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Needs Analysis for the Development of E-Student Worksheets for the PBL Model Based on PhET Simulations Oriented to Local Wisdom to Improve Students' Problem-Solving Skills for Fluid Material

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ABSTRACT

Physics plays an important role in developing problem-solving skills as a 21st-century learning demand. However, in fluid materials, this ability is still low due to difficulties in understanding abstract concepts and the limited use of interactive media. This research aims to determine the initial problem-solving ability and the need for the development of teaching materials. The study used a descriptive approach in the form of a preliminary study at MAN 3 Padang City in class XI Science 2 with 26 students. Data was collected through tests, interviews, and questionnaires, then analyzed descriptively. The results showed that 53.8% of students were in the category of failure, 3.8% lacking, 15.4% adequate, 15.4% good, and 11.5% very good, so problem-solving skills are still low. In addition, students have good technological readiness, but have not been supported by adequate learning media. Therefore, it is necessary to develop student worksheets based on Problem-Based Learning (PBL) supported by PhET Interactive Simulations and oriented to local wisdom to improve students' understanding of concepts and problem-solving skills.

INTRODUCTION

Physics is a branch of science that plays an important role in developing students' scientific thinking skills and problem-solving skills. In physics learning, not only the mastery of concepts is emphasized, but also the ability of students to analyze phenomena, formulate problems, and find solutions systematically. In line with the demands of 21st century learning, students are expected not only to master knowledge, but also to be able to develop various competencies that support readiness to face future challenges. This is strengthened by the results of the study Kuswanto & Salim (2025) in *Systematic Literature Review: Problem-Solving Skills in Physics Learning* which states that physics plays an important role in developing scientific thinking and problem-solving skills. In line with that, the concept of modern education also emphasizes the importance of comprehensive competency development that is not only limited to cognitive aspects. This is reflected in the latest education study that examines lifelong learning through four pillars, namely learning to study and build knowledge together *(learning to study, inquire and co-construct together),* Learn to act collectively *(learning to collectively mobilize)*, learn to care *(learning to attend and care),* and learning to live together in one world *(learning to live in a common world)* (Schmeiduch & Thevenot, 2025). The four pillars emphasize that the learning process must be able to develop cognitive, social, and personal competencies in a balanced manner.

Problem solving in learning, especially physics, is very important because it is one of the aspects of high-level thinking skills that can improve students' understanding of concepts and skills. In addition, this process trains students to think critically, analytically, and systematically in dealing with various scientific situations and daily life. By developing problem-solving skills, students are expected to be able to apply their knowledge effectively and independently. In physics learning, the problem-solving process is inseparable from scientific activities such as identifying problems, formulating solution strategies, and systematically evaluating results (Sarkingobir & Bello, 2024). The process helps students understand the relationship between the concepts learned and real phenomena in the surrounding environment. Therefore, physics learning not only emphasizes the mastery of concepts, but also on the ability of students to apply these concepts to solve various problems related to natural phenomena (Jita & Badmus, 2024). The development of this problem-solving ability also contributes to improving students' overall critical and analytical thinking skills.

Problem-solving skills themselves include several important stages, namely understanding the problem, planning a solution strategy, implementing a solution plan, and reviewing the results obtained (Polya, 1945). These stages show that problem solving is a systematic and structured process. Each stage has an important role in helping students find the right solution to the problems they face. According to Nasution (2021) Viewing problem-solving as an effort to find solutions to the gap between expected and real conditions. In line with that, Riantoni & Yelianti (2023) It also emphasizes that problem-solving is not only oriented to the end result, but also to the thought process used in achieving solutions. In physics learning, problem-solving involves a series of cognitive processes such as understanding problems, planning solution strategies, and systematically evaluating the results obtained. Therefore, problem-solving skills need to be trained on an ongoing basis so that students are able to think logically, systematically, and critically in dealing with various problems.

However, in learning practice, there are still many students who have difficulties in solving physics problems. Various studies show that these difficulties are generally caused by the low ability to understand concepts in depth and relate them to real situations. One of the physics materials that is often considered difficult by students is fluid materials. This material involves various abstract concepts, such as fluid pressure, lift, and fluid flow that cannot be observed directly. Difficulties in understanding the concept of fluids, especially static fluids, are often caused by the tendency of students to only memorize formulas without understanding the concepts in depth. They generally focus more on quantitative aspects and ignore conceptual aspects such as hydrostatic pressure and lift, so that the understanding gained becomes incomplete and has an impact on the difficulty in applying these concepts in problem solving (Rahma et al., 2022). Other research has also shown that the use of visual representations and interactive simulations can help students understand abstract concepts in physics more effectively (Banda & Nzabahimana, 2021). Therefore, innovation is needed in the use of learning media that is able to increase student involvement while helping them visualize abstract physics concepts.

One of the efforts that can be made to overcome these problems is to develop *Student Worksheet* based on PhET. *Student worksheet* as a teaching material, according to Fadilah (2025), It contains activity guides, material summaries, and assignments designed to help students understand concepts in a more targeted manner while increasing learning engagement and independence. Along with the development of technology, *Student Worksheet* transform into *Electronic Student Worksheet* which allows for more flexible and interactive learning (Sumanik, 2022). Research Riadhi et al (2025) shows that the development of *Electronic Student Worksheet* in Indonesia is experiencing rapid growth, although the distribution is still uneven and not fully contextual. In addition, findings from Satria (2025) emphasizing the importance of using media and active and interactive learning approaches in improving students' understanding. Therefore, the integration *Electronic Student Worksheet* allowing students' problem-solving skills to be improved optimally.

Utilization Electronic Student Worksheet can be combined with the use of interactive learning media such as PhET simulations. PhET is an interactive simulation-based learning media that is used to clarify physical concepts and natural phenomena through interesting and fun scientific activities (Tullah et al., 2021). The use of PhET simulations provides students with the opportunity to conduct experiments virtually, including ideal experiments that are difficult or even impossible to perform using real tools and materials in the laboratory (Prince, 2024). In addition, PhET helps learners to understand complex concepts through hands-on experience and self-exploration, which corresponds to the student's stage of cognitive development at the secondary school level (Hayati et al., 2024). This media has also been proven to improve memory of the material studied because the learning process takes place actively and meaningfully. Not only that, the PhET simulation encourages students to develop intuitive thinking and formulate hypotheses based on observations of variable changes. Thus, the learning process becomes more interesting, fun, and able to increase the active involvement of students in understanding physics concepts more deeply.

To find out the initial condition of physics learning, initial research was carried out through problem-solving ability tests, interviews with teachers, and the distribution of questionnaires to students. The results of the initial research show that students' problem-solving ability in fluid materials is still relatively low, and the use of interactive learning media in the learning process is still limited. This condition indicates that students are not fully able to construct and apply physics concepts systematically in solving problems. In addition, the learning process that takes place tends not to maximize the use of interactive learning technology. Therefore, this study aims to conduct a preliminary study on the conditions of physics learning and the need for the development of electronic student worksheets based on PhET simulations on fluid materials to improve students' problem-solving skills.

METHODS

This study uses a descriptive approach with a preliminary study research type that aims to obtain an overview of the initial conditions of physics learning and identify the need for the development of teaching materials in the form of Electronic Student Worksheet based on

PhET simulations on fluid materials to improve students' problem-solving skills. The data analysis used is descriptive statistics. Descriptive statistics is a data analysis technique used to analyze data by describing or describing the data that has been collected as it is without intending to make conclusions that apply to the general public or make generalizations. Descriptive statistics can be done through the presentation of data in the form of tables, graphs, pie charts, pictograms, as well as through the calculation of data center sizes such as means, medians, and modes, as well as data distribution measures such as percentages and standard deviations (Scott, 2013).

This research was carried out at MAN 3 Padang City on February 13, 2026 with the research subject being students of class XI Science 2. The selection of research subjects was carried out purposively considering that the class was studying fluid matter. Data collection was carried out through problem-solving ability tests, interviews with physics teachers, and the distribution of questionnaires to students. The test is used to determine students' initial problem-solving ability in fluid materials, while interviews are conducted to obtain information about the conditions of physics learning in the classroom. Meanwhile, the questionnaire was used to find out the needs of students for the use of interactive learning media in physics learning.

The data obtained was then analyzed using descriptive statistics and grouped into assessment scale categories to facilitate the interpretation of the results. The analysis process is carried out by calculating the average score and percentage of each indicator measured, so that the level of achievement of students can be known more systematically. The results of this grouping are used to identify the tendency of students' abilities, both those that have developed and those that still need to be improved. In addition, the data from the questionnaire was analyzed descriptively to describe the conditions of students' needs and characteristics in physics learning. The data from the interview results were analyzed through the stages of data reduction, data presentation, and conclusion drawing to gain a deeper understanding of the learning conditions in the classroom. By integrating the results of the quantitative and qualitative analysis, this study is able to provide a comprehensive picture as a basis for designing the development of relevant and effective learning media.

RESULTS AND DISCUSSION

Results

The results of the preliminary study were obtained through several data collection techniques, namely the initial problem-solving ability test, the distribution of needs analysis questionnaires to students, and interviews with physics teachers at MAN 3 Padang City. The three techniques are used to obtain a comprehensive picture of the initial conditions of physics learning, especially in fluid materials, both in terms of students' abilities and the learning process that takes place in the classroom. The initial problem-solving ability test is given to students in class XI Science 2 with the aim of measuring their ability to solve physics problems based on the stages of systematic problem-solving. The results of the test are then analyzed to find out the level of ability of students and difficulties experienced in solving problems. Furthermore, the results of the analysis are presented in detail in Table 1 as a basis for determining the need for the development of appropriate teaching materials. In addition, data from questionnaires and interviews are used as support to strengthen the findings of the test results so that a more comprehensive picture is obtained.

Table 1. Initial Ability Test Results

Remarks	Interval	Number of Students	Percentage
Very good	81 - 100	3	11.5 %
Good	66 – 80	4	15.4 %
Enough	56 – 65	4	15.4 %
Less	41 – 55	1	3.8 %
Fail	0 – 40	14	53.8 %

Based on the results of the initial ability test in Table 1, the distribution of students' problem-solving skills in fluid materials in MAN 3 Padang City shows a strong tendency in the low category. As many as 53.8% of students were in the failed category (0–40), while the less category was only 3.8%, which shows that most students have not reached the minimum limit of ability mastery. Meanwhile, students who are in the sufficient and good categories are only 15.4%, and the very good category is 11.5% each. This composition shows that more than half of the students do not have adequate problem-solving skills, so the distribution of abilities becomes unbalanced. This gap indicates that only a small percentage of students have been able to understand and apply physics concepts well, while the majority of others are still at a low level of understanding. Thus, classically problem-solving skills can be categorized as not yet optimally developed.

More deeply, the dominance of the failed category shows that students have not been able to carry out the stages of solving problems systematically, starting from understanding problems, identifying important information, to determining the right solution strategy. The low percentage in the good and excellent categories also indicates that high-level thinking skills, such as analysis and evaluation, have not been optimally developed. This condition shows that students still have difficulty in connecting the concept of fluids with the context of the problem, so the solutions carried out tend to be undirected. In addition, the low achievement in the category is enough to show that students' basic understanding of the concept of fluids is also limited. These findings indicate that there are other factors that also affect the low problem-solving ability of students. Therefore, to obtain a more comprehensive picture, further analysis was carried out through the distribution of student needs questionnaires, the results of which are presented in Figure 1.

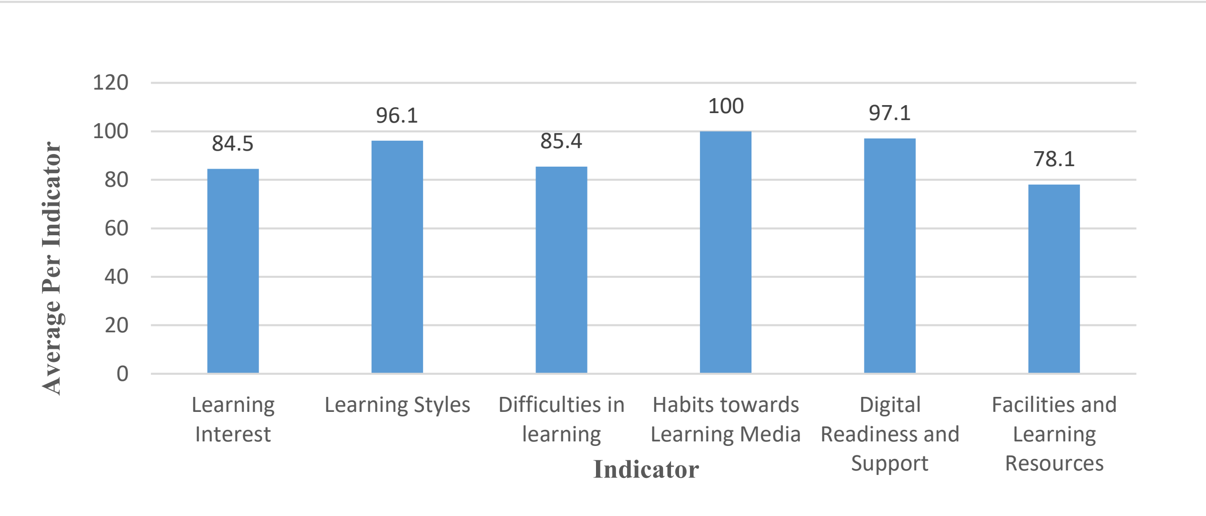

Figure 1. Student Survey Results

The results of the questionnaire show that some aspects of the physics learning process still require comprehensive attention. In terms of learning interest, a high average score indicates that students have an interest in physics as a subject. However, this high interest has not been fully reflected in active involvement during the learning process. This shows that the interest that students have is still at the potential stage and has not developed into a strong motivation to learn. This condition can occur because the learning strategies used are not fully able to accommodate the needs and characteristics of students. Thus, efforts are needed to transform these interests into active involvement through a more interactive and contextual learning approach.

In terms of learning style, a high average score indicates that students have diverse and moderately developed learning tendencies. This diversity includes visual, auditory, and kinesthetic preferences that should be used as a basis for designing learning. However, in practice, these variations in learning styles have not been fully accommodated in the learning process in the classroom. This causes the potential of students to understand concepts through an approach that suits their characteristics has not been developed optimally. The mismatch between learning strategies and students' learning styles has the potential to reduce learning effectiveness. Therefore, a more adaptive and differential learning design is needed so that all students can learn optimally according to their learning style.

In the aspect of difficulties in learning, the results of the questionnaire show that students still experience significant obstacles. These obstacles are mainly related to the understanding of physical concepts that are abstract and require a high level of reasoning. In addition, students also experience difficulties in solving problems systematically, starting from understanding the problem to determining the right solution. These difficulties indicate that high-level thinking skills, such as analysis and evaluation, have not been optimally developed. These findings are in line with the results of the initial test which showed the low problem-solving ability of students. Thus, it can be interpreted that the difficulties experienced are not only conceptual, but also procedural and strategic in problem solving.

In the aspect of habit towards learning media, the highest average score shows that students are used to using various media in the learning process. This indicates that students have sufficient experience in utilizing media as a means of supporting learning. This condition is strengthened by the high readiness and digital support that students have. This means that in general, students are ready to take part in technology-based learning. This potential is a very important opportunity to develop more innovative learning. Therefore, the integration of digital media in physics learning can be a solution to increase student engagement and understanding.

However, in terms of facilities and learning resources, the average score obtained is the lowest compared to other aspects. This shows that the availability of learning support facilities and infrastructure is still limited. This limitation has the potential to hinder the optimal use of learning media in the classroom. In other words, there is a gap between students' readiness to use technology and the support of available facilities. This condition shows that the success of technology-based learning is not only determined by the readiness of students, but also by the availability of supporting facilities. Therefore, improving facilities is one of the important factors that need to be considered in learning development.

Overall, the results of the questionnaire show that there is a gap between the internal potential of students and external factors of learning. Internal potentials such as interests, learning styles, and digital readiness are in the category of being quite good. However, the learning strategies used and the availability of facilities have not fully supported this potential. This gap causes the learning process to not take place optimally and has not been able to produce a deep understanding. In addition, this condition also has an impact on students' low problem-solving skills. Therefore, efforts are needed to integrate the potential of students with the right learning strategies and media so that the learning process becomes more effective and meaningful.

The results of interviews with physics teachers reinforce the findings obtained from the results of the questionnaire. The learning process that takes place is still dominated by conventional lecture and question and answer methods. Learning usually begins with independent reading activities by students, then continues with discussion of sample questions together in class. Although this approach provides basic understanding, it has not been able to encourage the active involvement of all students. The activity rate of only about 50% shows that some students still tend to be passive. This condition indicates that learning is still teacher-centered and not fully student-oriented.

Furthermore, students are still not used to expressing opinions and actively engaging in learning discussions. This shows that the learning environment has not fully supported the development of critical thinking skills. As a result, students' problem-solving skills have also not developed optimally. Students are not used to carrying out the stages of solving problems systematically. They tend to immediately look for answers without understanding the problem in depth. This condition causes the learning process to be less meaningful and less to train high-level thinking skills.

In terms of understanding the concept, students also have difficulty in interpreting the questions given. They often experience confusion in determining concepts that are relevant to the problems they are facing. In addition, students also have difficulty in choosing the right formula to use. This problem mainly occurs in fluid materials that have abstract characteristics. This shows that learning has not been able to connect concepts with more concrete representations. Therefore, learning media that can help visualize concepts more clearly is needed.

The limited use of learning media is also one of the factors causing this problem. The media used is still dominated by PowerPoint, printed books, and Student Worksheet conventional. The use of interactive technology such as digital simulations is still very rare. As a result, the learning process has not been able to facilitate the optimal visualization of physics concepts. This causes students to have difficulty understanding phenomena that cannot be observed directly. This condition shows that innovation in the use of learning media is very necessary.

In addition, the limitation of facilities such as projectors and laboratories is also an obstacle in the implementation of learning. The available facilities have not been fully utilized to support interactive learning. This has an impact on the limited variety of learning methods that can be applied by teachers. Students also have limitations in conducting experiments or exploring concepts directly. As a result, the learning experience obtained becomes less in-depth. This condition further emphasizes the importance of supporting facilities in learning.

Based on all these findings, it can be concluded that physics learning problems are complex and involve various factors. The problem does not only lie in the ability of students, but also in the learning strategies, media, and facilities used. These three aspects have not been optimally integrated in supporting learning. Therefore, innovation is needed in the development of teaching materials that are more interactive and technology-based. One of the alternatives that can be developed is Electronic Student Worksheet based on PhET. This media is expected to be able to help visualize concepts, increase student involvement, and train problem-solving skills systematically and independently.

Discussion

The results of the preliminary study show that students' problem-solving ability in fluid materials is still relatively low. This can be seen from the results of the initial ability test which shows that most students are in the failed category and only a small number are in the good and very good category. This condition indicates that students' problem-solving skills have not been developed optimally in physics learning (Puspitasari, 2022). In addition, students have also not been able to pass the stages of systematic and targeted problem-solving, which shows weaknesses in the scientific thinking process. These findings are reinforced by previous research that states that low problem-solving skills are related to a lack of structured practice in learning (Nurul et al., 2024), and further strengthened by recent studies showing that traditional learning with minimal problem-based exercises can reduce students' problem-solving skills (Musengimana et al., 2025). Therefore, efforts to improve learning are needed that emphasize more on strengthening the understanding of concepts and systematic thinking processes.

The difficulties experienced by students can also be seen from their tendency to use structured problem-solving steps in solving physics problems. Students often immediately look for formulas without understanding the basic concepts underlying the problem, thus causing errors in determining the right concept. This is in line with research Negara et al (2021) which emphasizes that understanding concepts is an important foundation in successful problem solving. In addition, difficulties in interpreting the questions showed that students were not able to relate the information provided to relevant physics concepts, which were also supported by the findings Maries & Singh (2023) that weakness of conceptual understanding is the main factor in low problem-solving skills because students have difficulty organizing and applying concepts in new situations. Thus, strengthening basic concepts is very important in learning physics so that students are able to solve problems more accurately and systematically.

In addition to cognitive factors, interest in learning also has a significant influence on students' problem-solving abilities. Students with low interest in learning tend to be less active in following the learning process and less motivated to understand the material in depth. On the other hand, the higher the students' interest in learning a lesson, the better their ability to solve problems because it is driven by curiosity, greater effort, and active involvement in learning (Yuliati, 2021). This is also reinforced by the Ezeddine et al (2023) which suggests that interest and engagement in learning play an important role in improving problem-solving abilities because highly motivated students tend to use more effective cognitive strategies in completing complex tasks. Thus, interest in learning is an important factor that not only affects students' involvement in learning, but also determines their success in solving problems more effectively and in a more targeted manner.

Based on these various problems, it is necessary to develop teaching materials that are more interactive and contextual to improve students' problem-solving skills. One alternative that can be used is an electronic student worksheet that can facilitate active and independent learning (Herman et al., 2025). This is in line with research Ferdy (2025) which states that interactive electronic teaching materials are needed to overcome various learning problems, especially in increasing student engagement and understanding. In addition, along with the demands of 21st century learning that integrates digital technology, electronic student worksheets are an innovation that supports learning that is more flexible, interactive, and relevant to the needs of students (Riadhi et al., 2025). Other studies have also shown that learning that lacks structured problem-based exercise can reduce students' problem-solving skills (Berbero et al., 2021). Thus, the development of electronic-based teaching materials not only increases student involvement, but also trains high-level thinking skills systematically and independently.

One relevant form of development is an electronic student worksheet based on Problem-Based Learning which is equipped with interactive simulations. This model allows students to be actively involved in the problem-solving process through systematic scientific stages (Puspita et al., 2025). The integration of Problem Based Learning in the student worksheet is also expected to help students understand the steps to solve the problem in detail (R. A. Utami & Riyasni, 2024). In addition, the use of PhET simulations as well as interactive features such as animations and virtual measuring tools can help students understand concepts more concretely because they provide a learning experience that resembles real conditions. This approach is also in line with the demands of 21st century learning that emphasizes the use of technology to improve the quality of the learning process. Furthermore, this development can be combined with local wisdom through an ethnoscience approach so that learning becomes more meaningful and contextual (H. G. Utami, 2025). Thus, electronic student worksheets based on PBL and local wisdom are expected to be able to improve students' problem-solving skills more optimally and sustainably.

CONCLUSION

Based on the results of the preliminary study, it can be concluded that students' problem-solving skills in fluid materials are still relatively low and have not developed optimally, which is reflected in difficulties in understanding concepts, designing solution strategies, and determining the right solutions. This condition is influenced by various factors, such as the limited use of learning media, the dominance of learning methods that are still teacher-centered, and the lack of activities that encourage independent exploration and knowledge construction. In addition, the abstract characteristics of fluid matter further strengthen obstacles in the process of understanding and applying concepts in problem solving. On the other hand, the results of the needs analysis show that students actually have a good interest and readiness in utilizing technology as a means of learning. However, this potential has not been balanced by the use of interactive learning media that is able to facilitate the visualization of concepts and active involvement of students. Therefore, the development of an electronic student worksheet based on Problem-Based Learning (PBL) supported by PhET Interactive Simulations and integrated with an ethnoscience approach based on local wisdom is a relevant solution. This approach has the potential not only to improve understanding of concepts in a more concrete and contextual way, but also to train problem-solving skills systematically, so as to be able to bridge the gap between students' potential and learning practices that have been taking place.

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