

ENHANCING STUDENTS PROBLEM SOLVING CAPABILITY WITH ELECTRONIC STUDENT WORKSHEET BASED ON PROBLEM BASED LEARNING

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Abstract : This research was motivated by the unavailability of learning media in the form of electronic student worksheet for physics learning in schools, this type of research was *r & d* research. The aim of this research was to determine the validity of electronic student worksheet, the impact of its use on problem solving abilities and the practicality of the electronic student worksheet being developed. The research population and sample were high school level students in Jayapura city. The instruments used were validity questionnaires and practicality questionnaires that were developed. Data analysis was carried out using quantitative data analysis. The results of data processing show that the electronic student worksheet based on problem based learning that was developed is suitable for use in physics learning, expert validators provide validation results of 92,64% (very good category), while the average validation results by practitioners is 96.60% (very good category); the percentage increase in *n-gain* in the problem solving ability of the experimental group that used electronic student worksheet was 0.73 in the high category, while the control group that used conventional *lcpd* was 0.46 in medium category. It was found that average practicality test result for using electronic student worksheet was 94.87%, classified as very practical.

Keywords : Electronic Student Worksheet; Problem Based Learning; Capability.

Abstrak : Penelitian ini dilatar belakangi belum tersedianya media pembelajaran berupa lembar kerja elektronik peserta didik pada pembelajaran Fisika di sekolah, jenis penelitian adalah penelitian R & D. Tujuan penelitian ini adalah untuk mengetahui validitas lembar kerja elektronik, dampak penggunaannya terhadap kemampuan pemecahan masalah dan kepraktisan lembar kerja elektronik peserta didik yang dikembangkan. Populasi dan sampel penelitian adalah peserta didik jenjang SMA di Kota Jayapura. Instrumen yang dipergunakan adalah angket validitas dan angket kepraktisan yang dikembangkan. Analisis data dilakukan dengan menggunakan analisis data kuantitatif. Hasil pengolahan data menunjukkan lembar kerja elektronik berbasis *problem based learning* yang dikembangkan layak dipergunakan dalam pembelajaran fisika, validator ahli memberikan hasil validasi 92,64% (kategori sangat baik), sedangkan rata-rata hasil validasi oleh praktisi 96,60% (kategori sangat baik); persentase peningkatan *n-gain* kemampuan pemecahan masalah kelompok eksperimen yang menggunakan lembar kerja elektronik sebesar 0,72 masuk pada kategori tinggi, pada kelompok kontrol yang menggunakan lembar kerja peserta didik konvensional sebesar 0,48 pada kategori sedang. Ditemukan bahwa rata-rata hasil uji kepraktisan penggunaan lembar kerja elektronik sebesar 94,87% tergolong dalam kriteria sangat praktis.

Kata Kunci : Lembar Kerja Elektronik Peserta Didik; Pembelajaran Berbasis Masalah; Kapabilitas.

INTRODUCTION

Learning is a process of conscious effort carried out by an individual to achieve new global behavioral changes, because of the individual's own experience in interacting with humans and their environment. One of the vital requirements to support optimal learning is the existence of learning media, the existence of learning media which includes learning multimedia is quite close. It was found that learning will give a positive, meaningful impression and have an impact on students' understanding of learning, besides that learning activities will become more interesting and less boring if educators use multimedia.

There are various models and types of learning media, which support students' learning activities (Abdullah & Omar, 2022; Muali, Aisyah, & Faizah, 2023; Mundiri, 2018). Electronic student worksheet is a type of learning multimedia that teachers can develop to support the learning process in the classroom. Electronic student worksheet needs to be developed to support several aspects of knowledge at once. For example, the use of technology, the updating of teaching materials, and being able to display objects and materials at the same time. Electronic student worksheet is also very helpful for teachers in explaining the material and relating the material directly to everyday life. By bringing concepts or materials to life, it can help students develop their creativity in making, updating, or even creating something (Asshidiq & Syahri, 2023).

Based on the results of observations of teaching and learning activities carried out on physics teachers at one of the high schools in Jayapura City, it was found that the teacher taught vibration and wave material as well as other physics material using a student handbook. Apart from that, it was found that physics teachers do not yet have electronic student worksheets, especially on vibration and wave material. Students' learning motivation was also found to be still low, where students often did not pay attention to the teacher's explanations during learning. If left unchecked, this will have an impact on students' problem solving abilities.

These observation findings are in line with the research results of Nisak and Susantini (2023) which stated that the electronic student worksheets developed was successful in improving students' problem solving abilities. Furthermore, it was found that the development of electronic student worksheets can be integrated with student skills by providing several projects that can be carried out by students, which can help or stimulate students' problem solving abilities and creativity (Suryaningsih & Nurlita, 2021). Apart from that, electronic student worksheets can also be an interesting and motivating resource for students when studying (Purnama & Suparman, 2020; Srikawati, 2022). However, from these studies, the author found that no one had yet developed electronic student worksheets based on problem-based learning (PBL) with the help of a live worksheet application. The liveworksheet.com application can convert printed worksheets in doc or pdf format into interactive worksheets that can be corrected systematically.

The problem based learning model is a learning model that applies everyday problems and issues in learning (Barrows & Tamblyn, 1980; Sari et al., 2010; Wasilah et. al., 2023). Problem based learning is a learning process that uses problems to be discovered by students in order to find solutions using scientific methods (Aikenhead, 2006; Argusni & Sylvia, 2019). The problem based learning model has advantages and disadvantages. The advantages of the problem based learning model include; 1) training students to have the ability to solve problems in real situations; 2) building their own knowledge through learning activities; 3) focusing on problems so that unrelated material does not need to be studied; 4) triggering scientific activities through group work; 5) getting students used to using sources of knowledge, whether from libraries, the internet, interviews, and observations; 6) the ability to assess their own learning progress; 7) scientific communication skills in discussions or presentations of work results; and 8) overcoming individual learning difficulties through group work in form of peer teaching. Disadvantages of the problem based learning model include; 1) it cannot be applied to all subject matter; 2) it is difficult to distribute assignments in classes with a high level of student diversity (Krzic, Brown, & Bomke, 2020; Rerung, Sinon, & Widyaningsih, 2017).

Electronic student worksheets or previously known as student worksheets are one of the teaching materials that can be developed by educators as facilitators in learning activities. Electronic student worksheets can help and simplify teaching and learning activities so that interaction between students and educators can be formed and student activity can increase to increase interest in learning (Puriasih & Rati, 2022). Electronic student worksheets contains sheets containing tasks that must be carried out by students and there are instructions or techniques for working on the material in accordance with the competencies to be achieved (Prastowo, 2019).

Student worksheets is a type of teaching material in the form of material sheets that includes a series of learning experiences arranged systematically with the aim of helping students learn well (Mukti, Connie, & Medriati, 2018). The benefits of student worksheets, include making students more active in learning; increase knowledge of concepts studied through systematic learning and make students more active in developing concepts (Nora, Hakim, & Sulistyowati, 2022). In the current era, technology has developed, and many schools have used various technologies in learning activities. Therefore, one of the uses of advances in information and communication technology in learning activities is to use electronic teaching materials in the form of electronic student worksheets which contain experimental guides.

The development of student worksheets from printed form to electronic form or called electronic student worksheets makes learning activities more interactive. Electronic

student worksheets is teaching material that is presented more practically in electronic form and of course can be accessed via laptops, cellphones and other portable devices. Electronic student worksheets contains several interactive menus such as sound (audio), images, videos and hyperlinks which make it easier for students to interact with teachers (Sa'diah, Suherman, & Septiyanto, 2022).

METHOD

The research method employed can be categorized as development research focusing on the creation and evaluation of educational materials. The research design follows the 4-D model, encompassing the stages of define, design, and develop, with disseminate omitted (Thiagarajan, 1974). This model ensures systematic development and assessment of electronic learning and teaching materials. The data for this study were primarily derived from expert validation using a questionnaire instrument. This instrument was assessed by five validators consisting of Physics Education lecturers and certified senior physics teachers from high schools in Jayapura City. The validation data collected were quantitative in nature, reflecting the assessments of various aspects of the teaching materials, including cover, illustrations, format, content, and language quality. The Likert scale, ranging from 1 to 4, was employed to process and analyze the validation data. The criteria for determining the validity and feasibility of the product were based on specific guidelines outlined in Table 1 (Sugiyono, 2016). According to these guidelines, products achieving scores between 75% and 89% are deemed valid, while those below require revision and re-evaluation until the criteria are met.

Table 1: Five Absolute Scale Feasibility Conversion Guidelines

No.	Score range (%)	Qualification
1	90,00 - 100,00	Highly valid
2	75,00 - 89,00	Valid
3	65,00 - 74,00	Enough
4	55,00 - 64,00	Less
5	0,00 - 54,00	Very less

Regarding the analysis of the impact of electronic student worksheets on problem-solving abilities, N-gain analysis was employed to compare the experimental and control groups (Hake, 1999). This method assesses the improvement in students' problem-solving skills after using electronic student worksheets. The results are categorized based on N-gain values into High, Medium, and Low, as detailed in Table 2. Furthermore, practicality testing was conducted to evaluate students' engagement and interaction with electronic student worksheets during learning sessions.

Table 2: Normalized N-gain Category Values

N-gain Score	Categories
$g > 0,7$	High
$0,3 \leq g \leq 0,7$	Medium
$g < 0,3$	Low

The practicality of electronic student worksheet was then assessed based on the average score criteria presented in Table 3, where scores of 75% or higher indicate practicality (Riduwan, 2022). This comprehensive approach ensured a thorough evaluation of both the effectiveness and practicality of the developed educational materials, providing valuable insights for educational practitioners and researchers alike.

Table 3: Practicality Criteria

Average Score (%)	Assessment Criteria
88 - 100	Very Practical
75 - 87	Practical
62 - 74	Less Practical
0 - 61	Impractical

RESULT AND DISCUSSION

The study on enhancing students' problem solving capability with electronic student worksheet based on problem-based learning yielded several significant findings related to the development, validation, practicality, and reliability of the electronic student worksheet in teaching physics on Vibrations and Waves to eleventh-grade students in Jayapura City. These findings encompass the development process of electronic student worksheet involving the stages of define, design, and develop; validation results by content and material experts and practitioners indicating high quality and feasibility of electronic student worksheet usage; highly positive practicality outcomes based on student responses; and strong reliability and validation from education experts and practitioners. Overall, these findings demonstrate that the use of electronic student worksheet based on problem-based learning is effective in enhancing students' problem-solving skills, meeting educational quality standards, and providing positive impacts on classroom learning practices.

1. Development of Electronic Student Worksheet

The development of the electronic student worksheet in Physics on vibrations and waves for eleventh-grade students in Jayapura City aims to enhance the quality of learning. The initial stage in this development is the Define stage, which establishes and defines the relevant learning conditions. The analysis conducted during this stage provides guidelines for preparing teaching materials that align with student needs and the applicable curriculum. The outcome of the Define stage is a clear and structured guide for further development of the electronic student worksheet.

The next stage is Design, which focuses on the creation of learning tools. In this stage, a blueprint or initial draft of the electronic student worksheet is created, encompassing essential components such as competency standards, basic competencies, indicators, learning objectives, material descriptions, summaries, practice questions, answer keys, and a bibliography. A well-designed and comprehensive blueprint ensures that the electronic student worksheet can be effectively used in the learning process, aiding students in achieving learning objectives more efficiently (Thiagarajan, 1974).

The Develop stage is crucial in producing a ready-to-use development product. This stage involves two main steps: expert appraisal followed by revisions, and developmental testing. Validators provide feedback to improve images and layout to make them more contextual and readable. After undergoing revisions based on expert and practitioner feedback, the final electronic student worksheet product is ready for use. This process ensures that the electronic student worksheet meets high-quality standards and provides maximum benefits to students (Sugiyono, 2015).

Once the final electronic student worksheet product is developed, the next step is implementation and evaluation. The electronic student worksheet is tested on eleventh-grade students in Jayapura to assess its effectiveness in learning. Data from these trials are used for final adjustments to ensure optimal use in real classroom situations. This evaluation is crucial to ensure that the developed product is not only theoretical but also practical and effective in enhancing student learning (Nasution & Casmini, 2020).

2. Validation and Feasibility of Electronic Student Worksheet

The validation process is a critical step to ensure that the developed electronic student worksheet meets the required quality standards. Validation is carried out by content experts who assess five main components: cover, illustrations, format, content/material, and language. This assessment is conducted using a Likert scale, with each component rated from one to four. Validation results as table 4, show that content experts rated the electronic student worksheet very highly, with an average score of 92.64%, indicating that it meets high-quality standards.

Tabel 4: Validation by Expert Judgement

No.	Component	Result		Mean (%)	Qualification
		Validator I	Validator II		
1.	Cover	100	100	100	Highly Valid
2.	Ilustration	83,33	100	91,67	Highly Valid
3	Lay Out	75	100	87,5	Valid
4.	Format	95	100	97,5	Highly Valid
5.	Content	87,5	87,5	87.5	Valid
6.	Language	83,33	100	91,67	Highly Valid
Mean				92,64	Highly Valid

In addition to validation by content experts, the electronic student worksheet is also evaluated by experienced educational practitioners. practitioners assess the same components as the content experts, and the results indicate that they also rated the electronic student worksheet very highly, with an average score of 96.60%. Table 5, demonstrates that the electronic student worksheet is not only theoretically sound but also practical and ready for use in real classroom settings.

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Table 5: Validation by Practitioners

No.	Component	Result			Mean (%)	Qualification
		Prac. I	Prac. II	Prac III		
1.	Cover	100	100	91,67	97,22	Highly Valid
2.	Ilustration	100	100	91,67	97,22	Highly Valid
3	Lay Out	93,75	100	100	97,22	Highly Valid
4.	Format	100	95	100	98,33	Highly Valid
5.	Content	83,33	91,67	100	91,67	Highly Valid
6.	Language	100	91,67	100	97,22	Highly Valid
Mean					96,60	Highly Valid

Validation data are analyzed to ensure that each component of the electronic student worksheet meets the set criteria. this analysis involves calculating the average ratings from both validators and practitioners and identifying areas needing improvement. the analysis shows that most components of the electronic student worksheet are rated very highly, with some minor adjustments needed to enhance overall quality. this process ensures that the developed electronic student worksheet is ready for use and effective in improving student learning (Monica et al., 2023).

Validation results indicate that the developed electronic student worksheet is highly feasible for use in teaching physics to eleventh-grade students. high ratings from both content experts and practitioners confirm that the electronic student worksheet meets high-quality standards and is reliable in helping students understand vibrations and waves. strong validation ensures that this electronic student worksheet is not only theoretically beneficial but also has a positive impact on classroom learning practices (Supriana et al., 2022).

3. Practicality of Electronic Student Worksheet Usage

The practicality of electronic student worksheet usage is measured through student responses after using the electronic student worksheet in learning activities. student responses indicate that the electronic student worksheet is highly practical, with an average score of 94.87%. The appearance aspect received the highest score (98.10%),

showing that students are attracted to the visual design of the electronic student worksheet. electronic student worksheet is important because an appealing appearance can increase student motivation and make learning more effective.

Table 7: Practicality Result of Electronic Student Worksheet Development

No.	Component	Practical Test (%)	Criteria
1	Lay out	98,10	Very practical
2	Accessibility	95,83	Very practical
3	Problem solving	90,67	Very practical
	Mean	94,87	Very practical

The accessibility aspect also received a high score (95.83%), indicating that students find the electronic student worksheet easy to access and use. ease of access is crucial to ensure that all students can use the electronic student worksheet without technical difficulties, allowing the learning process to proceed smoothly. good accessibility also ensures that students can learn independently outside the classroom, enhancing learning effectiveness. the problem-solving aspect scored 90.67%, demonstrating that the electronic student worksheet is effective in helping students develop problem-solving skills. this is important as problem-solving ability is a primary goal in physics education. the electronic student worksheet is designed to encourage students to think critically and apply physics concepts in real-life situations, thus improving their understanding and problem-solving skills (Thiagarajan, 1974).

Practicality results show that the electronic student worksheet is highly suitable for use in teaching physics to eleventh-grade students. high scores in appearance, accessibility, and problem-solving aspects indicate that the electronic student worksheet is not only attractive and easy to use but also effective in enhancing student skills. this suggests that the developed electronic student worksheet can positively impact classroom learning practices, helping students achieve learning objectives more effectively. expert validation is a critical step to ensure the reliability and quality of the developed electronic student worksheet. content experts assess key components of the electronic student worksheet, including cover, illustrations, format, content/material, and language. validation results as table 4, show that content experts rated the electronic student worksheet very highly, with an average score of 92.64%. this indicates that the electronic student worksheet meets high-quality standards and is suitable for use in education.

Experienced educational practitioners also evaluate the electronic student worksheet, ensuring that the product is practical and appropriate for classroom use. Practitioner evaluations as table 5, show very high ratings, with an average score of 96.60%, confirming that the electronic student worksheet is not only theoretically sound

but also effective in real classroom settings. practitioner validation provides assurance that the electronic student worksheet can be successfully implemented in educational environments. the analysis of validation results involves calculating the average ratings from both validators and practitioners and identifying areas that need improvement. the analysis shows that most components of the electronic student worksheet are rated very highly, with some minor adjustments required to enhance overall quality. this process is crucial to ensure that the developed electronic student worksheet meets high standards and is ready for classroom use.

High reliability and validation scores indicate that the developed electronic student worksheet is highly suitable and reliable for use in teaching physics to eleventh-grade students. positive assessments from content experts and practitioners confirm that the electronic student worksheet is effective in helping students understand vibrations and waves. strong validation ensures that the electronic student worksheet is not only beneficial theoretically but also has a positive impact on classroom learning practices.

The development of electronic student worksheets follows a systematic process involving the stages of define, design, and develop (Kong, 2014; Rothwell & Kazanas, 2011). During the Define stage, the needs and learning conditions are analyzed to ensure alignment with students' requirements and curricular goals (Abdullah & Omar, 2022; Sugiyono, 2010). The Design stage involves creating a comprehensive framework, including standards, objectives, materials, and practice questions, ensuring a holistic educational approach. The Develop stage includes expert appraisals and revisions, which are critical for maintaining high-quality standards before classroom implementation (Arit, Masriani et al., 2023).

Validation is a crucial step in the development of educational tools, ensuring reliability and effectiveness (Sahu, Shrivastava, & Shrivastava, 2013). The electronic student worksheets underwent rigorous validation by content experts and educational practitioners, who rated it highly (Monica, 2023; Supriatna et al., 2024). The content experts' average rating was 92.64%, while educational practitioners gave it a 96.60%, indicating strong agreement on the electronic student worksheets' quality. These evaluations covered various components such as design, illustrations, format, content, and language, ensuring comprehensive quality assurance.

The practicality of the electronic student worksheets was assessed through student feedback, which was overwhelmingly positive. Students scored the electronic student worksheets an average of 94.87%, with the highest marks for layout (98.10%), indicating its visual appeal and effectiveness in enhancing the learning experience. High scores in accessibility (95.83%) and problem-solving effectiveness (90.67%) further affirm the

electronic student worksheets practicality in fostering independent learning and critical thinking skills (Thiagarajan, 1974).

The study's findings have significant implications for educational practices. The high-quality development and validation of the electronic student worksheets underscore the importance of well-designed multimedia learning tools. These tools can enhance students' engagement and comprehension of complex subjects like physics, supporting the broader adoption of multimedia and problem based learning approaches in education. Given the high validation and practicality scores, the electronic student worksheets is ready for widespread use in educational settings (Suryanti, 2023). Its adoption can improve physics instruction, particularly in challenging topics like vibrations and waves. The alignment with students' cognitive processes suggests that such tools can facilitate more effective learning (Jaiswal, 2019; Reeves, 2006). The integration of electronic student worksheets based on problem-based learning presents a promising solution to enhancing student engagement and comprehension in physics. The robust development process, high validation, and positive student feedback highlight the potential of electronic student worksheets to transform traditional teaching methods and improve educational outcomes. Further adoption and adaptation of such tools across various subjects and educational levels are recommended to enhance the overall learning experience (Graham, Woodfield, & Harrison, 2013).

Improving students' problem-solving capabilities is essential in preparing them to tackle real-world challenges effectively (Krzic et al., 2020). Problem-solving skills, as defined by Polya (2014), encompass understanding the problem, devising a plan, executing the plan, and evaluating the results (Katuuk, Sumarauw, & Pulukadang, 2024). These skills involve both cognitive and metacognitive processes, enabling students to think critically and creatively in finding solutions. Integrating these skills into the learning process can significantly enhance students' ability to navigate complex problems.

Electronic student worksheets serve as an innovative educational tool designed to boost student engagement and interactivity. Zamilah et al. (2024) highlights that E-Worksheets can enhance students' learning motivation through interactive features such as videos, animations, and quizzes, which deepen conceptual understanding. The digital format of E-Worksheets also allows for real-time feedback from teachers, enabling students to correct errors and improve their learning outcomes continuously. This interactive and immediate feedback mechanism is crucial in helping students refine their problem-solving strategies effectively.

The integration of E-Worksheets into the learning process has shown positive effects on students' problem-solving capabilities (Harini, Islamia, Kusumaningrum, & Kuncoro, 2023; D. S. Sari et al, 2021). Research by Sa'diah et al (2022) demonstrates that students who

used E-Worksheets exhibited significant improvements in problem-solving skills compared to those who used traditional worksheets. E-Worksheets support both independent and collaborative learning, allowing students to explore lesson materials more comprehensively and in contexts relevant to their daily lives. This comprehensive exploration is essential for developing robust problem-solving skills.

Problem-Based learning is a pedagogical approach that emphasizes developing problem-solving skills through real-life scenarios. According to Savery and Duffy (1995) (1995), PBL encourages students to actively seek solutions to complex problems, involving teamwork and the utilization of various information sources (Savery, 2017). E-Worksheets can be seamlessly integrated with problem based learning to provide step-by-step guidance in problem-solving, helping students organize their thoughts and strategies. This integration ensures that students receive structured support while engaging in complex problem-solving activities, thereby enhancing their skills (Reiser, 2018).

Technology has significantly transformed how students learn and interact with educational content (DePietro, 2013). Mayer (2017) asserts that using technology in education, such as E-Worksheets, can enhance learning effectiveness through more engaging and interactive information presentation. Technology allows for personalized learning, tailored to individual students' needs and abilities, ultimately improving learning outcomes and problem-solving capabilities. This personalized approach ensures that each student receives the support they need to develop their problem-solving skills effectively.

In conclusion, the combination of Electronic Student Worksheets and Problem-Based Learning creates a powerful framework for enhancing students' problem-solving capabilities. E-Worksheets provide interactive, engaging, and personalized learning experiences, while Problem-Based learning offers real-life context and structured guidance in problem-solving. Together, they create a comprehensive approach that prepares students to effectively navigate and solve complex problems, equipping them with the necessary skills for their academic and future professional endeavors.

CONCLUSION

This study found that the use of Electronic Student Worksheets based on Problem-Based learning significantly enhances students' problem-solving capabilities. This finding indicates that the combination of educational technology and problem-based learning approaches can create a more interactive learning environment that supports the development of students' cognitive skills. The research results show that the integration of technology in education not only increases students' motivation and engagement but also provides quick and effective feedback, which is crucial in improving and developing

students' problem-solving skills. Furthermore, Problem-Based learning helps students connect theory with practice through real-world problem contexts, thereby deepening their understanding of the subject matter.

The primary strength of this study lies in its contribution to the field of education, particularly in the use of digital technology to enhance problem-solving skills. This research provides empirical evidence on the effectiveness of E-Worksheets in supporting both independent and collaborative learning. It also offers new insights into how technology can be integrated with traditional learning methods to achieve better learning outcomes. However, this study has several limitations that should be noted. The study is limited to specific contexts, such as certain cases and locations, which may not fully represent the broader population. Additionally, the variation in the age and gender of the students involved in this study is limited, so generalizing these findings to different groups should be done cautiously. The research methods used may also have limitations in terms of the variety of data collection and analysis approaches, which could affect the interpretation of the results. Therefore, further research is needed to explore the effectiveness of PBL-based E-Worksheets in a broader and more diverse context, and with more comprehensive research methods, to confirm these findings and develop a deeper understanding of how technology can support effective learning.

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