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Needs Analysis for the Development of E-Student Worksheet on Measurement and Quantity Assisted by Web Wordwall Integrated with the PBL Model

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ABSTRACT

Education in Indonesia continues to transform with technology integration, yet its utilization remains suboptimal. This study analyzes the needs for developing a web-assisted E-Student Worksheet (E-SWS) using wordwall integrated with Problem-Based Learning (PBL), to enhance students' understanding of physics concepts and scientific process skills. The research employs the Educational Design Research method in the Preliminary Research phase. The subjects include 34 tenth-grade students from Sungai Tarab Public Senior High School 1, assessed through practical activities for scientific process skills, and 20 students surveyed to identify learning needs. Knowledge scores were taken from summative assessments on measurement and quantity topics. Questionnaire results show that 80% of students struggle with physics concepts, 90% require extended time for comprehension, and 60% need additional learning resources. All students use learning materials such as Student Worksheet (SWS), but only 70% have access to printed versions. The average knowledge score is 35, while scientific process skills score 57, indicating low comprehension. Teachers face challenges in implementing the independent curriculum due to limited training and resources. This study recommends developing an interactive PBL-based E-SWS to enhance student engagement, conceptual understanding, and scientific process skills.

INTRODUCTION

Education in Indonesia continues to undergo transformation with the integration of technology in learning. Ideally, technology can enhance learning effectiveness, facilitate access to information, and enable students to learn independently and flexibly (Wahyuni et al., 2021). To emphasize the importance of exploration and connecting concepts to real-world phenomena in enhancing students' understanding of physics, recent studies can be referenced. For example, Wiyono et al. (2024) explored physics concepts embedded in South Sumatera's local wisdom, aiming to develop students' 21st-century skills. They found that integrating local cultural elements into physics education can make learning more contextual and engaging, thereby improving conceptual understanding. Furthermore, scientific process skills are a crucial aspect of physics learning that should ideally develop through an approach that encourages exploration and problem-solving (Sari et al., 2020).

However, in reality, the utilization of technology in learning remains suboptimal. Although students have good internet access, not all learning materials effectively connect physics concepts to real-world phenomena (Rahman & Santoso, 2023). Learning is still teacher-centered, and most students struggle to understand the material and require additional learning resources (Putri et al., 2021). The available Student Worksheets (SWS) do not fully support independent learning, and only a small percentage of students have participated in interactive evaluations (Yulianti, 2020). Additionally, students' scientific process skills remain low, impacting their ability to observe, classify, conclude, and solve problems in physics learning (Saputra et al., 2019). This low level of scientific process skills correlates with poor academic performance in physics, indicating that students have not yet fully grasped fundamental concepts (Nasution & Siregar, 2021).

Research indicates that the development of teaching materials based on information and communication technology (ICT), which integrates local values and character, can enhance students' competence in physics (Asrizal et al., 2018). Moreover, the use of simulations and interactive applications in physics learning can improve students' conceptual understanding and learning motivation (Inggriyani & Pujawati, 2024). Therefore, the effective integration of technology in physics learning must continue to be improved to address existing challenges and enhance the quality of education. To address these issues, the development of more interactive and contextual electronic teaching materials is necessary. One potential solution is the development of a web-assisted E-SWS using Wordwall, integrated with the Problem-Based Learning (PBL) model. This approach not only enhances student engagement through interactive media but also helps them connect physics concepts with real-life applications. Moreover, the PBL model encourages students to think critically, collaborate, and develop their scientific process skills, ultimately contributing to a better understanding of physics concepts.

The digital era is a term used to describe the age of digital technology, in which digital age literacy is defined as the ability in a specific field that can be applied within this technological landscape. In education, digital literacy is essential for helping students adapt to technological advancements in learning (Asrizal et al., 2017). Several studies have demonstrated that integrating technology into learning, particularly through electronic teaching materials and innovative learning models, significantly enhances education quality. The use of technology facilitates access to information and improves learning effectiveness (Hidayat, 2021), while also fostering independent and flexible study habits that empower students to take control of their own learning (Sari, 2020). Additionally, interactive electronic teaching materials increase student engagement and support contextual learning, making lessons more meaningful and effective (Rahman, 2021). Aligning with this, the Independent Curriculum emphasizes conceptual exploration and its connection to real-world phenomena, enabling students to develop a deeper understanding of physics and improve their scientific process skills (Nugroho, 2021). Thus, the adoption of digital tools in learning not only enhances comprehension but also prepares students to meet the challenges of the modern technological era.

Learning has context, meaning that the learning material needs to be connected to real-world situations (Asrizal et al., 2018). This approach ensures that students can relate theoretical concepts to practical applications, making learning more meaningful and effective. Beyond technology integration, one instructional model that effectively supports this principle is Problem-Based Learning (PBL). The PBL model has been proven to help students bridge the gap between theory and practice while fostering critical thinking skills (Santoso, 2021). According to Arends (2019), PBL encourages students to explore real-world problems and develop solutions based on scientific concepts, reinforcing the importance of contextual learning. Research further indicates that PBL enhances conceptual understanding, as students actively construct their knowledge through inquiry-based learning (Hmelo, 2006). Additionally, implementing this model has been linked to improved analytical thinking and problem-solving skills, particularly in physics education (Schmidt, 2011). By integrating contextual learning with PBL-based instruction, students can develop a deeper understanding of concepts and enhance their ability to apply knowledge in real-world scenarios. This approach not only strengthens cognitive skills but also prepares students to tackle complex challenges beyond the classroom.

By integrating contextual learning with PBL-based instruction, students can develop a deeper understanding of concepts and enhance their ability to apply knowledge in real-world scenarios. This approach not only strengthens cognitive skills but also prepares students to tackle complex challenges beyond the classroom. In addition to conceptual understanding, students' scientific process skills are a crucial aspect of physics education. However, various studies have shown that these skills remain low (Rustaman, 2017). Scientific process skills include the ability to observe, classify, conclude, and apply scientific methods to problem-solving (Rahayu, 2021). According to Setiawan (2020), students' low scientific process skills result from the limited use of inquiry-based learning methods. This finding is supported by Fauzi (2021), who noted that conventional teaching methods tend to limit students' active participation in experiments and data analysis. Consequently, students struggle to develop a deep understanding of physics concepts and apply them to real-life situations (Widodo, 2020).

To overcome these challenges, using a web-assisted E-SWS with Wordwall can be a solution to improve students' scientific process skills. E-SWS allows the integration of various interactive media, such as simulations and online quizzes, which can enhance conceptual understanding and learning motivation (Prasetyo, 2020). Several studies have stated that digital E-SWS improves learning effectiveness, as students find it easier to understand material through engaging visual displays (Zainuddin, 2021). According to Rahmat (2022), web-based electronic teaching materials enable students to access learning independently and receive instant feedback, helping them better understand physics concepts. Additionally, research by Hakim (2023) indicates that using PBL-based E-SWS significantly enhances students' critical thinking and scientific process skills. Other studies have highlighted the potential of technology-based teaching materials in developing analytical thinking skills (Suryani, 2022). Furthermore, interactive learning approaches using technology can also boost students' motivation (Mahardika, 2023).

Based on these considerations, this study aims to analyse the needs for developing an E-SWS on measurement and quantity, assisted by Wordwall and integrated with the PBL model. This needs analysis is essential to ensure that the teaching materials developed align with students' characteristics and available resources. Additionally, a deeper understanding of students' learning needs will assist teachers in determining more effective teaching strategies. The findings of this study are expected to serve as a foundation for designing optimal educational products suited to current learning conditions, ultimately enhancing students' conceptual understanding of physics and their scientific process skills.

Furthermore, this study specifically aims to analyse the needs of students and teachers for Student Worksheets (SWS) in schools, identify the challenges faced by teachers in utilizing teaching materials in the classroom, and examine students' scientific process skills in physics learning. Understanding these aspects will provide valuable insights for developing more effective and accessible digital Student Worksheets that support independent learning and improve the quality of physics education.

METHODS

This study employs a Research and Development (R&D) methodology using the Educational Design Research model developed by Tjeerd Plomp. This model consists of three main phases: Preliminary Research, Prototyping Stage, and Assessment Phase (Plomp & Nieveen, 2013). The primary focus of this study is on the initial phase, Preliminary Research, which aims to identify user needs and characteristics as the foundation for developing instructional materials. This preliminary research stage serves as a guideline for designing and developing electronic learning materials that align with students' needs and learning conditions (Plomp & Nieveen, 2013).

The study was conducted in March 2023, involving tenth-grade students from Sungai Tarab Public Senior High School 1 for the 2023/2024 academic year as research subjects. A student needs questionnaire was administered to 20 students from different classes to gain a broader understanding of their preferences and challenges in learning physics. Additionally, 34 students participated in the assessment of scientific process skills, selected based on their prior knowledge scores. The study also involved physics teachers to gather insights into the requirements for developing more effective and interactive learning materials.

The research process began with a needs analysis through student questionnaire responses. This questionnaire aimed to identify students' difficulties in understanding physics concepts and their preferences for electronic learning materials. Following this, students' scientific process skills were assessed, correlating with their previously recorded knowledge scores. The next step involved interviews with physics teachers to explore challenges in teaching physics and their expectations for the development of instructional materials. To ensure consistency in the responses provided during the interviews, teachers were also given a questionnaire to evaluate their confidence in their answers.

The research instruments used for data collection included various tools: student questionnaires, scientific process skills assessment sheets, teacher interview sheets, and teacher questionnaires. The student questionnaire was used to determine their needs and preferences for electronic learning materials and was distributed to 20 students from different classes. The scientific process skills assessment sheet measured students' scientific thinking abilities, with 34 students selected based on their prior knowledge scores. Teacher interviews were conducted to obtain insights into the challenges of teaching physics, supplemented by a teacher questionnaire to assess their confidence in their responses.

The data analysis technique used in this study is descriptive analysis. Data obtained from the questionnaires, scientific process skills assessments, teacher interviews, and teacher questionnaires were analyzed both qualitatively and quantitatively to describe the needs of students and teachers for electronic instructional materials. The results of this analysis served as the basis for designing and developing a web-assisted E-SWS using Wordwall, integrated with the Problem-Based Learning (PBL) model. Through this approach, the study aims to provide a more comprehensive understanding of the learning needs in physics education and develop instructional materials that better align with students' characteristics and current learning conditions.

RESULTS AND DISCUSSION

Results

The preliminary research aims to identify field problems through a step-by-step data collection process. The first stage involves gathering students' knowledge data to assess their understanding of the concepts of quantities and measurements in physics. In the second stage, an assessment of students' scientific process skills is conducted, covering their ability to observe, classify, conclude, and solve problems based on previously obtained data. The third stage involves distributing a questionnaire to students to identify their needs regarding the instructional materials used and the challenges they face in understanding the subject matter. The fourth stage consists of teacher interviews to gain insights into the teaching methods implemented and the difficulties encountered in delivering the concepts of quantities and measurements. Subsequently, a teacher questionnaire is administered to measure the extent to which teachers are confident in their interview responses, ensuring more accurate data on the need for developing electronic instructional materials.

Analysis of Students' Knowledge and Scientific Process Skills

The analysis of students' knowledge and scientific process skills was conducted by assessing their knowledge scores and evaluating their skills during practical sessions. The purpose of this analysis is to determine the extent of students' understanding of the topic of quantities and measurements. This study was carried out with 34 students from Sungai Tarab Public Senior High School 1.

Table 1. Students' Knowledge Scores and Scientific Process Skills

No.	Statistical Parameters	Student Competence	
		Knowledge	Scientific Process Skills
1	Number of Students	34	34
2	Average Score	35	57
3	Mode	35	56
4	Median	35	57
5	Lowest Score	20	32
6	Highest Score	60	77
7	Range	40	45

Statistical data presents the analysis results of students' knowledge scores and science process skills in the topic of quantities and measurements. Knowledge scores were taken from the summative assessment of the topic, while science process skills were assessed during practical activities. Among 34 students, the average knowledge score was only 35, whereas the average science process skills score was higher at 57, yet both remained relatively low. The mode of the knowledge scores was 35, and the mode of science process skills was 56, indicating that the most frequently occurring scores in this group were relatively low. This suggests that the majority of students have weak theoretical understanding and science process skills. The median knowledge score was 35, and the median science process skills score was 57, meaning that half of the students scored below and half scored above these values. In other words, most students achieved unsatisfactory results in both theoretical and practical aspects.

The lowest and highest scores in knowledge assessment were 20 and 60, respectively, while in science process skills, they were 32 and 77. The range was wider for science process skills (45) compared to knowledge (40), indicating significant variation in students' practical performance. Overall, these findings suggest that students' understanding of theoretical concepts and their science process skills are still relatively low and have not reached satisfactory levels. Therefore, improvements in teaching methods are necessary to help students better understand theoretical concepts and enhance their science process skills.

Meanwhile, integrated science process skills include predicting, which is estimating outcomes based on patterns or previous data; inferring, which means drawing conclusions based on observed facts; identifying and controlling variables, which involves understanding independent, dependent, and control variables in an experiment; interpreting data, which consists of analysing relationships between variables; formulating hypotheses, which refers to constructing statements that can be tested scientifically; and defining operationally, which explains how a variable is measured in an experiment (Rezba, Sprague, & Fiel, 2007).

However, Rustaman (2005) refined this concept of science process skills by adding a 13th indicator: experimenting as a separate skill. This indicator includes the ability to design, conduct, and evaluate experiments systematically. Rustaman emphasized that this skill is crucial in science learning because it allows students to apply the scientific method comprehensively, from identifying problems, designing experiments, controlling variables, and collecting data to drawing conclusions (Rustaman, 2005). With this addition, science process skills become more comprehensive in equipping students with deep scientific thinking abilities.

Student Needs Analysis

The analysis of student needs was conducted through a preliminary study using a questionnaire distributed to 20 students at Sungai Tarab Public Senior High School 1. The purpose was to identify difficulties in learning physics within the independent curriculum, the availability of learning media, and the use of teaching materials (E-SWS). The questionnaire covered aspects of the physics learning process, the use of teaching materials, and students' needs for E-SWS. The findings from the questionnaire revealed several key insights into students' learning experiences and challenges in physics. Many students reported difficulties in understanding abstract concepts, particularly in topics involving measurements and formulas. Additionally, while most students acknowledged the availability of learning materials such as textbooks and printed SWS, a significant number expressed the need for more interactive and engaging resources to enhance their comprehension. Furthermore, students highlighted the importance of diverse learning methods, with some preferring independent study while others found group discussions more effective.

The need for digital-based learning tools was also evident, as students increasingly rely on online resources to supplement their understanding. These findings emphasize the necessity of developing an E-SWS that is not only accessible but also tailored to students' learning preferences, providing interactive content that supports their academic progress. The next section will further explore the implementation of teaching materials in physics learning and how they impact students’ engagement and understanding. Where several components are analysed, including students' difficulty in understanding physics material (SDP), students' enthusiasm in participating in the physics learning process in class (SEP), the time required by students to understand physics material (TSP), the sufficiency of teacher explanations for students to comprehend physics material (STE), students' preference for independent learning (SPI), and students' preference for group learning (SPG).

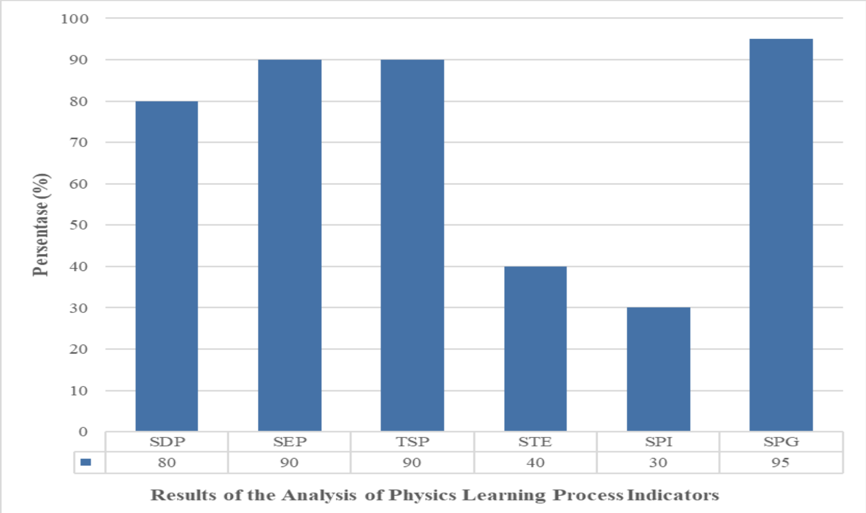

Figure 1. Results of the Analysis of Physics Learning Process Indicators

Based on Figure 1, shows that the majority of students demonstrate high enthusiasm for learning physics, with 90% of respondents expressing interest. However, challenges in understanding the material persist, as 80% of students struggle with grasping physics concepts. This difficulty is further emphasized by the fact that 90% of students require a long time to fully understand concepts before mastering them.

Despite these challenges, 40% of students feel that the teacher’s explanations are sufficient, while 60% still need additional learning resources. Furthermore, there are differences in learning preferences, with 30% of students preferring independent learning, whereas 95% feel more comfortable learning in groups. In this context, independent learning refers to studying individually without communication with other students. These findings highlight the need for more varied learning strategies to accommodate students’ diverse learning needs. Additionally, in the remarks section of the student questionnaire, the majority of students mentioned that the most challenging topics in physics are "Measurements and Quantities" and topics involving physics formulas.

After understanding how students generally respond to physics learning, it is essential to examine how instructional materials can assist them in comprehending the subject matter. Therefore, Figure 2 will discuss the use of instructional materials in physics learning, there are several components, namely using teaching materials in the learning process (UTL), having printed Student Worksheet (HPL), and searching for other materials besides Student Worksheet (SOM).

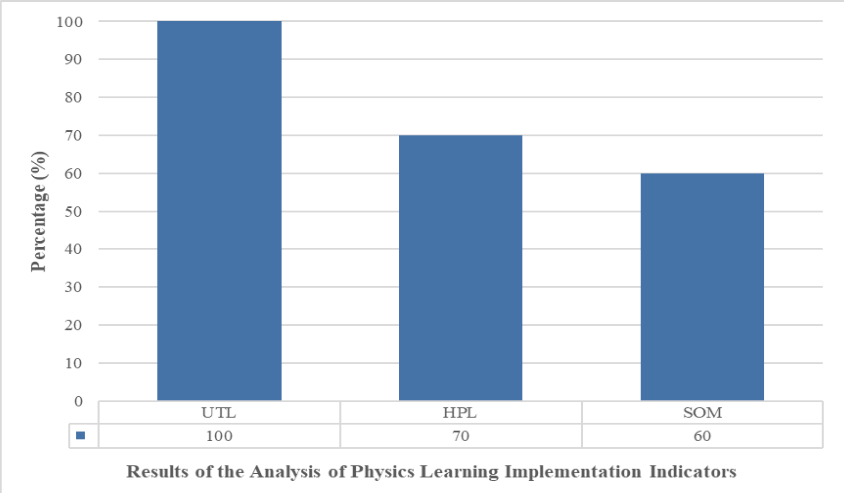

Figure 2. Results of the Analysis of Physics Learning Implementation Indicators

Based on the data, it can be concluded that although the use of learning materials in physics lessons is quite good, there are still gaps in accessibility and effectiveness. The lack of printed SWS (Student Worksheets) ownership among some students may hinder their independent learning outside the classroom. Additionally, the fact that 60% of students seek additional learning materials suggests that the existing SWS and textbooks may not fully meet their needs, either in terms of conceptual understanding or variation in material presentation. Many students feel that the available materials are not interactive enough and lack engaging elements that can facilitate deeper comprehension.

Thus, the development of more interactive and contextual learning materials, such as web-based E-SWS, is necessary. This approach can provide a more flexible, engaging, and student-centered learning experience. Furthermore, it can help enhance students' independent learning skills and reduce their reliance on teacher explanations in the classroom. By incorporating digital and multimedia elements, an E-SWS can make learning more dynamic and cater to different learning styles.

To ensure the effectiveness of such materials, it is crucial to gather further insights into students' specific learning preferences and difficulties. After identifying that students still require additional learning resources, it is important to further assess the effectiveness of SWS in helping them understand the material. Therefore, Figure 3 will discuss students' needs regarding physics SWS in greater detail, several components can be observed, including Physics SWS assisting students in the learning process (IPA), Physics SWS supporting students' independent learning (SSS), and students experiencing difficulties in learning physics through SWS and the teaching methods applied by teachers (SEA).

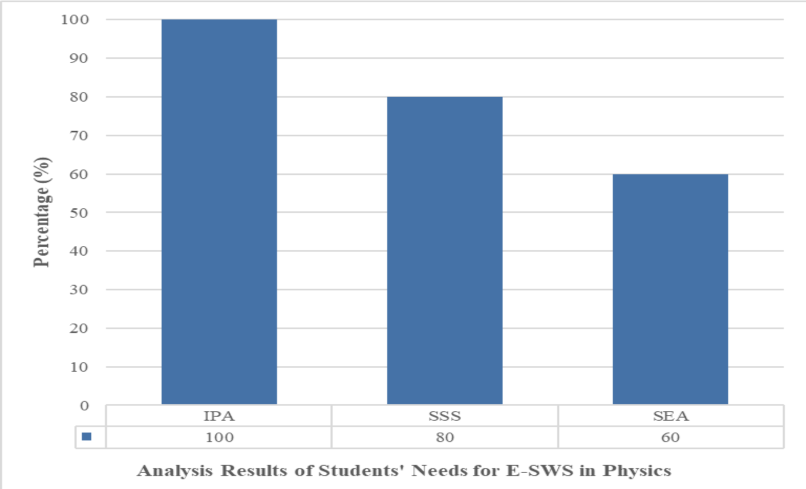

Figure 3. Analysis Results of Students' Needs for E-SWS in Physics

Based on Figure 3, shows that all students (100%) stated that Physics SWS significantly helps them in the learning process. Additionally, 80% of students assessed that Physics SWS also supports their independent learning, indicating that this learning medium is quite effective in enhancing learning autonomy. However, 60% of students still experience difficulties in understanding physics concepts despite using SWS, suggesting the need for improvements in SWS design or the teaching methods employed by teachers. These difficulties may arise from a lack of interactivity or limitations in delivering material in a way that is easier for students to comprehend.

In addition to using learning materials such as SWS, it is also important to understand how learning evaluation is conducted. Therefore, Table 2 will discuss students' experiences with interactive evaluation in physics learning.

Table 2. Analysis Results of Students' Experiences with Interactive Evaluation

Analyzed Aspect	Percentage (%)	Description
Students who have experienced interactive evaluation	25%	Only a small portion of students have experience with interactive evaluation.
Students who have never experienced interactive evaluation	75%	The majority of students have not had experience with interactive evaluation, either in previous levels or in Grade X, Phase E.

Based on Table 2, only 25% of students have ever participated in interactive evaluations, indicating a lack of experience with this method both in previous levels and in Grade X, Phase E. The initial analysis shows that students struggle to understand physics concepts and require a long time to grasp them. They find teacher explanations insufficient and still rely heavily on printed learning materials. Additionally, students seek additional references from the internet and require physics modules to support their learning, including independent study. Most of them have also never engaged in interactive evaluations, which could optimize the use of technology in the learning process.

Teacher Needs Analysis

The teacher needs analysis was conducted through interviews and questionnaires with the only Grade X physics teacher at Sungai Tarab Public Senior High School 1, who teaches under the independent curriculum. The interview results indicate that the preparation for the independent curriculum is still lacking, with minimal training and workshops provided.

Reference materials are limited, with only 40 books available, while students continue to rely heavily on the teacher. The teacher has not yet implemented innovative teaching models due to difficulties in understanding the curriculum. Although students have started to become more active, their critical thinking skills remain low.

Furthermore, 80% of classrooms are equipped with projectors and Wi-Fi, but the utilization of ICT in learning still needs improvement. The teacher more frequently uses printed SWS rather than e-SWS and emphasizes the importance of mapping student characteristics from the beginning, although this has not yet been fully implemented.

To assess the teacher's confidence in their responses, they were asked to complete a teacher needs questionnaire. Figure 4 illustrates the teacher's level of agreement regarding various aspects observed in the implementation of the independent curriculum, including CT (Curriculum & Training), MLR (Materials & Learning Resources), MP (Methods & Participation), FT (Facilities & Technology), SM (SWS & Media), and SCM (Student Character Mapping).

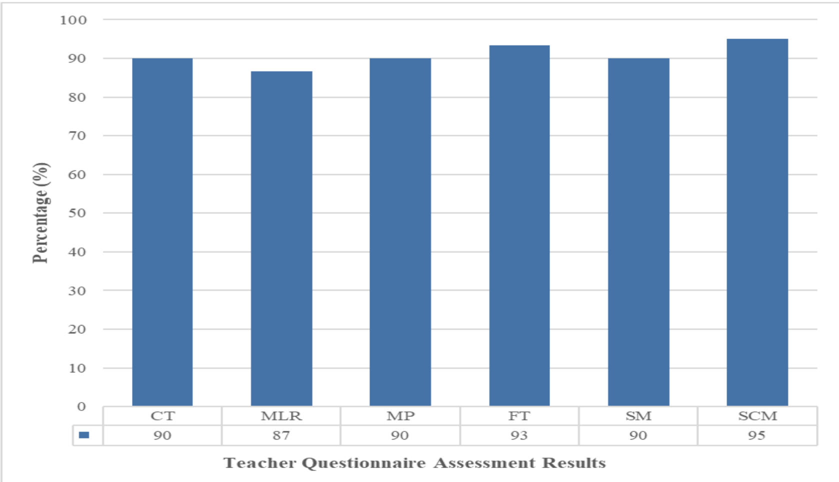

Figure 4. Teacher Questionnaire Assessment Results

Based on Figure 4, the graph indicates that the teacher faces difficulties in implementing the independent curriculum due to a lack of preparation and introduction. Physics teaching references are still limited, even though the material itself has not changed significantly. Students remain highly dependent on the teacher, while innovative teaching models have not been implemented due to limited understanding.

The use of technology in teaching needs improvement, despite most classrooms already being equipped with projectors and internet access. The teacher more frequently utilizes printed SWS but still struggles with developing electronic SWS. Student character mapping is considered essential for determining appropriate teaching methods and enhancing collaboration.

Discussion

Science process skills are one of the essential competencies in physics learning, as they reflect students' ability to observe, classify, conclude, and solve problems through practical activities (Rezba, Sprague, & Fiel, 2007). Based on research findings, students' science process skills are still relatively low, with an average score of 57 (Saputra et al., 2019). Statistical data shows that the mode of science process skills is 56, with a median of 57, indicating that most students are at a low skill level. The lowest score obtained by students is 32, while the highest score reaches 77, with a range of 45. This considerable variation demonstrates significant differences in students' ability to apply science process skills during practical activities.

The low level of science process skills correlates with students' poor understanding of physics concepts, as reflected in their average knowledge score of only 35 (Nasution & Siregar, 2021). This suggests that students have not yet effectively connected theory with practice. One contributing factor to the low science process skills is the minimal use of investigative and experimental learning methods in the teaching process (Rustaman, 2005). Students tend to be more passive in conducting experiments and analyzing data, making them less trained in developing scientific thinking skills.

To address this issue, the development of more interactive and problem-based teaching materials is a potential solution (Rahman, 2021). One type of teaching material that can be developed is an electronic Student Worksheet (E-SWS) supported by the Wordwall platform. E-SWS can serve as an alternative to enhance students' science process skills through various interactive features that support exploratory and hands-on learning (Zainuddin, 2021). Additionally, E-SWS allows students to learn independently and flexibly while providing access to more diverse learning resources (Rahmat, 2022).

The Problem-Based Learning (PBL) approach is also an appropriate solution to improve students' science process skills. The PBL model encourages students to actively explore real-world problems, conduct observations, and find solutions based on scientific concepts (Arends, 2019). This model has proven effective in enhancing students' conceptual understanding and critical thinking skills (Hmelo-Silver, 2006). Previous studies have shown that implementing PBL in physics learning can improve students' science process skills because they are more engaged in experiments, data analysis, and designing solutions to given problems (Santoso, 2021).

Rezba, Sprague, and Fiel (2007) classified science process skills into two main categories: basic science process skills and integrated science process skills. Basic skills include observing, which involves using the senses and tools to gather information; classifying, which refers to grouping objects based on similarities or differences; measuring, which involves using measuring instruments with appropriate units; using space and time relationships, which reflects how objects change in the context of space and time; using numbers, which involves calculations and quantitative analysis; and communicating, which relates to presenting data in the form of tables, graphs, or diagrams.

Besides science process skills, this study also revealed that students struggle to understand physics concepts, particularly in measurement and quantities and topics involving physics formulas (Widodo, 2020). This is reflected in the students' average knowledge score of only 35. Although 90% of students show enthusiasm for learning physics, 80% experience difficulties in understanding concepts, and 90% require more time to master the material. About 60% of students feel that the teacher's explanation is insufficient and need additional learning resources, while 30% prefer independent learning, and 95% feel more comfortable learning in groups.

The use of printed SWS teaching materials has been implemented, but only 70% of students have full access to them, and 60% still seek additional resources from the internet or other books (Putri et al., 2021). Although 100% of students stated that SWS helps in the learning process, 60% still struggle to understand the material through the existing SWS, indicating the need for improvements in the design and interactivity of teaching materials. Furthermore, only 25% of students have ever experienced interactive evaluation, highlighting the lack of technology integration in the assessment process (Yulianti, 2020).

On the teacher's side, it was found that preparation for implementing the independent curriculum is still limited, with minimal training and available resources. Teachers rely more on printed SWS and have not fully utilized technology, despite 80% of classrooms being equipped with projectors and Wi-Fi access. Teachers also emphasize the importance of student character mapping to determine appropriate teaching methods, but this has not been fully implemented (Hidayat, 2021).

Educational games have been widely recognized as effective tools for enhancing students' understanding and critical thinking skills in academic subjects (Aruna et al., 2024). Their engaging features encourage students to be more active in the learning process by integrating interactive challenges and exercises. One such application, Wordwall, provides various game-based activities that help students sharpen their critical thinking abilities while making learning more enjoyable and immersive. Research has also shown that game-based learning strategies, such as the Team Game Tournament (TGT) model, effectively foster students' critical thinking skills (Aruna et al., 2024).

Building on these findings, the development of E-Student Worksheets (E-SWS) supported by the Wordwall platform and integrated with the Problem-Based Learning (PBL) model offers a promising approach to improving students' understanding of physics concepts and scientific process skills. The PBL model encourages students to explore real-world problems and develop solutions based on scientific principles, making learning more meaningful and contextual (Arends, 2019). Furthermore, integrating Wordwall into E-SWS enhances engagement and accessibility by supporting both independent and collaborative learning. The combination of PBL and interactive educational games ensures that students not only gain conceptual knowledge but also develop essential problem-solving and analytical skills.

This approach is expected to meet students' needs for more engaging and interactive learning materials while promoting deeper understanding. However, this study was conducted with limitations at one high school in Tanah Datar Regency, namely Sungai Tarab Public Senior High School 1, and was restricted to the topic of measurement and quantities. Future research should explore the broader implementation of E-SWS across different physics topics and educational settings to maximize its effectiveness.

Future research is recommended to analyze the need for E-SWS development in other physics topics, such as dynamics, energy, or waves. Additionally, this research should be expanded to various schools with different characteristics to obtain a more comprehensive picture of the effectiveness of E-SWS in improving science process skills and physics concept understanding more broadly. Thus, innovations in teaching methods and instructional materials can continue to be developed to support the overall improvement of physics learning quality.

CONCLUSION

Based on the research findings, it can be concluded that students' understanding of physics concepts and science process skills are still relatively low, with an average knowledge score of 35 and a science process skills score of 57. Students struggle to understand the material, particularly in the concepts of quantities, measurement, and physics formulas, and require a long time to master the subject. Although teaching materials such as SWS have been used, 60% of students still need additional learning resources, and only 25% have ever experienced interactive evaluation. On the teacher's side, there are challenges in implementing the independent curriculum, including limited training, resources, and technology utilization. To address these issues, the development of an E-SWS supported by the Wordwall web and integrated with the Problem-Based Learning (PBL) model is recommended as a solution. This approach is expected to enhance concept comprehension, science process skills, and support a more interactive and contextual learning experience. Thus, innovation in teaching methods and instructional materials is key to improving the quality of physics education and supporting the successful implementation of the independent curriculum.

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