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Implementation of PJBL-Based Worksheet with a STEAM Approach to Improve High School Students' Creative Thinking Abilities: A Synthesis of Empirical Insights

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ABSTRACT

Objective: *This research uses a literature review to analyze the implementation of PJBL-based LKPD with a STEAM approach to improve high school students' creative thinking abilities.* ***Method:*** *The research method used is a qualitative approach with a library study design. This method was carried out by searching for articles from various sources such as Google Scholar, Scopus, and so on, as well as national and international journal websites, totaling 10 articles. The data that has been obtained will be classified and studied in depth, and then authentic data will be analyzed. The data analysis used is critical.* ***Results:*** *So, it can be concluded that the STEAM approach integrated with Project Based Learning (PjBL) consistently improves students' creative and critical thinking skills in various subjects. This approach effectively facilitates understanding of concepts and encourages active student engagement. Using innovative teaching materials such as LKPD and e-LKPD based on STEAM-PjBL has also proven to be practical and efficient in improving the quality of learning.* ***Novelty:*** *This research is expected to provide valuable insights for educators in utilizing innovative teaching materials, such as LKPD and e-LKPD integrated with the STEAM-PjBL approach, to improve students' creative and critical thinking skills while encouraging active involvement in 21st-century education.*

INTRODUCTION

Education is currently more advanced and developed when viewed from this broad side of the world (Fakhriyah et al., 2019). Education development has been conceptualized by educational novices, where 21st-century education is skill-oriented and realizes graduates who can compete in the era of the Industrial Revolution 4.0 (Marshel & Ratnawulan, 2020). With the Industrial Revolution 4.0, all students must have 21st-century skills to adapt and compete globally (Syerlita & Siagian, 2024). Several skills will support the 21st century, including critical thinking, creative thinking, communication, and collaboration (Yulianti et al., 2020). Learners need these skills to face social changes and compete well (Seminar et al., 2021). The 4C skills allow learners to utilize their potential in any field, such as finding new ideas in creative thinking (Tabieh et al., 2021).

Creative thinking skills are a thought process that will produce a variety of active and positive responses (Nurnaningsih et al., 2023). Creative thinking is also a process that can bring up new ideas (Maksum et al., 2021). This skill involves flexibility, fluency, novelty, and elaboration (Yildiz & Guler Yildiz, 2021). Learners who think creatively will learn to generate various ideas and other points of view (Shari et al., 2024). The importance of this skill is applied in learning to change the world's learning process (Tabieh et al., 2021). Project-based learning will facilitate learners in developing creative thinking skills (Taliak et al., 2024) because learning will be learner-centered (Zulkarnaen et al., 2023). Indirectly, the application of project-based learning will be one of the opportunities for students to develop creative ideas (Syarifah & Emiliasari, 2019). Project-

based Based Learning, commonly referred to as PJBL, is one of the learning models that requires students to design and implement projects to produce a product (Guo et al., 2020). That way, students will be able to play an active role, where students and teachers will act as facilitators and mediators so that the atmosphere in the classroom is not boring (Warr & West, 2020). According to Cahyani, the project-based learning model, or PJBL, can improve creative thinking skills in the learning process. This learning model significantly impacts students' creativity because it can involve students directly in learning (Cahyani, 2021).

STEAM (Science, Technology, Engineering, Arts, and Mathematics) is an approach to 21st-century learning related to soft skills development that connects science, technology, engineering, arts, and mathematics (Jumarniati et al., 2023). The learning process is critical in education (Wening & Hayuhantika, 2023). A teacher's success in learning in the classroom will not be separated by developing models, methods, and learning media (Syahid et al., 2024). Involving PJBL and the STEAM approach can improve 21st-century skills, especially critical thinking (Zayyinah et al., 2022). The importance of creative thinking skills through the STEAM approach in high school learning that involves elements of art is outstanding (Hilman Hadi et al., 2024; Safriana et al., 2022) and very important to bring out the creative side of students so that students can have another point of view to solve complex problems that exist in the 21st century (Sudarman & Anggoro, 2021). Integrating arts in the STEAM approach creates more creative and holistic learning opportunities by focusing on projects that actively engage learners (Dasuki et al., 2024). These projects focus on developing learners' skills through hands-on experience and collaboration that support a project-based learning approach (Oktiara & Pratamawati, 2024).

Good learning must be supported by appropriate learning media so that learning can be fun, such as using student worksheets (LKPD) (Hasiru et al., 2021). Learner worksheets contain material, instructions for using LKPD, and learning tasks that students must do (Qusyairi et al., 2024). With 21st-century learning, it is necessary to have an LKPD oriented towards 21st-century skills such as creative thinking (Makhrus et al., 2018). In a lesson, teachers are expected to be able to be creative and have the ability to make learning fun (Fariza & Kusuma, 2024), one of which is with interesting variations in the learning model used (Najib et al., 2024). The function of the student worksheet itself is to educate by leading students to interact directly with the material that has been provided because the student worksheet (LKPD) can increase students' understanding of the material that has been delivered by the teacher (Said et al., 2023; Ansumarwaty et al., 2023). Based on this description, this article aims to analyze the application of Project-Based Learning (PJBL) based LKPD with STEAM approach to improve the creative thinking ability of high school students. Through this approach, students are expected to be actively involved in a collaborative, contextual, and problem-solving-based learning process to encourage the development of their creativity and innovation abilities.

RESEARCH METHOD

This research uses a qualitative method approach with a literature study design. According to (Fadli, 2021), this qualitative method approach is carried out to understand certain situations in depth. Meanwhile, according to Sugiyono, library study is the process of retrieving research data from the literature of books, scientific journals, and the internet, then calcifying and analyzing from studies relevant to the discussion (Sugiyono, 2017). This method is done by looking for several articles from various sources such as Google Scholar, Scopus, and so on, as well as national and international web journals. The articles obtained were 10 articles, which will be reviewed according to the criteria sought by the author.

The data that has been obtained will be classified and examined in depth, then authentic data will be analyzed to obtain relevant and reliable results. The data analysis used is critical analysis, which according to Creswell (2012), is an interpretation of the reading text and addresses the meaning behind an event scientifically and objectively. The data sources in this research come from literatures related to the subject and object under study, which are used as secondary sources that can enrich the discussion. After the analysis is complete, the results will be compiled in the form of systematic and directed conclusions.

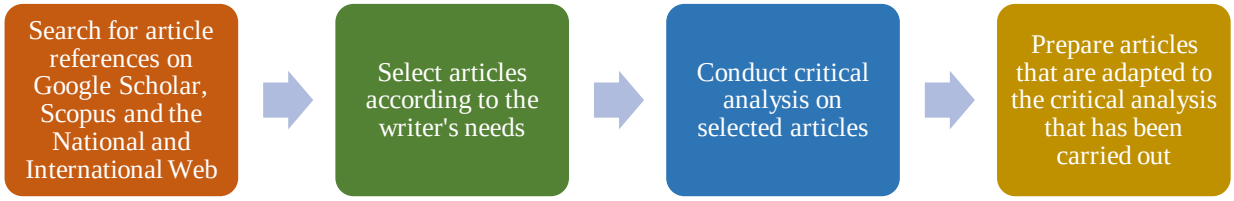

Figure 1. The flow of data analysis

Based on Figure 1, the initial step in this research method begins with finding reference articles through trusted sources such as Google Scholar, Scopus, and national and international databases. After obtaining relevant articles, selection is carried out to select articles that meet the needs and objectives of the research. The selected articles are then critically analyzed to evaluate their content, methods, and relevance to the topic under study. The results of the critical analysis become the basis for preparing new articles tailored to the research focus and meeting the established academic rules.

This step is supported by previous research, which states that it is important to use trusted reference sources to improve the quality and relevance of research (Destiarti et al., 2021). In addition, research by Dianah et al. (2024) showed that article selection based on research needs helps narrow the focus and increase the effectiveness of the analysis. In addition, Kurniawan et al. (2023) stated that critical analysis of relevant articles can lead to deeper insights, which become a strong foundation for preparing structured and valid scientific articles.

RESULTS AND DISCUSSION

Results

STEAM is an approach that allows students to understand surrounding phenomena and solve daily life problems through scientific methods (Jumarniati et al., 2023). To support this learning, the use of STEAM-PjBL-based LKPDs and E-LKPDs has proven effective in improving students' creative thinking skills and enabling active interaction in learning that connects theory with practical applications (Hasiru et al., 2021). The following is a review of various studies that discuss the relationship between the STEAM approach and 21st-century skills in Physics learning, as shown in Table 1.

Table 1. Results of development of PjBL-based LKPD with STEAM approach to improve creative thinking ability of high school students in physics learning

Author	Year	Title	Research result
Siti Suryaningsih, Fakhira Ainun Nisa	2021	Kontribusi STEAM Project Based Learning dalam Mengukur Keterampilan Proses Sains dan Berpikir Kreatif Siswa	This research shows that the integration of the STEAM approach with Project Based Learning in chemistry learning can improve junior high school students' science process skills and creative thinking.
Ria Wastiani, Mokhamad Taufiq, Adi Bangga Wijaya	2023	Pengaruh Pendekatan Steam Berbasis Project based learning Terhadap Kemampuan Berfikir Kreatif Dan Berfikir Kritis Pada Mata Pelajaran Matematika Siswa SMP Labschool Cibubur (Quasi Eksperimen)	This research shows that the application of a STEM approach based on project learning significantly improves students' critical and creative thinking abilities in junior high school mathematics.
Mitha Nur Cahyani, Viyanti, Anggreini	2023	Penerapan Model PjBL Terintegrasi STEAM Berbantuan LKPD Elektronik untuk Meningkatkan Kemampuan Berpikir Kreatif Peserta Didik	This research shows that the application of the STEAM integrated PjBL model with the help of electronic LKPD can significantly improve students' creative thinking abilities on the topic of global warming.
Nela Andani, Wawan Wahyu, Ali Kusrijadi	2021	Uji Kelayakan LKS Model PjBL Terintegrasi STEAM untuk Membangun Kreativitas Siswa SMA pada Pembuatan Indikator Asam Basa Berbahan Bunga	This research developed STEAM integrated PjBL model worksheets which were assessed as very good in terms of internal feasibility by content and construct experts. This worksheet is suitable to be used to build student creativity.
Niki Dian Permana, Ina Lestari, Fatimah Depi Susanty Harahap, Azhar, Aprina Defianti	2023	Project Based Learning (PjBL) Model with STEM Approach: Its Impact on Students Creative Thinking Skills on Energy in Living System Topic	This research shows an increase in students' creative thinking skills after implementing the PjBL model with a STEM approach to energy materials in living systems. The N-gain value in the control class was 47.4 (medium category) and in the experimental class was 71 (high

Author	Year	Title	Research result
			category), showing a significant increase.
Fitri Ayuningsih, Siti Malikah, Muh Rifki Nugroho, Winarti, Budi Murtiyasa, Sumardi	2022	Pembelajaran Matematika Polinomial Berbasis STEAM-PjBL Menumbuhkan Kreativitas Peserta Didik	Research shows that the STEAM-PjBL learning model on polynomial material is successful in increasing student creativity with average indicators of flexibility (96%), originality (96%), elaboration (100%), and fluency (92%). The average class score reached 86, exceeding the KKM of 75.
Rr Tasya Noor Nabila, Agus Kamaludin	2023	Development of E-Worksheet Based on STEAM-PjBL in Reaction Rate Material to Improve Creative Thinking Skills High School Student	This research developed a STEAM-PjBL based E-Worksheet which was assessed as very good by material experts (93%), media experts (97%), reviewers (90%), and student responses (93%). This e-Worksheet is suitable for use as a learning medium to improve creative thinking skills.
Edy Suprapto, Ika Krisdiana, Davi Apriandi, Fitria Rizqi Yuanawati	2023	Development of Steam-C Integrated Student Worksheets to Improve Creative Thinking Ability on Flat Side Building Materials	This research developed a STEAM-C integrated worksheet that is valid with a validity percentage of 81%, very practical with a practicality level of 93%, and effective with an N-Gain value of 71%, so it is suitable for use to improve creative thinking skills.
Tyas Candra Wening, Diesty Hayuhantika	2023	Pengembangan LKPD dengan Pendekatan STEAM melalui Model PjBL untuk Menumbuhkan Keterampilan Berpikir Kreatif pada Materi Lingkaran Kelas VIII	This research shows that LKPD innovation with a STEAM approach through the PjBL model is valid for fostering creative thinking skills. Feasibility was assessed by media experts (80%), material experts (86.8%), practitioners (86.7%), and users (86.9%).
Desta Alvionita, Joko Sudomo, Purwanti Widhy H	2021	Development Of Student Worksheet Oriented On Steam With PjBL Model On Environmental Pollution Matter To Improve Creative Thinking Skill	This research shows that STEAM-oriented LKPD with the PjBL model on environmental pollution material can improve students' creative thinking skills with a high percentage of validity, practicality and effectiveness.

Discussion

Based on Table 1, shows that the integration of the STEAM approach with Project-Based Learning (PjBL) consistently has a positive impact on improving students' creative thinking skills in various subjects. For example, research conducted by Nisa (2021) showed that applying this approach to learning chemistry can improve the creative

thinking of junior high school students, especially in their ability to design experiments and solve context-based problems. Similarly, Wastiani et al. (2023) found that the PjBL-based STEAM approach significantly improved students' creative thinking skills in mathematics subjects at SMP Labschool Cibubur, emphasizing innovative problem-solving and applying concepts to real situations. Another study, Ritonga & Napitupulu (2024) mentioned that this integration motivates students to learn actively and trains them to solve complex problems creatively. In other words, applying this approach successfully creates an innovative learning environment relevant to the needs of 21st-century education.

In addition, other studies emphasize the importance of using teaching materials that support this approach, such as LKPD and e-LKPD. For example, Cahyani et al. (2023) revealed that the use of e-LKPD integrated with the PjBL model on the topic of global warming was able to significantly improve students' creative thinking skills, especially in identifying environmental problems and designing technology-based solutions. A similar study by Nabila & Kamaludin (2023) also showed that STEAM-PjBL-based e-LKPD was very effective in improving high school students' creative thinking skills on reaction rate material, especially in the ability to analyze experimental data and draw conclusions. The use of this innovative learning media not only facilitates better concept understanding but also encourages students' active and creative involvement in the learning process. Furthermore, teaching materials such as e-LKPD also enable optimal integration of technology, provide a more dynamic learning experience that is relevant to the needs of today's digital era, and improve students' ability in collaboration and communication through interactively designed project tasks (Wudda et al., 2024).

The development and validation of STEAM-PjBL-based teaching materials show positive results in terms of practicality and effectiveness, becoming an important solution in 21st-century learning. Research conducted by Alvionita et al. (2021) showed that the STEAM-integrated LKPD developed was highly valid, practical, and effective in improving students' creative thinking skills, especially in solving complex problems through challenging projects. Similar results were also reported by Suprapto et al. (2023), who found that STEAM-PjBL-based teaching materials not only make it easier for teachers to manage learning but also provide flexibility for students to explore creative ideas independently and improve their analysis and innovation skills. Another study by Trisnawati et al. (2024) confirmed that this LKPD supports collaborative learning and increases student engagement in various subjects, especially science, such as physics, biology, and chemistry. In addition, the STEAM-PjBL approach facilitates technology integration in learning, thus providing learning experiences relevant to modern technological developments and equipping students with the skills needed in the digital era.

The assessment from the content expert provides an assessment that the STEAM-integrated PjBL model LKS has an excellent level of feasibility, especially in terms of presenting material that is in accordance with the learning needs and applicable

curriculum (Gunawan et al., 2023). In addition, construct experts also provide a positive evaluation of the structure, systematics, and relevance of the LKS to the learning objectives to be achieved, indicating that this product is designed with a systematic and quality approach (Permana et al., 2023). Similar support is also explained from other studies that reveal that overall, this STEAM-PjBL-based worksheet is considered feasible and effective to be implemented in learning, especially for its ability to support educational innovations that focus on developing 21st century skills, although the relevance and challenges of its implementation, especially in the context of curriculum adaptation and readiness of educational resources, still need to be further evaluated to ensure long-term sustainability and effectiveness (Ayuningsih et al., 2022).

CONCLUSION

Fundamental Finding: Based on a review of articles covering 2019 to 2024, the STEAM approach integrated with Project-Based Learning (PjBL) consistently improved students' creative and critical thinking skills across various subjects. This approach effectively facilitates concept understanding, encourages active engagement, and is relevant to 21st-century challenges. Using innovative teaching materials such as STEAM-PjBL-based LKPDs and e-LKPDs has also been shown to improve the quality of learning significantly. **Implications:** The application of the STEAM-PjBL approach is urgently needed to produce a generation that is creative, critical, and adaptive to the times and requires proactive educational policy support. This method can provide important insights in designing a more dynamic and future-focused learning environment. **Limitation:** While this study highlights the positive impact of the STEAM-PjBL approach, it should be noted that there is still a need for further evaluation of its practical challenges, including curriculum adaptation, teacher readiness, and resource availability, to ensure sustainable and long-term effectiveness. **Future Research:** Future research could explore strategies to overcome these challenges and investigate the long-term impact of STEAM-PjBL-based teaching materials in various educational settings. In addition, studies could examine the role of digital learning platforms and online resources in enhancing the effectiveness of STEAM-PjBL-based approaches.

REFERENCES

Alvionita, D., Sudomo, J., & Widhy, P. (2021). Jurnal pendidikan MIPA pancasakti development of student worksheet oriented on steam with pjbl model on environmental pollution matter to improve creative thinking skill. *Jurnal Pendidikan MIPA Pancasakti*, *5*(2), 2021–2111. https://e-journal.ups.ac.id/index.php/jpmp

Annisa Wudda, A., Hufri, H., Gusnedi, G., & Satria Dewi, W. (2024). Validasi E-LKPD interaktif berbasis model pembelajaran contextual teaching and learning pada materi hukum termodinamika. *Jurnal Pendidikan Tambusai*, *8*(1), 7543–7552. https://doi.org/10.31004/jptam.v8i1.13533

Ansumarwaty, F., 'Ardhuha, J., Hikmawati, H., & Makhrus, M. (2023). Development of student worksheet for sound waves based on project based learning model to

improve students' science literacy. *Jurnal Penelitian Pendidikan IPA*, *9*(8), 6255–6264. https://doi.org/10.29303/jppipa.v9i8.4651

Ayuningsih, F., Malikah, S., Nugroho, M. R., Winarti, W., Murtiyasa, B., & Sumardi, S. (2022). Pembelajaran matematika polinomial berbasis STEAM PjBL menumbuhkan kreativitas peserta didik. *Jurnal Basicedu*, *6*(5), 8175–8187. https://doi.org/10.31004/basicedu.v6i5.3660

Cahyani, M. N., Viyanti, V., & Anggreini, A. (2023). Penerapan model PjBL terintegrasi STEAM berbantuan LKPD elektronik untuk meningkatkan kemampuan berpikir kreatif peserta didik. *Prosiding Sinapmasagi 2023, 3(3)*, 65–77.

Cahyani, N. K. C. (2021). Effectiveness of project-based learning models in improving students' creativity (a literature review). *The Art of Teaching English as a Foreign Language*, *2*(1), 73–77. https://doi.org/10.36663/tatefl.v2i1.107

Dasuki, A., Hawari, M., Iryani, A., & Noor, M. (2024). Pembelajaran berasaskan projek STEAM dalam pengajaran dan pembelajaran pendidikan seni visual untuk meningkatkan kemahiran insaniah (STEAM project-based learning in visual arts education teaching and learning to enhance soft skills). *6*(2), 126–138.

Destiarti, L., Yuspriyanto, M., Herman, M., Alimuddin, A. H., Wahyuni, N., & Gusrizal, G. (2021). Pentingnya laboratorium penguji terakreditasi di perguruan tinggi untuk perolehan data terpercaya bagi publik. 215–222. https://doi.org/10.26418/pipt.2021.41

Dianah, H. S., Sukaesih, N. S., & Sejati, A. P. (2024). Gambaran dampak waktu layar terhadap tidur pada remaja: Tinjauan pelingkupan. *Jurnal Keperawatan Florence Nightingale*, *7*(1), 180–190. https://doi.org/10.52774/jkfn.v7i1.166

Fakhriyah, F., Masfuah, S., & Mardapi, D. (2019). Developing scientific literacy-based teaching materials to improve students' computational thinking skills. *Jurnal Pendidikan IPA Indonesia*, *8*(4), 482–491. https://doi.org/10.15294/jpii.v8i4.19259

Fariza, N. A., & Kusuma, I. H. (2024). Implementasi model pembelajaran berbasis proyek dalam meningkatkan kreativitas siswa sekolah dasar. *Pubmedia Jurnal Penelitian Tindakan Kelas Indonesia*, *1*(3), 10. https://doi.org/10.47134/ptk.v1i3.453

Gunawan, T. I., Alvian, A., Hermani, Halimatul, H. S., Nurhadi, A. R., & Nata, S. L. (2023). Jurnal riset dan praktik pendidikan kimia. *Jurnal Riset Dan Praktik Pendidikan Kimia*, *11*(2), 39–49.

Guo, P., Saab, N., Post, L. S., & Admiraal, W. (2020). A review of project-based learning in higher education: Student outcomes and measures. *International Journal of Educational Research*, *102*, 101586. https://doi.org/10.1016/j.ijer.2020.101586

Hasiru, D., Badu, S. Q., & Uno, H. B. (2021). Media-media pembelajaran efektif dalam membantu pembelajaran matematika jarak jauh. *Jambura Journal of Mathematics Education*, *2*(2), 59–69. https://doi.org/10.34312/jmathedu.v2i2.10587

Hilman Hadi, Nur'aini, Wawan Muliawan, & Marhamah. (2024). Pengaruh pembelajaran biologi berbasis steam terintegrasi literasi sains terhadap kemampuan berpikir kreatif siswa. *Cocos Bio*, *9*(1), 18–23. https://doi.org/10.29408/cob.v9i1.26890

Ibrahim Maulana Syahid, Nur Annisa Istiqomah, & Azwary, K. (2024). Model ADDIE dan assure dalam pengembangan media pembelajaran. *Journal of International Multidisciplinary Research*, *2*(5), 258–268. https://doi.org/10.62504/jimr469

John W. Creswell. (2012). *Research design : pendekatan kualitatif, kuantitatif, dan mixed*. Pustaka Pelajar.

Jumarniati, J., & Fitriani A, F. A. (2023). Pembelajaran STEAM dalam pendidikan anak usia dini. *Jurnal Pelita: Jurnal Pembelajaran IPA Terpadu*, *3*(2), 72–82. https://doi.org/10.54065/pelita.3.2.2023.315

Kurniawan, I., Humaira, H., Akbar, M. R., Mahesa, S., Rahmawati, A., Nafisah, Z., & Muntazhimah, M. (2023). Analisis bibliometrik pembelajaran berbasis masalah terhadap berpikir kritis matematis siswa pada publikasi ilmiah menggunakan vosviewer. *JIPM (Jurnal Ilmiah Pendidikan Matematika)*, *12*(1), 121. https://doi.org/10.25273/jipm.v12i1.12642

Makhrus, M., Harjono, A., Syukur, A., Bahra, S., & Muntari. (2018). Identifikasi kesiapan LKPD guru terhadap keterampilan abad 21 pada pembelajaran IPA SMP jurnal ilmiah profesi pendidikan. *Jurnal Ilmiah Profei Pendidikan*, *3*(2), 124–128.

Maksum, A., Wayan Widiana, I., & Marini, A. (2021). Path analysis of self-regulation, social skills, critical thinking and problem-solving ability on social studies learning outcomes. *International Journal of Instruction*, *14*(3), 613–628. https://doi.org/10.29333/iji.2021.14336a

Marshel, J., & Ratnawulan. (2020). Analysis of students worksheet (LKPD) integrated science with the theme of the motion in life using integrated connected type 21st century learning. *Journal of Physics: Conference Series*, *1481*(1). https://doi.org/10.1088/1742-6596/1481/1/012046

Muhammad Rijal Fadli. (2021). *Memahami desain metode kualitatif*. *21*(1), 33–54.

Najib, M. A., Fariha, S., & Pribadi, R. A. (2024). Keterampilan guru dalam membuat media pembelajaran membaca permulaan di kelas rendah. *Alpen: Jurnal Pendidikan Dasar*, *8*(1), 11–22. https://doi.org/10.24929/alpen.v8i1.261

Nurnaningsih, N., Hanum, C. B., Sopandi, W., & Sujana, A. (2023). Keterampilan berpikir kritis dan berpikir kreatif siswa sekolah dasar dalam pembelajaran berbasis RADEC. *Jurnal Basicedu*, *7*(1), 872–879. https://doi.org/10.31004/basicedu.v7i1.4773

Oktiara, R. E., & Pratamawati, E. . S. D. (2024). Integrasi pembelajaran berdiferensiasi dengan kesenian bantengan dalam mata pelajaran seni budaya. *JoLLA Journal of Language Literature and Arts*, *4*(2), 116–122. https://doi.org/10.17977/um064v4i22024p116-122

Permana, N. D., Lestari, I., Susanty Harahap, F. D., Azhar, A., & Defianti, A. (2023). Project Based Learning (PjBL) model with STEAM approach: Its impact on students creative thinking skills on energy in living system topic. *Journal of Natural Science and Integration*, *6*(2), 186. https://doi.org/10.24014/jnsi.v6i2.25791

Qusyairi, K. A., Kesumawati, N., & Imansyah, F. (2024). Pengaruh Lembar Kerja Peserta

Didik (LKPD) terhadap kemampuan pemahaman konsep matematis. *Widyacarya: Jurnal Pendidikan, Agama Dan Budaya*, *8*(1), 11. https://doi.org/10.55115/widyacarya.v8i1.3380

Ritonga, D., & Napitupulu, S. (2024). Implementasi metode pembelajaran aktif dalam meningkatkan keterampilan berpikir kritis siswa sekolah dasar. *Education & Learning*, *4*(1), 38–45. https://doi.org/10.57251/el.v4i1.1292

Rr Tasya Noor Nabila, & Agus Kamaludin. (2023). Development of E-Worksheet based on STEAM-PjBL in reaction rate material to improve creative thinking skills high school student. *Jurnal Iqra' : Kajian Ilmu Pendidikan*, *8*(1), 299–317. https://doi.org/10.25217/ji.v8i1.3540

Safriana, S., Ginting, F. W., & Khairina, K. (2022). Pengaruh model project based learning berbasis steam terhadap kemampuan berpikir kreatif siswa pada materi alat- alat optik di sma. *Jurnal Dedikasi Pendidikan*, *6*(1), 127–136. https://doi.org/10.30601/dedikasi.v6i1.2315

Said, F. F., Susanto, A., & Utami, N. P. (2023). Pengembangan Lembar Kerja Peserta Didik (LKPD) berbantuan canva yang efektif. *Jurnal Ilmiah Soulmath : Jurnal Edukasi Pendidikan Matematika*, *11*(1), 85–98. https://doi.org/10.25139/smj.v11i1.6020

Shari, I. M., Yulisma, L., Ernasari, E., & Nurani, D. (2024). Implementasi model project based learning dalam membekalkan kemampuan berpikir kreatif peserta didik pada materi sistem peredaran darah di smp terpadu al hasan ciamis. *J-KIP (Jurnal Keguruan Dan Ilmu Pendidikan)*, *5*(1), 1–8. https://doi.org/10.25157/j-kip.v5i1.13647

Sudarman, S., & Anggoro, S. (2021). The validity of PjBL STEAM-based themathic learning device material for the growth and organism developmnent for elementary school students. https://doi.org/10.4108/eai.19-7-2021.2312712

Sugiyono. (2017). *Qualitative and Quantitative Research Methods R&D*. Alfabeta.

Suminar, T., Arbarini, M., Shofwan, I., & Setyawan, N. (2021). The effectiveness of production-based learning models in the icare approach to entrepreneurial literacy ability. *Journal of Nonformal Education*, *7*(2), 142–149. https://journal.unnes.ac.id/nju/index.php/jne

Suprapto, E., Krisdiana, I., Apriandi, D., & Yuanawati, F. R. (2023). Development of steam-c integrated student worksheets to improve creative thinking ability on flat side building materials. *AL-ISHLAH: Jurnal Pendidikan*, *15*(1), 549–564. https://doi.org/10.35445/alishlah.v15i1.2480

Suryaningsih, S., & Ainun Nisa, F. (2021). Kontribusi STEAM project based learning dalam mengukur keterampilan proses sains dan berpikir kreatif siswa. *Jurnal Pendidikan Indonesia*, *2*(06), 1097–1111. https://doi.org/10.59141/japendi.v2i06.198

Syarifah, E. F., & Emiliasari, R. N. (2019). Project-Based learning to develop students' ability and creativity in writing narrative story. *Indonesian EFL Journal*, *5*(1), 85. https://doi.org/10.25134/ieflj.v5i1.1627

Syerlita, R., & Siagian, I. (2024). Dampak perkembangan revolusi industri 4.0 terhadap pendidikan di era globalisasi saat ini. *Journal on Education*, *7*(1), 3507–3515.

https://doi.org/10.31004/joe.v7i1.6945

Tabieh, A. A. S., Hamzeh, M., Abu-Foudeh, B. K. S., Jarrar, N., Al-Manaseer, S., Al-Shawabkeh, A., & Seikaly, R. (2021). Digital literacy and its acquisition by teachers and principals at educational workplaces. *International Journal of Learning, Teaching and Educational Research*, *20*(5), 38–55. https://doi.org/10.26803/ijlter.20.5.3

Taliak, J., Al Farisi, T., Sinta, R. A., Aziz, A., & Fauziyah, N. L. (2024). Evaluasi efektivitas metode pembelajaran berbasis proyek dalam mengembangkan kreativitas siswa. *Journal of Education Research*, *5*(1), 583–589. https://doi.org/10.37985/jer.v5i1.876

Trisnawati, T., Salimi, M., & Wahyudi, W. (2024). Penerapan model Problem Based Learning (PBL) dengan LKPD elektronik untuk meningkatkan pembelajaran IPA tema peristiwa dalam kehidupan pada siswa SD kelas V. *Kalam Cendekia: Jurnal Ilmiah Kependidikan*, *12*(1). https://doi.org/10.20961/jkc.v12i1.75411

Warr, M., & West, R. E. (2020). Bridging academic disciplines with interdisciplinary project-based learning: Challenges and opportunities. *Interdisciplinary Journal of Problem-Based Learning*, *14*(1), 1–23. https://doi.org/10.14434/ijpbl.v14i1.285901

Wastiani, R., Taufiq, M., & Wijaya, A. B. (2023). Pengaruh pendekatan steam berbasis project based learning terhadap kemampuan berfikir kreatif dan berfikir kritis pada mata pelajaran matematika siswa SMP Labschool Cibubur (quasi eksperimen). *Jurnal Konatif: Jurnal Ilmiah Pendidikan*, *1*(1), 75–87. https://doi.org/10.62203/jkjip.v1i1.10

Wening, T. C., & Hayuhantika, D. (2023). Pengembangan LKPD dengan pendekatan STEAM melalui model PjBL untuk menumbuhkan keterampilan berpikir kreatif pada materi lingkaran kelas VIII. *Jurnal Tadris Matematika*, *6*(2), 245–262. https://doi.org/10.21274/jtm.2023.6.2.245-262

Yildiz, C., & Guler Yildiz, T. (2021). Exploring the relationship between creative thinking and scientific process skills of preschool children. *Thinking Skills and Creativity*, *39*(February), 100795. https://doi.org/10.1016/j.tsc.2021.100795

Yulianti, D., Wiyanto, Rusilowati, A., & Nugroho, S. E. (2020). Student worksheets based on Science, Technology, Engineering and Mathematics (STEM) to facilitate the development of critical and creative thinking skills. *Journal of Physics: Conference Series*, *1567*(2). https://doi.org/10.1088/1742-6596/1567/2/022068

Zayyinah, Z., Erman, E., Supardi, Z. A. I., Hariyono, E., & Prahani, B. K. (2022). STEAM-integrated project based learning models: Alternative to improve 21st century skills. *Proceedings of the Eighth Southeast Asia Design Research (SEA-DR) & the Second Science, Technology, Education, Arts, Culture, and Humanity (STEACH) International Conference (SEADR-STEACH 2021)*, *627*, 251–258. https://doi.org/10.2991/assehr.k.211229.039

Zulkarnaen, Z., Wardhani, J. D., Katoningsih, S., & Asmawulan, T. (2023). Manfaat model pembelajaran project based learning untuk pendidikan anak usia dini dan implementasinya dalam kurikulum merdeka. *Jurnal Bunga Rampai Usia Emas*, *9*(2), 394. https://doi.org/10.24114/jbrue.v9i2.52951

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