompanied by an explanation of its relevance to students' lives. The use of applications and knowledge source links related to the material should also be increased to enhance technology literacy. Additionally, it is necessary to correct some repetitive sentences and a few grammatical errors. The evaluation results from the six validators indicate that the material developed in the magazine is suitable for use in teaching

The practicality assessment of the teaching materials was obtained from the results of distributing questionnaires to teachers and students during the trial stages in the classroom. The teacher response questionnaire was distributed to six Physics teachers of 11th-grade high school students. There are six (6) indicators of the practicality of the teaching materials, which include: (1) the magazine's attractiveness for reading, (2) content alignment with learning indicators, (3) ease of use of application links and media in the magazine, (4) the magazine's content being easy to understand, (5) the logical sequence of material discussion according to the learning content, and (6) enhancement of technology literacy skills. The student response questionnaire contains thirty-four (34) statements across six (6) indicators regarding the practicality of using the magazine, distributed to 30 students. The following is the analysis of the practicality assessment of the developed teaching materials

a. Practicality Assessment of Teaching Materials Based on Teacher Responses

The practicality assessment based on the questionnaire responses from six teachers can be seen in Table 6 as follows.

Table 6. Practicality Assessment of Teaching Materials Based on Teacher Response Questionnaire Results

No	Practicality Indicator	Assessment	
		Percentage	Description
1	display practicality	85,56%	Very Practical
2	suitability of learning indicators	91,11%	Very Practical
3	Ease of Use of the Application	89,16%	Very Practical
4	Ease of Understanding Content	95,83%	Very Practical
5	Coherence of the Material	90%	Very Practical
6	Enhancing Technology Literacy	91,67%	Very Practical
Overall Average Score		**90,56%**	Very Practical

(Data processed in 2024)

Based on the teacher response test in Table 6 the average actual score of the practicality assessment for the developed teaching materials falls into the 'very practical' category (90.56%). Teachers gave positive feedback on the ease of understanding the content and material, with the highest score among all indicators. The highest teacher response was on the indicator of ease of understanding the content within the magazine, with a response percentage of 96%. Nevertheless, the assessment results for the indicator of enhancing technology literacy skills also fall into the 'very practical' category (92%). Based on this assessment, it can be concluded that the practicality assessment of the teaching materials, based on the results of the teacher response test, shows that they are practical for use as a Physics teaching medium in schools. Thus, the TPACK-based electronic magazine Physics teaching materials aimed at improving technology literacy among high school students can be implemented as a learning medium.

b. Assessment of Teaching Material Practicality Based on Student Responses

The practicality assessment of the teaching materials based on student responses was conducted during the trial phase in the classroom. The trial involved 30 students who filled out response questionnaires during the learning process. Students were given the opportunity to operate the electronic magazine and provide their assessments on the response sheets distributed during the trial process.

Table 7. Assessment of Teaching Material Practicality Based on Student Response Questionnaire Results

No	Practicality Indicator	Assessment

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		Percentage	Description
1	Display practicality	86%	Very Practical
2	Ease of Understanding Content	86,76%	Very Practical
3	Ease of Use of the Application	87,67%	Very Practical
4	Coherence of the Material	87,55%	Very Practical
5	Enhancing Technology Literacy	89,27%	Very Practical
6	Digital Ethics	86,83%	Very Practical
	Overall Average Score	**87,35%**	Very Practical

(data processed in 2024)

Based on the practicality assessment data in Table 7. it shows that the development of the teaching materials based on student responses has an overall percentage of 87.35%, which falls into the 'very attractive' category. Students provided the highest responses for the aspect of enhancing technology literacy. The detailed data from the practicality assessment indicate that the designed teaching materials can improve technology literacy, with a rating of 'very practical' (89%). The percentage from the student response questionnaires shows that the electronic magazine teaching materials can enhance technology literacy. The percentage of student responses, based on the weighted rating scale, can be seen in Diagram 4 below..

Table 8. Recapitulation of Students' Response Results

Criteria of practicality		Percentage
Very Attractive	5	**37,8574**
Attractive	4	**62,1429**
Quite Attractive	3	0
Less Attractive	2	0
Not Attractive	1	0
Total	**100**	

(data processed in 2024)

Based on the practicality assessment data from student responses in Diagram 1.9, it shows that the developed teaching materials fall into the 'attractive' category. The percentage of students who rated the materials as 'attractive' is 62.74%, while those who rated them as 'very attractive' is 37.85%. Students provided positive feedback on the practicality of the teaching materials, indicating that the TPACK-based electronic magazine for enhancing technology literacy among high school students is practical for use as a Physics teaching medium.

In line with the study by (Jannah, et al 2022; Handika et al 2020; Alwi et al, 2020; Handika et al 2022), if the average practicality rating of the electronic magazine is above 85%, then the developed electronic magazine is considered very practical. Furthermore, [Author] explains that if the average practicality rating falls into a high category, the developed product aligns with instructional learning goals and meets the quality of content and material. The development of electronic magazine teaching materials in Physics can influence students' interest in learning, improve technology literacy, and elicit positive responses from students during the learning process. [Author] also notes that the attractiveness of the magazine's appearance significantly affects students' interest in reading. This attractiveness includes images in the magazine that visualize the material, engaging text presentation, and magazine layout that facilitates material comprehension. Several suggestions and feedback from students indicate that the use of magazine-based teaching materials should not be limited to rotational dynamics and rigid body balance but also cover other difficult-to-learn abstract Physics topics. Integrated technology in electronic magazines can enhance students' interest and responses in Physics learning in the classroom.

Discussion

The development of Physics teaching materials in the form of an electronic magazine based on TPACK has been proven to improve the technological literacy of high school students in Banda Aceh. The technology-integrated electronic magazine enhances students' interest and responses in physics learning in the classroom (Permana et al., 2024; Haafida & Nur Diyana, 2023; Sulisworo et al., 2019). This experience is shared by all students during the learning process. Each student has the opportunity to use technology, filter information, and access learning resources independently. The preparation of the magazine in the form of a soft file integrated with links to learning media and virtual laboratories makes it easier for students to understand the material. According to Hardanti et al. (2024), the development of TPACK-based teaching materials is an innovative approach that incorporates knowledge of technological literacy to support the achievement of learning objectives, thereby engaging students in creating meaningful learning experiences. The structured application of technology in understanding learning materials, with content that suits students' needs, is essential. In line with research by Setiyadi et al. (2019), critical thinking skills, language learning skills, and skills in speaking, listening, and reading can be enhanced with the help of digital technology. Students' digital technology skills must be balanced with the cultivation of technological literacy values in schools. Introducing digital literacy early is crucial to help students become wise in accessing digital information systems. Students should not only be able to distinguish between sites they should access and those they should avoid, but they should also internalize digital ethics. These ethics involve using technology wisely, maintaining confidentiality, respecting intellectual property, and avoiding plagiarism in education.

The TPACK concept, which is applied in the development of this magazine, has been proven to create effective and efficient learning experiences in the digital era. During the learning process, students are able to access a wider range of information, not only through the learning media links presented in the electronic magazine but also by finding various learning resources through social media platforms (Facebook, Instagram, and TikTok), using artificial intelligence tools such as ChatGPT, Bing AI, ChatSonic, You.com, Perplexity, and other websites. Students can expand their knowledge by accessing available data in a wise and ethical manner. Furthermore, students are able to guide their peers in socializing the technology they have acquired and collaborate with interdisciplinary knowledge, thereby enhancing their ability to utilize technology at every stage of scientific learning.

During the implementation process in the classroom, teachers can integrate ICT (Information and Communication Technology) components within each aspect of TPACK. The results of this study align with Kadıoğlu-Akbulut et al. (2023), who state that the TPACK components are integrated differently into ICT competencies depending on the teacher's ability to collaborate. The skills required to use ICT are influenced by the diverse TPACK competencies of the teacher. Through this electronic magazine, teachers can apply the integration management of TPACK and ICT to create a comprehensive ICT-TPACK SCIENCE framework during the learning process. This integration allows teachers to effectively combine various digital resources and collaborate using the electronic magazine teaching materials. Throughout the learning process, teachers introduce various technologies related to the content, guiding and directing students in the use of technology. The use of the electronic magazine helps teachers deliver information comprehensively as an alternative media that attracts students' interest, enhancing reading and learning motivation (Haafida & Nur Diyana, 2023). The presence of a TPACK-based electronic magazine offers many benefits in improving

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the technological literacy competencies of both teachers and students. Teachers can make the teaching and learning process more enjoyable, facilitate the management of available resources, provide wider access to education, and ultimately improve the quality and standards of classroom learning.

Conclusion

Based on the results of developing TPACK-based electronic magazine Physics teaching materials to enhance technology literacy among high school students in Banda Aceh, the following conclusions can be drawn:

1. The design of the development of TPACK-based electronic magazine Physics teaching materials to enhance technology literacy among high school students in Banda Aceh was carried out through three stages: the first stage is planning, the second stage is design, and the third stage is development. The output of this research is a Physics teaching material in the form of an electronic magazine on the topics of Rotational Dynamics and Rigid Body Balance.
2. The feasibility assessment of the TPACK-based electronic magazine Physics teaching materials for enhancing technology literacy among high school students in Banda Aceh is classified as very feasible based on expert validation results. The overall average feasibility score from media experts is 4.43, with a feasibility percentage of 88.56%. The assessment of the material aspect has an average score in the feasible category of 4.41 (88.27%).
3. The practicality assessment of the TPACK-based electronic magazine Physics teaching materials for enhancing technology literacy among high school students in Banda Aceh shows that both teachers and students gave positive responses regarding the practicality of the teaching materials. This is supported by the very positive analysis of teacher responses with a score of 90.56% and confirmed by an average positive student response score of 87.35%. The percentage of student responses indicates that the electronic magazine teaching materials can enhance technology literacy.
4. This indicates that the development of TPACK-based electronic magazine Physics teaching materials for enhancing technology literacy among high school students in Banda Aceh falls into the category of being both feasible and practical for use in teaching.

Suggestions

Based on the conclusions of the research and discussion, the researcher suggests that this study could be further developed with other materials by enhancing the use of interactive learning software to improve students' understanding of technology literacy in education.

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