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Role of Physics Student Worksheet Integrated PBL Model to Improve the 21st Century: A Systematic Literature Review

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ABSTRACT

This study aims to systematically analyze the role of Problem-Based Learning (PBL)-b Student Worksheets in improving 21st-century skills, which include critical, creative, collaborative, and communicative thinking skills in physics learning. The method employed is a literature review, examining 15 relevant national and international articles published between 2015-2025. The results of the study show that the implementation of PBL-based student worksheet is consistently able to improve critical thinking skills through scientific analysis and reflection activities, as well as encourage students' creativity in producing innovative ideas based on contextual problems. In addition, the incorporation of collaboration rubrics and digital-based activities has been proven to strengthen interaction, responsibility, and communication between students in physics learning. The integration of digital collaboration aspects and authentic assessment makes the student worksheet not only a learning medium but also a means of strengthening scientific character and social skills in the 21st century. This research makes an important contribution to the development of PBL-based physics learning tools that are relevant to the challenges of the digital era and can be used as a reference for teachers and curriculum developers to create active, reflective, and collaborative learning.

INTRODUCTION

The development of science and technology in the 21st century has brought about a major change in the educational paradigm around the world. Education is no longer only oriented towards mastering concepts and memorization, but must be able to equip students with high-level, adaptive, and collaborative thinking skills in order to face the complexity of global problems (Thornhill-Miller et al., 2023). In this context, the essential competencies for the 21st century, often referred to as the 4C, include Critical Thinking, Creativity, Communication, and Collaboration are the main focus in the modern curriculum. These four skills are the foundation for forming a profile of students who are able to think logically, generate innovation, work together in teams, and communicate ideas effectively in various situations (Mardhiyah et al., 2021).

Physics learning as a branch of science has an important role in fostering these skills because it is contextual, analytical, and applicable to daily life. However, most students still

have difficulty in associating physics concepts with real phenomena (Hayati & Nuriyah, 2023). The learning process in the classroom is still dominated by lecture methods and is oriented towards the final result, not the thinking process (Hayati & Nuriyah, 2023). As a result, students' 21st-century skills, especially critical and creative thinking skills, have not been optimally developed. Therefore, a learning tool and model that is able to foster active, independent, and reflective learning activities is needed.

One of the tools that can direct students towards active learning is the Student Worksheet. The student worksheet functions as a guide for students' activities in finding concepts through investigation, discussion, and reflection activities (Nazira et al., 2024). In the current digital era, student worksheets have evolved into an e-student worksheet that combines elements of technology to increase student motivation and engagement (Umar & Yakub, 2025). However, the effectiveness of a student worksheet is not only determined by its format, but also by the learning approach that underpins it. One of the most relevant approaches to cultivating 21st-century skills is Problem-Based Learning (Zhang & Ma, 2023).

The Problem-Based Learning (PBL) model positions students as the main focus of the learning process by presenting contextual problems that motivate them to analyze, investigate, and independently discover solutions (Zhang & Ma, 2023). Through the stages of problem orientation, data collection, group discussions, and reflection on results, students are actively involved in constructing their own knowledge. Problem-Based Learning (PBL) has been shown to enhance students' critical thinking abilities and their comprehension of scientific concepts (Khovivah et al., 2022), as well as develop scientific attitudes such as curiosity, cooperation, and responsibility. The incorporation of PBL in the student worksheet provides a great opportunity for teachers to integrate challenging problem-solving activities while facilitating higher-level thinking skills (Matsuda et al., 2024).

Problem-Based Learning (PBL) has been demonstrated to effectively develop students' critical thinking skills and deepen their understanding of scientific concepts (Hayati & Nuriyah, 2023). Project-based student worksheet PBL is also able to encourage student creativity in designing innovative solutions to environmental problems (Ardha & Emiliannur, 2025). In addition, the use of the PBL student worksheet resulted in an increase in N-Gain values of 0.57 in critical thinking skills, indicating high effectiveness in practicing analysis and evaluation (Khovivah et al., 2022). The importance of collaboration rubrics in student worksheet -PBL has also been emphasized because it is able to increase cooperation and group communication in science learning (Prafitasari et al., 2024).

However, most of the existing research still focuses on the development of critical and creative thinking aspects, while the communicative and collaborative dimensions have not been studied in depth. In fact, both aspects are equally important to form a complete profile of 21st-century learners (Kain et al., 2024). This shows that there is a research gap that needs to be bridged, namely by comprehensively examining how PBL-based student worksheet can improve the four 4C skills simultaneously. This study is important to provide an empirical mapping of the direction of student worksheet PBL development in Indonesia in the last five years (2015–2025).

Based on this, this study aims to systematically analyze the role of student worksheet based on Problem-Based Learning in improving 21st-century skills, which include critical, creative, communicative, and collaborative thinking skills. Through the literature review approach, this research is expected to contribute to strengthening the theoretical basis for the development of PBL-based learning tools, as well as providing practical recommendations for physics educators in designing learning that is relevant to the demands of the 21st century.

This literature review aims to systematically analyze how the integration of the Problem-Based Learning (PBL) model in student worksheets contributes to enhancing students' 21st-century skills, which include critical, creative, communicative, and collaborative thinking

abilities. In addition, this study seeks to identify recent research trends, the extent of each skill's contribution, and the remaining research gaps in the field of PBL-based learning tools. Through this systematic analysis, the study is expected to strengthen the theoretical framework of 21st-century physics education and provide insights for the practical implementation of PBL-oriented student worksheets. The results are anticipated to offer theoretical reinforcement and evidence-based recommendations for the design of innovative and effective physics learning media. Thus, the findings of this research can serve as both an academic reference and a practical guideline for teachers, curriculum developers, and researchers focusing on 21st-century physics education innovations.

METHODS

This study uses a qualitative approach with a literature review-based research design. This approach was chosen because it is suitable for analyzing and synthesizing various previous research results related to the development of Problem-Based Learning Student Worksheets and improving 21st-century skills. The qualitative method is employed to interpret the data in depth through the content analysis process, enabling the researcher to understand the conceptual relationship between the application of the PBL model and the development of 4C skills (critical thinking, creativity, communication, and collaboration).

The articles used as study materials in this study are selected based on four main criteria, ensuring that the analysis results are focused and relevant. First, the article must discuss the topic of developing or implementing Problem-Based Learning (PBL)-based Student Worksheets in physics or science learning. Second, the research includes at least one indicator of 21st-century skills, namely critical, creative, communicative, or collaborative thinking. Third, the article will be published in the period 2015–2025 to ensure up-to-date data and conformity with the latest research directions. Fourth, the selected article must be available in full-text form so that it can be analyzed methodologically and thematically more comprehensively.

The scope of this research includes conceptual, theoretical, and empirical analysis of the development and application of PBL-based student worksheet in improving students' 21st-century skills in physics learning. The focus of the study is directed at the identification of the role of PBL in shaping a learning environment that emphasizes contextual problem-solving, collaboration, and critical reflection. In addition, the study also covers aspects of LKPD design (structure, content, and integration of PBL syntax), the results of validity and practicality tests, and their impact on critical, creative, communicative, and collaborative skills indicators. This scope also considers the variation in educational contexts as well as the integration of digital technology in the development of Student Worksheets. Thus, this review not only describes the empirical conditions but also examines the theoretical and practical implications of the application of PBL-based Learner Worksheets to 21st-century physics learning innovations.

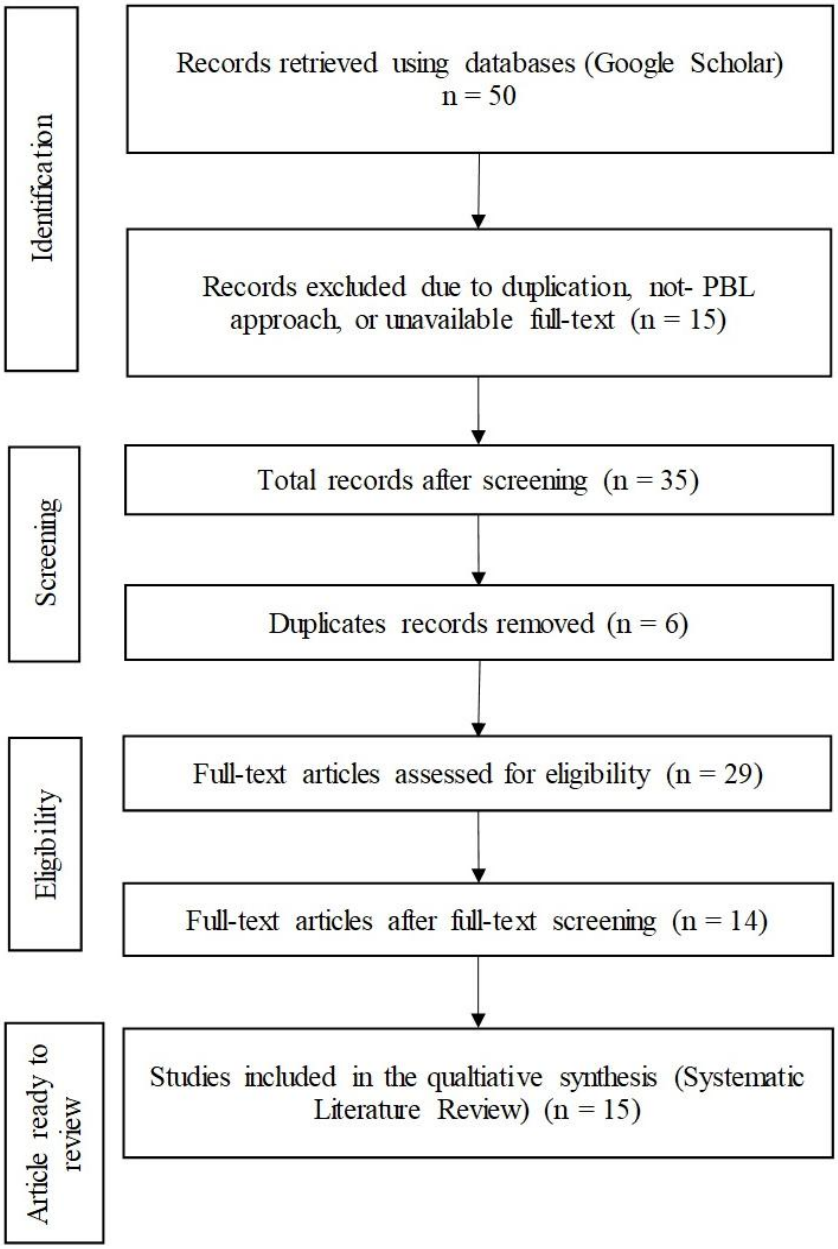

Figure 1 Flow diagram of Literature Selection Process

The literature review process is carried out systematically following the *Systematic Literature Review (SLR) stage*, which includes five main steps. The first step is to identify the literature, which is to search for scientific articles using keywords such as "Problem-Based Learning-based Learner Worksheet", "4C skills", "21st century skills", and "21st century physics learning". The second step is screening, which is to filter articles based on the suitability of the topic and the quality of the publication. The third step, eligibility, reviews the content of the article in full to ensure its relevance to the focus of the research. The fourth step is data extraction, where important information such as the objectives, methods, and main results of the research is taken for analysis. The final step is data synthesis, which is to integrate the results of the study into conceptual patterns and thematic findings that illustrate the contribution of PBL-based Student Worksheets to strengthening 21st-century skills.

The analysis process is carried out through a qualitative descriptive approach by applying three main stages, namely data reduction, concept mapping, and synthesis of

findings. At the data reduction stage, the researcher selects the research results that are most relevant to the purpose of the study and eliminates the literature that does not meet the criteria. The concept mapping stage was carried out by grouping articles based on four categories of 21st-century skills, namely critical thinking, creative, communicative, and collaborative. Furthermore, at the stage of synthesis of findings, the researcher conducts comparative analysis and critical interpretation of the results of the reviewed research to find the general trends, advantages, and limitations of each study. This process provides a comprehensive overview of the relationship between the implementation of PBL-based Learner Worksheets and 21st-century skill ups, while providing direction for the development of more effective, innovative learning models in the future.

RESULTS AND DISCUSSION

Results

The results of the research can be presented in the form of descriptives, tables, or graphs. The author determines the presentation of results in the form of tables or graphs only; If a table is selected, it is no longer necessary in the form of a graph, and vice versa. Analysis and interpretation of these results are necessary before they are discussed.

Table 1. Critical Thinking Skills

Writer	Year of publication	Article Type	Result
Gusti & Ratnawulan	2021	National	An interactive e-student worksheet helps students understand concepts more deeply through contextual problem analysis, significant improvement in the aspects of analysis and evaluation.
Munawaroh & Budijastuti	2023	National	LKPD PBL improves students' critical thinking skills in aspects of scientific interpretation and reasoning; The results of validity and practicality indicate the category of "Excellent".
Triwahyudianto, Isnani, & Kumala	2024	National	PBL-based e-student worksheet improves the understanding of science concepts and critical thinking skills of elementary school-age children through problem-based exploration.
Khovivah, Gultom, & Lubis	2022	National	The application of PBL-based student worksheet increased the N-Gain to 0.57; Students are more skilled at analyzing experimental data and crafting logical arguments.
Azrina & Sandika	2023	National	PBL-based e-student worksheet has been proven to be effective in improving critical thinking skills through discussions, data analysis, and evaluation of experimental results.
Damayanti et al.	2024	National	The student worksheet is validated by experts in the category of "very feasible"

			(validity of 89%); Limited trials showed improved students' analytical abilities.
Susanti, Nurhanurawati, & Rohman	2024	National	Student worksheet*:* PBL improves children's critical thinking skills through simple experimental activities and reflection on learning outcomes.

Based on the data presented in Table 1, the results of the reviewed studies indicate that the implementation of *Problem-Based Learning (PBL)*-based Student Worksheets has a significant impact on improving students' critical thinking skills. The integration of PBL in learning activities helps students understand scientific concepts more deeply through contextual problem-solving (Evanti & Mawartingsih, 2024). Similarly, Munawaroh and Budijastuti (2023) found that PBL-based worksheets enhance students' ability to interpret and reason scientifically, with high validity and practicality scores. Triwahyudiaton, Isnani, and Kumala (2024) also demonstrated that PBL-based *e-student worksheets* improve students' comprehension of science and critical thinking through exploration-based learning. Furthermore, Khoiriyah, Gultom, and Lubis (2022) reported an *N-Gain* of 0.57, indicating increased skills in data analysis and logical reasoning. Azrina and Sandika (2023) confirmed that this learning tool effectively develops critical thinking through discussion and data evaluation, while Damayanti et al. (2024) validated the worksheet's feasibility for classroom application. Therefore, it can be concluded that PBL-based Student Worksheets play an essential role in strengthening students' analytical, evaluative, and reasoning skills, fostering a more active and reflective learning process compared to conventional methods.

The data in Table 2 presents research findings that focus on the role of *Problem-Based Learning (PBL)*-based Student Worksheets (LKPD) in developing students' creative thinking skills. Overall, the implementation of PBL-based Student Worksheets has been proven effective in encouraging students to generate innovative ideas, demonstrate originality, and apply flexible thinking in solving contextual problems. Through exploration activities, students are trained to design creative products, construct alternative solutions, and express imaginative ideas that go beyond conventional learning approaches. The integration of PBL syntax into the Student Worksheets enables students to engage in meaningful learning experiences that stimulate creativity and innovation. These findings indicate that PBL-based Student Worksheets serve as an effective medium for fostering creative thinking abilities, which are essential components of 21st-century learning competencies.

Table 2. Creative Thinking Skills

Writer	Year of publication	Type of article	Result
Ardha & Emiliannur	2025	National	LKPD PBL helps students come up with innovative ideas in solving problems; The improvement is seen in the aspects of originality and elaboration.
Widiyono & Ghufron	2024	National	The use of project-based student worksheet trains students' creativity in designing science models and coming up with alternative solutions.
Zulfa et al.	2023	National	The integration of local wisdom in student worksheet increases students' imagination and thinking flexibility;

			Posttest results showed an average increase of 26%.
Yunita et al.	2024	National	Project-based LKPD brings out new ideas and creativity in learning products that are more diverse than conventional learning.

The data in Table 2 shows the results of research that focuses on the role of Problem-Based Learning (PBL)-based Student Worksheets in developing students' creative thinking skills. Based on the analysis, the implementation of PBL-based Student Worksheets can foster the ability to generate new ideas, increase originality, and encourage flexibility in problem-solving. Each study shows an increase in student creativity, both in designing alternative solutions and in creating more innovative learning products compared to conventional learning. Thus, it can be concluded that PBL-based Student Worksheets play a significant role in facilitating the development of students' creative thinking aspects at various levels of education.

Based on the Table, it can be concluded that all studies confirm the effectiveness of PBL-based student worksheet in increasing students' creativity and innovative thinking. This student worksheet stimulates the emergence of new ideas, originality, imagination, and flexibility in thinking, while creating a more meaningful learning experience when compared to traditional approaches.

The data in Table 3 shows research results that emphasize the role of Problem-Based Learning (PBL)-based Student Worksheets (LKPD) in developing students' communication skills. In general, the use of PBL-based LKPD has proven effective in improving students' ability to convey ideas, explain scientific reasoning, and actively participate in group discussions. Through problem-solving and reflection activities, students are trained to articulate ideas verbally and in writing in a more systematic and data-driven manner. These findings indicate that the integration of PBL syntax into LKPD not only promotes conceptual understanding but also strengthens scientific communication competencies, which are an essential part of 21st-century skills.

Table 3. Communicative Thinking Skills

Writer	Year of publication	Type of article	Result
Wiwik Karuniawati, et al	2021	National	The physics learning tools developed were declared valid, practical, and effective in learning, and succeeded in improving students' communication skills.
Kiki Kurniawan, Haninda Bharata, & Syarifuddin Dahlan	2019	Nasional	The use of a Problem-Based Learning (PBL)–based student worksheet proved effective in improving learners' mathematical communication skills and self-confidence. Students showed greater ability to convey their thoughts and reasoning clearly, both in written form and during oral discussions of problem solutions.
Joni Wilson Sitopu, Ika Rosenta	2023	Nasional	Implementing the PBL approach led to a notable enhancement in students' mathematical communication abilities when compared to traditional instruction. Learners became more

Purba, & Dewi Asriyati			adept at presenting arguments, utilizing data to justify their reasoning, and participating actively in meaningful classroom discussions.
Sukti Nurwijayanti & Dwi Sulisworo	2022	Nasional	The integration of PBL within the developed e-LKPD enhanced students' proficiency in conveying mathematical concepts clearly. The interactive features of LiveWorksheet also supported collaborative dialogue and the sharing of ideas among classmates.
Ayu Arum Sari & Dyah Purwaningsih	2024	Nasional	The PBL-based e-LKPD supported by LiveWorksheet helped students articulate scientific reasoning and explanations more effectively during group tasks. The learning results indicated progress in communication aspects consistent with the competencies required in 21st-century education.

The results of the data analysis in Table 3 indicate that the implementation of Problem-Based Learning (PBL)-based Student Worksheets has a significant impact on improving students' communication skills. All reviewed articles demonstrate that learning using the PBL approach encourages students to express ideas, explain their thought processes, and defend arguments logically both orally and in writing. Student Worksheets designed with PBL syntax provide space for students to collaborate and interact actively in the problem-solving process, thus optimally developing their scientific communication skills. The integration of technology such as LiveWorksheet has also been shown to expand the reach of communication between students through interactive discussions and direct feedback. This improvement in communication skills not only reflects success in the cognitive aspect but also strengthens students' social and emotional dimensions in learning. Thus, PBL-based Student Worksheets play an important role as a learning medium capable of fostering scientific communication skills, which.

The data in Table 4 presents research findings highlighting the role of Problem-Based Learning (PBL)-based Student Worksheets (LKPD) in enhancing students' collaborative skills. Overall, the implementation of LKPD with a PBL approach encourages students to actively collaborate in solving problems, share responsibilities, and communicate ideas effectively within groups. The use of collaborative rubrics and the integration of learning technology have also been shown to strengthen student coordination, shared reflection, and teamwork. This demonstrates that PBL-based LKPD functions not only as a means of independent learning but also as a medium for strengthening social interactions that support collaborative learning in the 21st century.

Table 4. Collaborative Thinking Skills

Writer	Year of publication	Type of article	Result
Prafitasari, Sa'adah, & Eurika	2024	national	The use of collaborative rubrics in LKPD increases the responsibility and involvement of group members during problem investigation.
Novendra et al.	2024	National	Group task-based student worksheet improves coordination and communication; The value of

			collaboration increased from 72% to 88%.
Dewi	2023	National	Online collaboration increased through group discussion activities and digital reflection; Students show high enthusiasm for teamwork.

Based on the research results summarized in Table 4, it appears that the implementation of collaborative-based student worksheets (LKPD) can significantly improve students' collaborative thinking skills. Prafitasari, Sa'adah, and Eurika (2024) showed that the use of collaborative rubrics in student worksheets can foster a sense of responsibility and active involvement of each group member in the problem-solving process. This finding is supported by research by Novendra et al. (2024) which revealed that group-based task activities can improve coordination and communication between students, with collaboration scores increasing from 72% to 88%. Furthermore, Dewi's (2023) research confirmed that online discussion and digital reflection activities can foster a spirit of cooperation and enthusiasm among students within a team. Overall, these three studies demonstrate that collaboration-based learning through student worksheets and digital platforms plays a crucial role in developing collaborative thinking skills, which are a 21st-century competency.

Discussion

The results of this study confirm that PBL-based student worksheets play an important role in developing students' critical thinking skills, creativity, and collaboration (Evanti & Mawartiningsih, 2024; Khovivah, Suparman, & Hidayat, 2022). These findings are in line with previous research showing that the application of PBL significantly improves students' analytical and scientific reasoning abilities (Zhang & Ma, 2023; Matsuda, Tanaka, & Suzuki, 2024). The main advantage of this research lies in the integration of digital collaboration aspects and the use of collaboration rubrics, which have been proven to strengthen interaction between students, group responsibility, and creativity more thoroughly (Seifert, 2024; Kain, Johnson, & Miller, 2024). Thus, this research makes an important contribution to PBL-based physics learning through the development of integrated tools that incorporate 21st-century skills, as well as providing a practical reference for teachers and developers of teaching materials at the high school level (Thornhill-Miller, Brown, & Patel, 2023).

In addition, various previous studies, including Ardha and Emiliannur (2025) and Widiyono and Ghufron (2024), revealed that the use of student worksheets based on Problem-Based Learning (PBL) has been proven to stimulate originality, flexibility of thinking, and the skill of developing students' ideas through exploration and reflection activities (Utami & Nurhidayati, 2023). This approach encourages students to think divergently and create innovative solutions relevant to the problems faced (Zulfa, Putri, & Sari, 2023). This research not only strengthens these findings but also complements them with a collaborative creativity dimension that explores how group dynamics in learning can give birth to new ideas collectively (Rahmawati & Prasetyo, 2022). The collaborative process during learning creates space for students to inspire each other, provide input, and construct common thoughts, so that the creativity formed is both individual and social (Ardha & Emiliannur, 2025). The findings of the study show that a PBL-based student worksheet that combines digital collaboration activities and creativity assessment rubrics has succeeded in stimulating original and flexible thinking (Yu, 2024; Widiyono & Ghufron, 2024). This occurs because students are actively involved in the exchange of perspectives, the assessment of ideas, and the process of innovating together. The integration of collaborative and project-based activities in LKPD strengthens students' creativity both individually and in groups (Zhang & Ma, 2023).

Based on literature reviews related to collaboration aspects, researchers such as Prafitasari, Anggraini, and Lestari (2024), Novendra, Rahman, and Fauzi (2024), and Dewi (2023) have proven that the use of LKPD equipped with collaboration rubrics and group activities is effective in developing a sense of responsibility, communication skills, and the ability to cooperate between students (Kain et al., 2024). This study expands on these findings by revealing a new dimension, namely that the effectiveness of collaboration is not limited to traditional face-to-face environments but can also be significantly realized through digital platforms and online reflection processes (Alghamdi, Alzahrani, & Hakim, 2023; Ma'arif, Ningsih, & Ridho, 2023). The integration of technology in the student worksheet allows greater flexibility in discussing, exchanging ideas, and providing feedback to each other, thus creating more dynamic and in-depth learning interactions (Matsuda et al., 2024). These findings are supported by Alghamdi et al. (2023), who also affirm that digital-based collaborative learning improves student motivation and the quality of interaction across learning contexts (Kain et al., 2024). Thus, this study makes a significant contribution to the development of physics learning in the modern era by emphasizing that digital collaboration can function as an effective medium to foster a spirit of cooperation, productive communication, and collective responsibility in the learning process (Thornhill-Miller et al., 2023).

Based on a study conducted by Wiwik Karuniawati (2021), the physics learning tools developed have been proven to meet the criteria of validity, practicality, and effectiveness in the teaching and learning process, while successfully improving students' communication competence (Rahmawati & Prasetyo, 2022). These findings confirm that a systematically designed learning tool involving students' active participation can encourage improved quality of interaction and articulation of ideas during learning (Utami & Nurhidayati, 2023). The results of this study further strengthen the view of scientific communication as a crucial 21st-century competence that needs to be developed through an active and collaborative learning approach (Thornhill-Miller et al., 2023). These findings are also in line with various previous studies, including Rahmawati and Prasetyo (2022) and Utami and Nurhidayati (2023), which concluded that the use of student worksheets and active learning model-based devices, such as PBL, plays a role in improving students' ability to express opinions, make scientific arguments, and present the results of their thoughts with confidence (Kain et al., 2024).

In general, the findings of this study indicate that developing student worksheets based on the Problem-Based Learning (PBL) model plays a significant role in enhancing students' critical thinking, creativity, collaboration, and communication skills as components of strengthening 21st-century competencies (Thornhill-Miller et al., 2023; Kain et al., 2024). The integration of digital collaboration aspects, assessment rubrics, and problem-based activities makes the student worksheet not only function as a learning medium but also as a means of forming scientific character, social responsibility, and students' reflective abilities in solving contextual problems (Ma'arif et al., 2023). This research not only strengthens previous findings but also contributes new insights to the development of physics education through the design of a student worksheet that combines problem-based learning with digital technology to create active, interactive, and collaborative learning (Zhang & Ma, 2023; Matsuda et al., 2024). Thus, the results of this study are expected to be a practical reference for educators and developers of teaching materials in designing learning that is not only oriented towards mastering concepts but also on the development of high-level thinking skills, collaborative skills, and effective scientific communication to face modern educational challenges (Thornhill-Miller et al., 2023; Kain et al., 2024).

CONCLUSION

Based on the conducted literature review, it can be concluded that student worksheets designed using the Problem-Based Learning (PBL) approach make a significant contribution to developing students' 21st-century skills, particularly in the areas of analytical ability, creativity, collaboration, and communication. By combining collaboration rubrics, problem-solving activities, and the use of digital technology, student worksheet have proven to be a learning tool that is able to build students' analytical competence, social responsibility, and scientific communication capacity. This research not only confirms previous findings but also presents a new perspective by highlighting the need for digital collaboration and online reflection as an essential component in today's physics learning. Therefore, the results of this analysis are expected to be a conceptual foundation and implementation guide for educators in creating effective PBL-based learning tools.

REFERENCES

Abdillah, D. M., & Astuti, D. (2020). Pengembangan lembar kerja peserta didik (LKPD) berbasis problem-based learning (PBL) pada topik sudut. *PYTHAGORAS: Jurnal Matematika dan Pendidikan Matematika, 15*(2), 190–200.

Ardha, R., & Emiliannur, A. (2025). The design of the student worksheet (LKPD) integrated with problem-based learning (PBL) to facilitate students' creative thinking skills. *Journal of Innovative Education, 13*(2), 145–158.

Azrina, N., & Sandika, B. (2023). The development of e-LKPD based on problem-based learning to train students' critical thinking skills on respiratory system material in class XI science. *Journal of Nusantara Biology Education, 10*(1), 34–45.

Damayanti, L., Rahmadani, E., & Syahrial, D. (2024). Development of PBL-based LKPD: A study of validity and practicality for critical thinking skills in elementary mathematics learning. *Journal of Basic Learning Innovation, 8*(1), 11–20.

Dewi, F. S. (2023). Development of digital LKPD to improve critical thinking skills and train collaborative skills of grade XI students. *Journal of Science and Technology Education, 11*(2), 95–106.

Gusti, D. A., & Ratnawulan. (2021). Efektivitas LKPD IPA terpadu tema energi dalam kehidupan dengan PBL terintegrasi pembelajaran abad 21 untuk meningkatkan sikap peserta didik. *Jurnal Penelitian dan Pembelajaran Fisika, 7*(1), 77–84.

Hayati, N., & Nuriyah, T. S. (2023). Development of LKPD PBL (problem-based learning) model in training students' critical thinking skills. *Journal of Binomial Studies, 6*(2), 175–185.

Kain, C., Koschmieder, C., Matischek-Jauk, M., & Bergner, S. (2024). Mapping the landscape: A scoping review of 21st century skills literature in secondary education. *Teaching and Teacher Education, 151,* 104739.

Khovivah, R., Gultom, R., & Lubis, E. (2022). The development of LKPD based on problem-based learning and its influence on students' critical thinking skills. *Journal of Science Learning Innovation, 8*(2), 102–111.

Kurniawan, K., Bharata, H., & Dahlan, S. (2019). Pengembangan LKPD berbasis PBL untuk meningkatkan kemampuan komunikasi matematis dan self confidence peserta didik. *Jurnal Pendidikan Matematika Universitas Lampung, 7*(1).

Kurniawati, W., Harjono, A., Gunawan, G., Busyairi, A., & Taufik, M. (2021). Development of project-based physics learning tools to improve students' communication skills. *Journal of Physics and Technology Education, 7*(2), 141–146.

Ma'arif, M., Nissa, D. F., Aulia, S. S., & Immaniar, D. N. (2023). The use of live worksheets as e-LKPD pancasila education materials for intercultural collaboration in Indonesia. *Journal of Social Morality, 8*(1), 16–23.

Matsuda, Y., Falcon, A., Porter, A., Royer, A., Mohnkern, L., Vergara, D., & Valiente, Y. (2024). Implementation of problem-based learning modules in an introduction to public health course. *Frontiers in Public Health, 12,* 1405227.

Munawaroh, N. A., & Budijastuti, W. (2023). Development of PBL-based LKPD on respiratory system materials to train critical thinking skills of high school grade XI students. *Journal of Biology and Science Education, 12*(2), 87–96.

Nazira, N. K., Idris, S., Widya, W., Novita, N., & Setiawan, T. (2024). Pengembangan LKPD fisika berbasis PBL untuk meningkatkan pemahaman konsep peserta didik pada materi gerak lurus. *OPTIKA: Jurnal Pendidikan Fisika, 8*(1), 118–127.

Novendra, A., Prasetya, D., & Wulandari, R. (2024). The development of PBL-based e-LKPD has the potential to train high school students' collaboration skills on simple harmonic motion materials. *National Journal of Physics Education, 8*(2), 133–142.

Prafitasari, A. N., Sa'adah, U., & Eurika, L. (2024). Development of LKPD environmental change material based on the rubric of 21st century learning design class X collaboration ability. *Journal of Physics Education and Learning, 9*(1), 33–44.

Sari, A. A., & Purwaningsih, D. (2023). Pengembangan e-LKPD berbasis problem-based learning (PBL) dengan liveworksheets pada materi asam basa. *Jurnal Ilmiah WUNY, 5*(2).

Seifert, T. (2024). Enhancing online self-assessment of collaborative work through cocreating rubrics. *Journal of Educators Online, 21*(1), 1.

Sitopu, J. W., Purba, I. R., & Asriyati, D. (2022). Komunikasi matematis siswa melalui model problem-based learning (PBL). *Jurnal Pendidikan Matematika Raflesia, 7*(2), 66–75.

Susanti, R., & Rohman, F. (2025). Improving critical thinking skills by developing problem-based learning (PBL) based on LKPD for grade 2 elementary schools. *Pendas: Scientific Journal of Basic Education, 10*(3), 514–527.

Thornhill-Miller, B., Camarda, A., Mercier, M., Burkhardt, J. M., Morisseau, T., Bourgeois-Bougrine, S., ... & Lubart, T. (2023). Creativity, critical thinking, communication, and collaboration: Assessment, certification, and promotion of 21st century skills for the future of work and education. *Journal of Intelligence, 11*(3), 54.

Umar, I., & Yakub, P. (2025). Development of blended learning respiratory system materials for blended learning PBL to train students' critical thinking skills. *BioEdu, 14*(1), 54–61.

Widiyono, A., & Ghufron, A. (2025). Improving creative thinking skills through the PjBL-STEM model assisted by LKPD life cycle biology. *Journal of Education, 57*(3), 532–541.

Yu, H. (2024). RETRACTED: Enhancing creative cognition through project-based learning: An in-depth scholarly exploration. *Heliyon, 10*(6).

Yunita, R., Noviati, N., & Ningsih, Y. L. (2024). The effect of the use of PjBL-based LKPD on the learning creativity of elementary school students. *Journal of Innovation, Evaluation and Development of Learning (JIEPP), 4*(3), 492–498.

Zhang, L., & Ma, Y. (2023). A study of the impact of project-based learning on student learning effects: A meta-analysis study. *Frontiers in Psychology, 14,* 1202728.

Zulfa, S., Arsih, F., Alberida, H., & Rahmi, F. O. (2025). The effectiveness of LKPD-PjBL integrated local wisdom on the creative thinking ability of phase E students of SMAN 2 Lubuk Alung: A research. *Journal of Community Service and Educational Research, 3*(4), 3100–3105.