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Needs Analysis to Develop Sound Waves Interactive Multimedia Teaching Material to Promote Student's Conceptual Understanding and Technological Literacy

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ABSTRACT

The rapid development of technology has brought significant changes in the world of education. Students are expected to be able to understand technology in learning. Based on observations conducted at SMAN 3 Solok, several problems were found in physics learning, including the limited availability of interactive digital teaching materials and low technological literacy and conceptual understanding of students. To address this, a needs analysis stage was conducted with a Research and Development (R&D) approach using the Hannafin and Peck model. Data were obtained from teacher questionnaires in the form of teaching material use, student questionnaires to determine student characteristics, technological literacy performance assessment sheets in the form of questions according to technological literacy indicators, and learning outcome documents to see student conceptual understanding. The results of the analysis showed that the teaching materials used were not yet technology-based, students' technological literacy skills were low, and student scores were still below the minimum completeness criteria. Based on these data, it is necessary to develop interactive multimedia teaching materials that integrate conceptual understanding and technological literacy.

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INTRODUCTION

The world has now entered the era of the 4.0 industrial revolution. This era is characterized by increased connectivity, interaction, and the development of digital systems, artificial intelligence, and virtual reality. With the increasingly converging boundaries between humans, machines, and other resources, information and communication technology has undoubtedly impacted various sectors of life. One such impact is the education system in Indonesia (Lase, 2019).

Rapid technological developments have brought significant changes to the world of education. This technological development can be seen in the way learning materials are presented and delivered. Initially, traditional learning methods centered on lectures and memorization were the primary approach in various fields (Hayati, 2020). However, this

traditional, conventional learning approach is shifting toward digital-based learning that is more interactive, adaptive, and contextual.

In the era of the Industrial Revolution 4.0, everyone is expected to possess technological literacy skills. Technological literacy is the ability to understand the components of technology, such as hardware and software, as well as the ethics and etiquette of using technology (Nuraini et al., 2022). The current digital transformation has shifted the educational paradigm from a conventional system to technology-based learning that is more flexible, adaptive, and interactive. The use of technology serves not only as a tool but also as a means to create meaningful and contextual learning experiences for students. The integration of technological literacy into physics learning can encourage students to be more active, creative, and reflective in exploring scientific phenomena through various digital resources and interactive simulations.

The Industrial Revolution 4.0 era must be faced and responded to by developing creative, innovative, and competitive students. Efforts include studying and mastering technological applications to ensure educational progress is not hampered (Lase, 2019). The use of software, interactive applications, and online learning platforms now opens up new opportunities to integrate technology with the learning process (Rahmawati, 2024). Through this technology, students can access learning resources anytime and anywhere, and collaborate virtually. Teachers are also required to design innovative learning by utilizing various digital resources to make learning activities more engaging and relevant to current developments.

The use of technology plays a crucial role in learning. Technology facilitates education by acting as a medium that facilitates online interactions between students and their educators (Salsabila et al., 2020). Educators must capitalize on the challenges and opportunities of the 4.0 era, adapt to various changes, and be ready to serve millennial students in terms of pedagogy, digital skills, basic literacy, technological literacy, humanistic literacy, and strengthening character education and life skills (Nuraini, 2022). Technological literacy is still lacking, resulting in the underutilization of existing information and communication technology (ICT) facilities to support the learning process (Primayana, 2019). Students' technological literacy skills can be seen from four indicators: understanding the advantages of various technologies, utilizing multimedia features in learning, using technology when searching for sources related to learning materials, and accessing media such as virtual laboratories or learning resources (Greenstain, 2012).

As a branch of science that utilizes extensive mathematical representation, physics often presents a challenge for students in understanding its concepts. Physics is still considered a difficult subject, from elementary school science lessons to advanced levels (Wahyudi, 2024). Physics is a scientific product formed from a series of laws of natural phenomena, usually presented in mathematical equations (Fauzi, 2015). Mathematical modeling of natural phenomena can make it difficult for students to grasp the concepts (Permatasari, 2021). One important topic in physics learning, sound waves, is often considered difficult by students because it involves many interrelated equations (Sulistyarini, 2015). This difficulty arises because students must not only memorize formulas but also understand their physical meaning, such as the relationship between speed, frequency, wavelength, intensity, and the Doppler effect.

The Industrial Revolution 4.0 era supports students in improving their conceptual understanding. Conceptual understanding is the ability to understand a concept theoretically and its application to solve a problem. Through good conceptual understanding, students will be able to explain physical phenomena scientifically and apply a concept in a real and contextual way to solve existing problems (Rivai, 2018). Current field conditions indicate that students' conceptual understanding is still low. Pre-research data on

7 questions on sound waves material out of 30 questions in the Final Semester Assessment (PAS) for the even semester of 2020 shows that learning achievements that meet the Minimum Completion Criteria are 14 students out of 21 students. The average student score is 76.95 with a score range of 0-40 for 1 student, a score of 41-71 for 6 students, and a score of 72-100 for 14 students (Faisal, 2022). Low learning outcomes indicate low learning motivation among students (Putri, 2015). In this context, innovative strategies or teaching materials are needed to help students understand the concept of sound waves in a more concrete, contextual, and meaningful way, so that they can improve their motivation and learning outcomes.

The development of interactive multimedia teaching materials is a strategic effort to improve the quality of the learning process and outcomes of students. Based on observations in the 7th grade science class at SMPN 6 Yogyakarta, it was found that the use of discussions, lectures, and practice using textbooks and PowerPoint media was the teacher's preferred choice. However, observations showed that some students were less interested when the teacher began explaining, and sometimes they were unable to respond well during the discussion (Fahlevi, 2024). One study conducted by Resti Cahyaningsih (2016) found that the developed interactive multimedia teaching materials could increase student motivation, with an average score of 4.6, which is included in the good category. Interactive multimedia teaching materials enable the integration of text, images, animation, audio, and video in a mutually supportive unit, so that the material can be presented in a more interesting and easy-to-understand manner. Through this approach, students are not only recipients of information, but also active subjects in the learning process, where they can explore, interact, and construct their own understanding. Thus, interactive multimedia teaching materials have great potential to support technology-based learning that is aligned with the demands of the Industrial Revolution 4.0.

In addition, interactive multimedia teaching materials can increase students' interest in learning. Interactive multimedia teaching materials not only contain text and images that we usually find in conventional teaching materials, but also contain audio, animation, and video that make students not feel bored (Pribadi, 2017). Interactive multimedia in the use of teaching materials in the learning process can increase new desires and interests, arouse motivation and stimulation of learning activities, and even bring psychological influences on students (Supardi, 2014).

However, before developing interactive multimedia teaching materials, a comprehensive needs analysis is required to ensure that the developed product truly suits the characteristics of students and the learning context in schools. This needs analysis includes identifying problems in the ongoing learning process, gaps between expectations and learning reality, and the needs of teachers and students for relevant and engaging media. Thus, this study aims to analyze the needs in the development of interactive multimedia teaching materials on the topic of sound waves that not only focus on improving the understanding of physics concepts, but also on strengthening students' technological literacy as provisions in facing the challenges of education in the digital era.

METHODS

This research includes R&D method research using the Hanaffin and Peck model. The Hanaffin and Peck model is a product-oriented learning design model (Kustandi, 2020). The Hanaffin and Peck model is a learning design model for producing products such as learning media (Karim, 2021). The Hanaffin and Peck development model consists of three stages: (a) needs analysis; (b) design; and (c) development and implementation. This model focuses on developing effective media through problem identification, solution design, and

direct field trials.

In the needs analysis stage, researchers collected data related to the implementation of learning at SMAN 3 Solok carried out by teachers and students, especially regarding sound waves. According to Sugiyono (2013), data collection techniques are the most strategic step in research, because the main objective of the research is to obtain data. The data collection techniques used were questionnaires, performance assessment sheets, and learning outcome documents. The research subjects consisted of physics teachers and grade XI students of SMAN 3 Solok.

The first analysis was the use of teaching materials. The instrument used was a questionnaire. The questionnaire was distributed to physics teachers. This instrument contained four indicators: utilization of computer advantages, utilization of multimedia technology, utilization of electronic technology, utilization of independent teaching materials, and utilization of data exchange.

The second analysis was the student analysis, which consisted of an analysis of student characteristics, students' conceptual understanding, and students' technological literacy skills. The analysis of student characteristics was conducted by distributing questionnaires to 11th-grade students, which included four indicators: interest, motivation, background, and learning style. The analysis of conceptual understanding was carried out through an analysis of students' learning outcome documents. The documents analyzed were the daily test results of 11th-grade students in the subject of sound waves.

The analysis of students' technological literacy skills was conducted using a performance assessment sheet that included four indicators: (1) understanding the advantages of various technologies, (2) use of multimedia features in learning, (3) use of technology when searching for learning-related resources, and (4) accessing media such as virtual laboratories or learning resources (Greenstain, 2012).

The results of this analysis were used as a consideration in developing interactive multimedia teaching materials. The data analysis technique used in this study was descriptive statistical analysis. Descriptive statistics were used to describe research variables obtained through measurement results. The data were collected through closed-ended questionnaires. To determine the position of each variable, descriptive percentage analysis was used (Sudjana et al., 2009).

The collected data were then analyzed using a Likert scale as follows:

Table 1. Indicators of Likert Scale Variables

Indicator	Score
Very Poor	1
Poor	2
Fair	3
Good	4
Very Good	5

The percentage for each indicator was then calculated using the following formula (Ali, 2013):

$$P = \frac{n}{N} \times 100\%$$

Explanation:
P : Percentage
F : Sum of a Particular Item
N : Sum of the Maximum Score for a Particular Item

Based on the obtained scores, the results can then be categorized according to the level of achievement as presented in Table 2 below.

Tabel 2. Kategori Analisis Kebutuhan

NO	Category	Interval
1	Very Poor	0%-20%
2	Poor	21%-40%
3	Fair	41%-60%
4	Good	61%-80%
5	Very Good	81%-100%

(Riduwan, 2015)

RESULTS AND DISCUSSION

The first analysis was the analysis of teaching materials. The instrument used in the analysis was a questionnaire given to teachers. Based on the analysis results, the instrument's responses to teachers' questions regarding the use of teaching materials can be seen in the following table:

Table 3. Teaching Material Analysis

Indicator	Result	Category
Utilization of computer advantages	30%	Poor
Utilization of multimedia technology	27%	Poor
Utilization of electronic technology	35%	Poor
Utilization of self-directed teaching materials	48%	Fair
Utilization of data exchange	36%	Poor

Based on Table 3, the results of the analysis of the teaching material context show that the overall utilization of technology is still in the low category. In the aspect of utilizing computer advantages, a score of 30% was obtained, which falls into the "poor" category. This indicates that the teaching materials have not been optimal in utilizing computer capabilities to support learning interactivity. Features such as computer-based exercises, simulations, or automatic assessments have not been maximized, so the potential of computers to enrich the learning experience has not been fully utilized.

Meanwhile, for the indicator of multimedia technology utilization, the result was 26%, categorized as "poor." The teaching materials have not yet integrated many multimedia elements such as images, audio, video, or animations that can clarify the content and enhance the attractiveness of learning. The limited use of visual and auditory elements makes the learning process monotonous and less engaging for students. Therefore, future development of teaching materials should pay attention to integrating multimedia elements so that the material becomes more interactive and contextual.

Next, the indicator of electronic technology utilization received a score of 37%, also categorized as "poor." This value indicates that the teaching materials have not fully supported digital access through various devices such as computers, tablets, or smartphones. The format of the teaching materials is likely still conventional and not yet designed for online-based learning. To be more relevant to the needs of the Industrial Revolution 4.0 era, teaching materials need to be developed to be flexibly accessible across various digital platforms and to support distance learning activities.

Unlike the previous indicators, the utilization of self-instructional teaching materials obtained a score of 57%, categorized as "fair." This result illustrates that the teaching

materials have provided opportunities for students to learn independently, although not yet optimally. Further improvement is needed in the form of clearer learning instructions, more varied practice questions, and automatic feedback that helps students assess their own understanding. Strengthening this aspect will greatly support the enhancement of students' independent learning skills.

Finally, the indicator of data exchange utilization showed a score of 27%, categorized as "poor." This indicates that the teaching materials do not yet support activities such as information sharing, collaboration, or digital communication between teachers and students. In fact, data exchange is an essential aspect of modern learning to promote interaction, collaboration, and rapid information updates. Therefore, it is necessary to develop more interactive and collaborative teaching materials through the utilization of network technologies and online learning platforms.

Overall, the results of this analysis show that the teaching materials still need further development, especially in terms of computer utilization, multimedia integration, electronic technology, and support for digital data exchange. Although there has been progress in the aspect of independent learning, the overall integration of technology still needs to be strengthened so that the teaching materials can truly support modern, interactive, flexible, and technology-based learning.

The next step is to analyze students' understanding of technological literacy. The instrument used is a performance assessment sheet given to students at SMAN 3 Solok. Based on the analysis, the answers to students' understanding of technological literacy are shown in the following table:

Table 4. Technological Literacy of Students

Indicator	Result	Category
Understanding various technological advantages	50%	Fair
Understanding multimedia features in learning	39%	Poor
Using technology during the learning process	40%	Poor
Selecting and utilizing technology during learning	58%	Fair

Based on Table 4, it can be seen that for the indicator of understanding the various advantages of different technologies, a result of 50% was obtained, which falls into the "fair" category. This indicates that students already have basic knowledge of various technologies that can be used in learning, but they do not yet fully understand the specific advantages and functions of each technology. This is caused by teachers primarily using textbooks in teaching, which results in students being unaccustomed to seeing the potential of technology as a learning tool and viewing it mostly as a source of entertainment.

For the indicator of understanding multimedia features in learning, a result of 39% was obtained, categorized as "poor." Students do not yet understand how to use multimedia due to the limited integration of multimedia in learning activities. This indicates that students' understanding of multimedia features such as audio, video, animation, and interactivity is still limited. The lack of multimedia utilization has the potential to make the learning process less engaging and does not maximize the potential of technology. The analysis shows that students still rely primarily on textbooks and rarely use PowerPoint presentations, educational videos, or learning applications.

For the indicator of using technology during learning, a result of 40% was obtained, categorized as "poor." This shows that the use of technology by students or teachers in learning activities is still low. This may be caused by a lack of technical skills, limited resources, or a low habit of actively using technology in teaching and learning activities. Some technologies, such as social media and YouTube, are still rarely used by students as learning resources. Students mostly use social media and YouTube for entertainment

purposes.

Finally, for the indicator of selecting and utilizing technology during learning, a result of 58% was obtained, which falls into the "fair" category. This finding indicates a basic ability to select and use relevant technologies to support learning activities, although it still needs to be improved for more effective, varied, and content-appropriate usage. Technology can be used for communication and discussion with peers regarding learning assignments; however, students are still not accustomed to doing this through smartphones.

The low level of technological literacy among students is influenced by various factors. One of the main causes is the lack of habit in utilizing technology as part of the learning process. This reflects the suboptimal role of teachers in providing guidance and adequate support for technology use, so students are not yet accustomed to accessing and using interactive multimedia features that support technological literacy (Irwan, 2019). In addition, students' limitations in selecting and effectively utilizing technology during learning also contribute to their low technological literacy. This phenomenon aligns with observations in everyday life, as noted by Nurlaili (2023). As a result, students lack the literacy skills needed to solve real-world problems.

Student characteristics analysis was conducted by administering a questionnaire to students at SMAN 3 Solok. The student characteristics analysis included four indicators: interests, motivation, background, and learning styles. The data obtained can be seen in the following table:

Table 5. Student Characteristics

Indicator	Result	Category
Interest	35%	Poor
Motivation	56%	Fair
Learning Background	50%	Fair
Learning Style		
a. Auditory	54%	Fair
b. Visual	66%	Good
c. Kinesthetic	62%	Good

Based on Table 5, for the interest indicator, a result of 54% was obtained, which falls into the "fair" category. This indicates that most students have a moderate level of interest in Physics, particularly in the topic of sound waves. In other words, students have not yet fully demonstrated high curiosity, attention, and enjoyment in participating in learning. Nevertheless, there are indications that students possess initial interest, which can be further developed through more engaging, contextual, and interactive learning approaches. Therefore, efforts to increase learning interest are needed, for example through the use of relevant learning media, the implementation of experimental methods, or the connection of concepts to real-world phenomena so that students are more motivated and engaged in learning the material.

The data analysis shows that the learning motivation indicator obtained a percentage of 56%, which falls into the "fair" category. This indicates that most students have a moderate level of learning drive in participating in Physics lessons. That is, students already have the desire to understand the material and achieve good results, but their enthusiasm and effort are not yet optimal. Some students may still study due to external motivation, such as grades or teacher demands, rather than from their own awareness and desire to understand the material. This condition suggests that teachers need to foster students' intrinsic motivation through more engaging learning, relevant to real-life situations, and providing opportunities for students to be active and experience success in learning. In this way, students' learning motivation is expected to improve, thereby supporting more

optimal learning outcomes.

For the background indicator, the questionnaire analysis showed that students obtained a percentage of 50%, categorized as "fair." This indicates that the learning environment, family support, and facilities available to students are at a moderate level. Some students already have supportive learning environments and resources, while others still face limitations, such as a lack of learning facilities at home or minimal support from their surroundings. This condition can affect students' readiness and study habits in participating in Physics learning. Therefore, attention and efforts from educators are needed to adjust learning strategies to accommodate differences in students' backgrounds, for example by providing additional guidance, utilizing easily accessible learning resources, and creating an inclusive and supportive classroom environment for all students.

For the learning style indicator, the questionnaire analysis showed that students' learning styles were divided into three main tendencies: visual, auditory, and kinesthetic. Based on the data, the visual learning style obtained the highest percentage at 66%, categorized as "good," meaning that most students find it easier to understand material through visual displays such as images, diagrams, videos, or illustrations. Meanwhile, the kinesthetic learning style obtained a percentage of 62%, also categorized as "good," indicating that many students also prefer learning that involves direct activities, experiments, or hands-on practice. The auditory learning style obtained a percentage of 54%, falling into the "fair" category, showing that only some students find it easier to learn through listening to explanations or discussions.

The final analysis was conceptual understanding. The instrument used was student learning outcome documents. Based on the student learning outcomes, an average score was obtained, as shown in the following table:

Table 6. Student Learning Outcomes

Class	Average
XI F 1	42.32
XI F 2	49.12
Overall Average	**45.72**

Based on the analysis of student learning outcomes data, an average score of 45.72 was obtained. This score indicates that the level of students' conceptual understanding of the material being taught is still relatively low. These results indicate that most students have not been able to understand and apply Physics concepts optimally, especially in the material on sound waves. The low average score can be caused by several factors, such as interest and motivation to learn which are still in the sufficient category, differences in learning backgrounds, and diverse learning styles that have not been fully accommodated in the learning process. This condition indicates the need for the implementation of more effective and contextual learning strategies so that students can link concepts to real phenomena, so that their understanding of the material can increase significantly.

CONCLUTION

The results of the study indicate that the utilization of technology-based teaching materials is still considered inadequate, especially in the use of computers, multimedia, electronic technology, and data exchange, while independent teaching materials are only utilized adequately. Students' technological literacy is also not optimal, indicated by a limited understanding of the advantages of technology, multimedia features, and their use in the learning process. In addition, students' learning interests are in the low category, while their motivation and learning background are in the adequate category, with a

tendency towards varied learning styles including visual, kinesthetic, and auditory. Students' understanding of Physics concepts is also still low, indicating that they have not yet achieved a deep understanding of the material. Overall, these findings emphasize the need to improve the quality of learning through the development of interactive multimedia teaching materials so that students' technological literacy and conceptual understanding can be optimally improved.

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