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The Effectiveness of Problem-Based Learning-Based E-SWS on Sound Wave Material to Improve Students' Critical Thinking Skills

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ABSTRACT

Critical thinking skills are essential in facing the challenges of the 21st century, especially in physics learning, which requires analysis and problem solving. However, many students still find it difficult to develop these skills, especially in sound wave material, which is abstract and difficult to visualize. This study aims to determine the effectiveness of using PBL-based E-SWS in improving students' critical thinking skills. The method used is quantitative with a posttest-only control group quasi-experimental design. The research subjects were two 11th grade physics classes at SMAS Adabiah Padang: the experimental class used PBL-based E-SWS and the control class used conventional SWS. The instrument consisted of essay questions based on five critical thinking indicators. The results showed that the average posttest score of the experimental class was 73.984, which was higher than that of the control class, which was 63.083. The t-test showed that the t-count value of 2.167 was greater than the t-table value of 2.0003, with a significance level of 5%. These results indicate a statistically significant difference. It can be concluded that PBL-based E-SWS is effective in improving students' critical thinking skills in sound wave material.

INTRODUCTION

The rapid development of science and technology (IPTEK) has driven a global transformation in the education paradigm towards the digital age. The integration of digital technology has now become an integral part of various aspects of life, including the implementation of education in Indonesia. Learning systems can no longer rely solely on conventional methods but must transform in line with the times through the integration of digital technology that can improve the quality of the learning process (Aliyah & Masyithoh, 2024). In the context of globalization, students are required to have 21st-century skills, such as critical thinking, communication, collaboration, and creativity in order to adapt to the demands of the modern world (Mulyani & Haliza, 2021).

The current Indenpendent Curriculum focuses on developing 21st-century competencies, which include critical thinking, problem solving, effective communication, and collaboration in various learning contexts. The Indenpendent Curriculum implemented in Indonesia is a strategic step to improve learning effectiveness through a more meaningful, adaptive, and learner-oriented process. This curriculum is designed to equip students with various important skills covering the cognitive, affective, and psychomotor domains, there by promoting improvements in the quality of both the learning process and outcomes (Natalia & Sukraini, 2021; Suryaman, 2020). In addition, the implementation of learning in the Indenpendent Curriculum requires teachers to create interactive, collaborative learning experiences that are relevant to real-life contexts, so that students can build their understanding independently (Widyastuti et al., 2023). However, the application of this curriculum in terms of technology utilization still faces various challenges. Amidst rapid technological advances, the world of education should not only use digital devices as a supplement, but also make them a key component in supporting the learning process (Mulyasa, 2023; Anggraini, 2025).

Critical thinking skills are one of the key competencies that need to be developed in 21st-century education because these skills help students analyze, evaluate, and solve various complex problems (Faqiroh, 2020). These skills also provide a foundation for students to understand concepts in depth and make the right decisions in academic situations and everyday life. However, based on interviews with a physics teacher at Adabiah High School in Padang, it was found that students' critical thinking skills are still relatively low. This condition shows that students are not yet fully capable of processing information systematically or assessing the validity of an argument independently. One of the factors contributing to this problem is the lack of technology utilization in the learning process. The minimal use of digital media has resulted in students not gaining interactive and challenging learning experiences. Therefore, innovation in the use of learning technology is needed to encourage the improvement of students' critical thinking skills.

The PBL model is one of the learning approaches that is considered relevant to the demands of modern education, because it places students as the main subjects in the learning process and encourages their active involvement in discovering and solving real contextual problems (Hadiat, 2024). PBL enables students to construct knowledge through exploratory, collaborative, and reflective activities, thereby training their critical thinking skills on an ongoing basis. On the other hand, technological developments have led to the emergence of innovative digital teaching materials such as E-SWS, which can increase the effectiveness of learning through interactivity and independent learning (Cahyani & Ahmad, 2024).

The use of PBL-based E-SWS is expected to create more interactive, contextual, and concept-oriented physics learning. In sound wave material, students often have difficulty understanding abstract concepts such as resonance, interference, and sound velocity (Yana et al., 2020). E-SWS allows students to explore these phenomena through digital visualization and problem-based activities that relate physics concepts to everyday life (Yuliana, 2023). Previous studies have shown that the application of PBL-based E-SWS can significantly improve students' critical thinking skills and learning motivation (Nurwijayanti & Sulisworo, 2022).

Based on this, this study was conducted to test the effectiveness of PBL-based E-SWS on sound wave material in improving students' critical thinking skills. The use of E-SWS is expected to create a more interactive and meaningful learning experience. In addition, this study is expected to contribute to the development of technology-based physics learning innovations that are oriented towards strengthening higher-order thinking skills. The findings of this study are also expected to be a reference for educators in designing more creative and adaptive learning. Thus, this study supports the implementation of the Indenpendent Curriculum, which emphasizes active, reflective, and contextual learning.

METHOD

This study applied a quantitative approach with a quasi-experimental method using a posttest-only control group design (Sugiyono, 2019). The design involved two research groups, namely the experimental class, which received treatment through the use of PBL-based E-SWS, and the control class, which used printed SWS. Both groups received the same PBL learning model, but differed in the teaching materials used. The research was conducted at SMAS Adabiah Padang in the even semester of the 2024/2025 academic year.

The research population included all Grade XI Fase F students at SMAS Adabiah Padang, consisting of eight classes. Three classes were physics specialization classes, namely XI F1, XI F6, and XI F7. The sampling technique used purposive sampling, with consideration of initial ability equality based on the results of the First Semester Final Assessment. Normality and homogeneity tests were conducted beforehand to ensure that the population data was normally distributed and had homogeneous variance. Based on the analysis results, two classes that met these criteria, namely class XI F1 and XI F7, were selected as samples. Subsequently, class XI F1 was designated as the experimental class and class XI F7 as the control class.

The instrument used in this study was an essay test based on six critical thinking skill indicators according to Facione (2015), namely interpretation, analysis, inference, evaluation, explanation, and self-regulation. The test was administered after the learning process (posttest) to measure the students' critical thinking skills. Before implementation, the instruments underwent a trial phase to determine their validity, reliability, level of difficulty, and item discrimination. Validity was tested using the Product Moment correlation technique, while reliability was calculated using Cronbach's Alpha formula. Meanwhile, the level of difficulty and discrimination were analyzed based on the guidelines proposed by Sundayana (2016).

This research was conducted based on the syntax stages of the Problem-Based Learning (PBL) model, which includes five main steps, namely: (1) orienting students to the problem, (2) organizing students for learning, (3) conducting independent or group investigations, (4) developing and presenting work or findings, and (5) analyzing and evaluating the problem-solving process (Kurniawati, 2020). The experimental class received learning with the help of PBL-based E-SWS containing interactive videos, illustrative images, and contextual problem-solving activities on sound wave material. The control class carried out learning with the same steps but used printed SWS.

Posttest data were analyzed using inferential statistical tests to obtain more accurate conclusions regarding the effectiveness of the treatment. A normality test was first conducted using the Liliefors test to ensure that the data distribution was normal, thereby fulfilling the basic assumptions of parametric analysis (Sundayana, 2016). After that, a two-variance homogeneity test was conducted using Fisher's test to verify that the variance between the experimental and control groups was equivalent. Fulfilling these two requirements was important so that the hypothesis testing results could be trusted and unbiased. After normality and homogeneity were fulfilled, the next step was to conduct a hypothesis test. The test of equality of two means was performed using the independent two-sample t-test to identify whether there was a significant difference between the two groups. This test aimed to determine the extent to which the treatment given to the experimental class had an effect on students' critical thinking skills. The results of the t-test then became the basis for drawing conclusions about the effectiveness of the learning intervention used.

RESULTS AND DISCUSSION

Result

The results of the research on students' critical thinking skills were obtained from a written test consisting of 10 essay questions. This test was given to both sample classes at the end of the learning period or at the end of the meeting. Based on statistical calculations, the mean ($\bar{X}$), standard deviation (S), and variance (S^2) of the experimental class and control class were obtained. The mean, highest score, lowest score, standard deviation, and variance of the sample class can be seen in Table 1.

Table 1. Student Posttest Results Data

Data Criteria	Eksperiment Class	Control Class
Number of Students	32	30
Average	73.984	63.083
Highest Score	97.5	97.5
Lowest Score	27.5	27.5
Standard Deviation	20.487	19.025

Based on Table 1, it is known that the average posttest score in the experimental class is higher than that in the control class. This shows that the average score of students who use PBL-based E-SWS is higher than that of students who do not use PBL-based E-SWS. The highest and lowest scores of both classes are the same. The standard deviation describes the spread of values from the mean, where the spread of values in the experimental class is slightly greater than in the control class. Variance shows the level of data diversity; the greater the variance, the more varied the students' scores, which may have a positive impact on achievement.

Whether or not this difference in test results has an effect can be determined by conducting a hypothesis test. The hypothesis test is conducted after the data is normally distributed. The normality test is conducted to determine whether the critical thinking skills data is normally distributed or not. The critical thinking skills data used are the posttest data for the experimental class and the control class The normality test used in this study is the Liliefors test. Based on the normality test, the L_h and L_t values at the 5% or 0.05 level can be seen in Table 2.

Table 2. Normality Test for the Sample Class

Class	N	X	S	α	L_h	L_t	Description
Eksperiment	32	73.984	20.487	0.05	0.126	0.157	Normal
Control	30	63.083	19.025		0.146	0.161	Normal

Table 2 shows that the normality test results obtained $L_h$values smaller than L_t values at the 0.05 level for $N_1 = 32$ and $N_2 = 30$. The table shows that the normality test result L_h in the experimental class is 0.126, while the L_h value for the control class is 0.146. The L_t value in the experimental class is 0.157, while the L_t for the control class is 0.161. Therefore, it can be concluded that the data obtained is in accordance with the criteria $L_h < L_t$. In the experimental class, the value is 0.126 < 0.157, and in the control class, the value is 0.1456 < 0.1634, which indicates that the final test results of both sample classes come from a normally distributed population.

Next, to ensure that both sample classes have homogeneous variance, a homogeneity test was performed using Fisher's test. This test aims to determine whether the difference in variance between the two groups is within statistically acceptable limits. Based on the results of the Fisher's test, F_h and F_t values were obtained and then compared at a significance level of 5% or 0.05. The comparison of these two values became the basis for determining whether the variances of the two classes could be said to be homogeneous. If F_h was within the critical value range of F_t, it could be concluded that the variances of the two classes were homogeneous. These results then became the basis for selecting the appropriate follow-up statistical test. The results of this test are presented in Table 3.

Table 3. Sample Class Homogeneity Test

Class	*N*	S^2	*a*	F_h	F_t	Description
Eksperiment	32	419.701	0.05	1.160	1.848	Homogen
Control	30	361.932				

Table 3 shows that the F_h result for the experimental class and control class is 1.160. From the statistical analysis for the F_t value, it is 1.846. Both sample classes have homogeneous variance if the F_h value is less than F_t. The data shows that the sample has an F_h value less than F_t, namely 1.160 < 1.846. This condition indicates that there is no significant difference in variance between the two classes. Thus, it can be said that the experimental class and the control class meet the assumption of variance homogeneity. This result also confirms that the two samples have comparable levels of data diversity. Therefore, the two classes can be further analyzed under the assumption of homogeneous variance.

The hypothesis test used in this study is the test of equality of two means. The test aims to determine whether the formulated hypothesis can be accepted or must be rejected. In both sample classes, the test of equality of two means used is the t-test. The normality test results show that the critical thinking skills data in both classes are normally distributed. In addition, the homogeneity test also shows that both classes have homogeneous variances. Thus, the requirements for performing the t-test have been met. The t-test results can be seen in Table 4.

Table 4. Hypothesis Test

Class	*N*	*a*	*X*	S^2	t_h	t_t
Eksperiment	32	0,05	73.984	419.701	2,167	2.0003
Control	30		63.083	361.932		

Based on Table 4, the value of t_h= 2.167, while the value of t_t= 2.0003 at a level of 0.05 or 5% and df = 60. The acceptance criterion for Ho is if t_h< t_t. Because the value of t_h= 2.167, which means that the value of t_h> t_t, H_0 is rejected and H_1 is accepted. These conditions indicate that there is a significant difference between the treatment group and the control group. Thus, the research hypothesis can be accepted. These results indicate that the use of Problem-Based Learning-based E-SWS in Sound Wave material has an effect on improving students' critical thinking skills.

Discussion

The E-SWS developed in this study not only functions as a digital worksheet, but is also designed to be interactive to support the learning process. This interactive design is realized through the integration of a problem-based learning approach. This integration allows students to be actively involved in identifying problems, analyzing information, and finding solutions. In addition, the digital features used provide a more engaging learning experience. Thus, E-SWS becomes an adaptive and relevant medium for improving the quality of learning. E-SWS is an adaptive medium because it can be tailored to the needs and learning characteristics of students in the classroom. With the support of digital features such as hyperlinks, animations, and interactive navigation, students can explore the material more flexibly. This adaptive capability is increasingly relevant in the context of modern learning, which demands efficiency and accessibility. E-SWS is also designed so that the learning flow remains structured in accordance with the learning objectives.

This E-SWS gives students the freedom to learn independently but in a structured manner, as the steps for solving problems are designed to guide students to understand the material on sound waves gradually and in depth. The material is presented through contextual problem scenarios, such as the Doppler effect, which helps students relate theory to phenomena in everyday life. This contextual approach is very important because, according to Purwanto (2020), critical thinking skills can develop optimally when students are faced with real situations that challenge their understanding. Through the process of responding to and solving these problems, students not only memorize concepts but also learn to analyze, evaluate, and conclude based on the information they have gathered themselves. The contextual approach applied in E-SWS is an important aspect in fostering critical thinking skills. When students are faced with real-world problems, they are encouraged to analyze, evaluate, and draw conclusions based on the information they have obtained themselves. This process provides a more meaningful learning experience than conventional learning. Therefore, students not only understand concepts, but are also able to apply them in new contexts.

The results of data analysis show that the average posttest scores in the experimental class were higher than those in the control class. This finding indicates that the application of PBL-based E-SWS contributes significantly to improving students' critical thinking skills. This improvement also confirms that problem-based learning models can encourage students to be more active in the knowledge construction process. This finding is in line with the research by Nurjanah and Trimulyono (2022), which shows that the use of PBL-based E-SWS is effective in training and developing critical thinking skills. Thus, the implementation of PBL-based E-SWS can be seen as a relevant learning strategy to improve the quality of the learning process.

This improvement in results is due to the interactive nature of E-SWS, which facilitates digital problem-based learning. Students do not just read and answer questions as they do with printed SWS, but also explore through video links, simulations, and reflective activities integrated into E-SWS. This statement is in line with the views of Cahyani and Ahmad

(2024), who state that the integration of digital media in the application of the PBL model can increase the active participation of students in the process of observing phenomena, analyzing data, and drawing conclusions based on empirical evidence. Thus, E-SWS-based learning not only emphasizes cognitive aspects but also trains higher-order thinking processes that require in-depth analysis and evaluation.

The PBL model implemented through E-SWS not only provides an independent learning experience, but also encourages active engagement among students in the problem-solving process. At each stage of PBL, students are encouraged to discuss, test arguments, and refine solutions based on input from other group members. This interactive process helps students develop mutual respect and the ability to consider different perspectives. These collaborative activities also play an important role in building structured scientific communication and the social skills needed for 21st-century learning. Facione (2015) emphasizes that critical thinking skills cannot be separated from the process of working together to test and develop ideas collectively. Thus, the collaboration built through E-SWS can strengthen the process of internalizing concepts more deeply. Therefore, E-SWS is an effective tool for fostering a collaborative learning culture while improving the quality of academic interaction in the classroom.

Learning activities on sound waves that involve virtual experiments can enhance the meaningfulness of the learning process for students. Through these experiments, students can visualize various abstract concepts that are difficult to observe directly, such as frequency, wavelength, and interference patterns. The ability to see these visual representations makes the relationships between physical variables easier to understand. In addition, digital visualization helps students develop a deeper conceptual understanding because they can observe changes dynamically. Research conducted by Nurwijayanti and Sulisworo (2022) also shows that digital visual representations can improve the quality of conceptual understanding compared to traditional lecture methods. These findings reinforce the argument that the use of E-SWS is very effective in science learning. Thus, the integration of virtual experiments into E-SWS can be a relevant learning strategy that supports the achievement of student competencies.

From the learning process perspective, the use of E-SWS allows teachers to act as facilitators who guide students in constructing knowledge. Teachers are no longer the sole source of information, but rather guide students in discovering concepts through problem-based activities. The application of this model also encourages meaningful social interaction among students, thereby improving communication and collaboration skills. This statement is in line with Hadiat's (2024) view that the PBL model is highly relevant to the development of 21st-century skills, as it encourages students to collaborate, communicate, and think critically in an integrated manner.

Overall, this study confirms that innovation in learning is crucial for improving the quality of education, particularly in terms of developing critical thinking skills, which is one of the key indicators in the 21st century curriculum. The use of E-SWS supported by the PBL learning model has been empirically proven to produce higher learning outcomes. Therefore, it is important for educators to start adopting a student-centered approach and utilizing available learning technologies to create a more relevant and challenging learning environment. This study recommends that the implementation of PBL-based E-SWS should not be limited to one subject or level of education, but can be implemented widely because its effectiveness has been proven to improve the quality of the learning process and outcomes. In line with the opinions of Kusumawati and Lestari (2022), the integration of innovative learning models involving digital technology is one of the strategic solutions in responding to current educational challenges that require students to think critically, creatively, and adaptively in facing the complexities of the real world.

CONCLUSION

The results of the study show that the application of Problem Based Learning (PBL)-based E-SWS on sound wave material effectively improves students' critical thinking skills. The significant difference between the experimental class and the control class proves that the use of PBL-based E-SWS provides better learning outcomes. This learning encourages students to think analytically and solve problems independently. The integration of digital technology in E-SWS also increases student motivation and participation during the learning process. PBL-based E-SWS has been proven to create more interactive, contextual, and collaborative learning. This innovation is in line with the demands of the Indenpendent Curriculum and 21st-century skills. Thus, PBL-based E-SWS is recommended as an effective physics learning medium for developing students' critical thinking skills.

REFERENCE

Aliyah, H., & Masyithoh, S. (2024). Tinjauan Literatur: Peran Teknologi Digital dalam Meningkatkan Kualitas Pembelajaran di Sekolah. *Jurnal Teknologi Pendidikan dan Pembelajaran*, 1(4), 17-26 .

Anggraini, A. D. (2025). Integrasi Teknologi Pendidikan dalam Kurikulum Merdeka Berbasis Nilai-Nilai Pancasila. *Jurnal Kiprah Pendidikan*, 4(3), 402–410.

Cahyani, V. P., & Ahmad F. (2024). Efektivitas Problem Based Learning terhadap Keterampilan Berpikir Kritis, Hasil belajar dan Motivasi Siswa. *Journal of Sustainable Innovation on Education, Mathematics and Natural Sciences,* 3(2), 76-82.

Duri, R. N., Dewi, W. S., Hufri, H., & Hidayati, H. (2024). Pengembangan E-LKPD Berbasis Problem Based Learning Pada Materi Gelombang Bunyi Yang Memuat Keterampilan Berfikir Kritis Siswa. *Jurnal Pendidikan Tambusai*, 8(1), 9481–9489.

Facione, P. A. (2015). *Critical Thinking: What It Is and Why It Counts*. Insight Assessment.

Faqiroh, Z. (2020). Problem Based Learning Model for Junior High School in Indonesia. *Journal of Curriculum and Educational Technology Studies,* 8(1), 42-48.

Hadiat, H. (2024). Metode Pembelajaran Inovatif Kurikulum Merdeka: Integrasinya Dengan Kterampilan Abd-21. *Jurnal Pendidikan Agama Islam,* 2(2), 236-253.

Hidayah, F. N. (2022). PhET Simulation Berbasis PBL pada Materi Gelombang Elektromagnetik untuk Meningkatkan Keterampilan Berpikir Kritis. *Repository Universitas Lampung.*

Kurniawati, T. (2020. *Model Pembelajaran*. Purwokerto: CV IRDH.

Kusumawati, E., & Lestari, I. (2022). Inovasi Pembelajaran Berbasis Digital dalam Meningkatkan Keterampilan Berpikir Kritis Siswa. *Jurnal Pendidikan Inovatif*. 5(3), 120–130.

Masrinah, E, N, dkk. (2019). Problem Based Learning (PBL) Untuk Meningktakan Keterampilan Berpikir Kritis. *Seminar Nasional Pendidikan, 1, 924-932.*

Mukti, W.A.H. (2024). *Pengembangan e-LKPD Berbasis Pembelajaran Berbasis Proyek untuk Mata Pelajaran Fisika* Mulyani, F., & Haliza, N. (2021). Analisis Perkembangan Ilmu Pengetahuan dan Teknologi (Iptek) Dalam Pendidikan. *Jurnal Pendidikan dan Konseling,* 3(1), 101-109.

Mulyani, F., & Haliza, N. (2021). Analisis Perkembangan Ilmu Pengetahuan dan Teknologi (Iptek) Dalam Pendidikan. *Jurnal Pendidikan dan Konseling,* 3(1), 101-109.

Mulyasa E. (2023). *Implementasi Kurikulum Merdeka*. Jakarta Timur. PT Bumi Aksara.

Murih, R. (2023). Pengembangan e-LKPD berbasis masalah terintegrasi STEM untuk melatih keterampilan berpikir kritis dan keterampilan pemecahan masalah. *Repository Universitas Lampung.*

Natalia, K., & Sukraini, N. (2021). Pendekatan Konsep Merdeka Belajar dalam Pendidikan Era Digital. *In Prosiding Seminar Nasional IAHN-TP Palangka Raya*, 9(3), 22–34.

Nurjanah, N., & Trimulyono, G., (2022). Pengembangan E-LKPD Berbasis Problem Based Learning untuk Melatihkan Keterampilan Berpikir Kritis pada Materi Hereditas Manusia. *Jurnal Berkala Ilmiah Pendidikan Biologi (BioEdu),* 11(3), 765-774.

Nurwijayanti, S., & Sulisworo, D. (2022). Pengembangan LKPD Berbasis Problem Based Learning pada Materi Gelombang. *Journal AdMathEdust.* 9(2), 41-46.

Purwanto, A. (2020). Strategi Pembelajaran Kontekstual dalam Pendidikan Abad 21. *Jurnal Pendidikan Progresif*. 10(1), 57–65.

Sinaga, K., Festiyed, F., Asrizal, A., & Suherman, D. S. (2024). Pengaruh Model Problem Based Learning Berbantuan E-LKPD Terhadap Kemampuan Berpikir Kritis Siswa Pada Pembelajaran Fisika Materi Gelombang Bunyi Dan Cahaya. *Jurnal Pendidikan Tambusai*, 8(3), 44398–44406.

Sugiyono. (2019). *Metode Penelitian Kuantitatif, Kualitatif, dan R&D*. Bandung: Alfabeta.

Sundayana, R. (2016). *Statistika Penelitian Pendidikan.* Bandung: Alfabeta

Suryaman, M. (2020). Orientasi Pengembangan Kurikulum Merdeka Belajar. *Seminar Nasional Pendidikan Bahasa Dan Sastra*, 1(1), 13–28.

Widyastuti, R., Widiastuti, A. A., Febe, R., & Seviyani, A. (2023). Penerapan Kurikulum Merdeka Pada Sekolah Menengah Kejuruan Program Keunggulan Studi Kasus SMK Tanjung Priok. *Jurnal Basicedu*, 7(5), 3180-3185.

Yana, A. U., Antasari, L., & Kurniawan, B. R. (2020). Analisis Pemahaman Konsep Gelombang Mekanik Melalui Aplikasi Online Quizizz. *Jurnal Pendidikan Sains Indonesia*, 7(2), 143–152.

Yuliana, R. (2023). Pengaruh Model Problem Based Learning Berbantuan E-LKPD terhadap Kemampuan Berpikir Kritis Peserta Didik pada Materi Gelombang Bunyi. *Repository Universitas Lampung.*

Yuzan, I. F., & Jahro, I. S. (2022). Pengembangan e-LKPD Berbasis Inkuiri Terbimbing pada Pokok Bahasan Ikatan Kimia untuk Mengukur Kemampuan Berpikir Kritis Siswa. *Jurnal Pendidikan dan Inovasi Pembelajaran Saburai*. 2(1), 54-65.

Zohar, A., & Dori, Y. J. (2003). Higher Order Thinking Skills and Low-achieving Students: Are They Mutually Exclusive? *The Journal of the Learning Sciences, 12*(2), 145-181.