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Enhancing Science Learning Outcomes Through Project-Based Learning Integrated with Educational Board Games: A Classroom Action Research on Biotechnology at the Junior Secondary Level

Rifajrin*, Rifda Nur Hikmawati Arif
Makassar State University, Indonesia
**Corresponding author*: rifajrin02@gmail.com

Abstract: Low science learning achievement and insufficient active student engagement have necessitated the adoption of innovative instructional strategies. This study aimed to evaluate the effectiveness of a Project-Based Learning (PjBL) model integrated with educational board games on the learning outcomes of eighth-grade students at State Junior High School 26 Makassar, with a focus on Biotechnology content. A Classroom Action Research (CAR) design following the Kemmis and McTaggart spiral model was employed across three consecutive cycles, involving 29 students. Data were collected through pretest–posttest instruments and formative assessments administered at the conclusion of each cycle. Results indicated a progressive improvement in learning outcomes, with mean scores rising from 67.1 in Cycle I to 72.4 in Cycle II and 77.9 in Cycle III, alongside an improvement in class mastery rates from 44.8% to 58.6% and 68.9%, respectively. Normalised gain (N-Gain) analysis across cognitive indicators C1–C4 yielded an overall mean of 0.33, classified as moderate. The integrated PjBL and educational board game model demonstrably enhanced cognitive learning outcomes and fostered active, collaborative, and enjoyable learning environments. These findings support the adoption of this integrated approach as a viable pedagogical alternative in science education at the junior secondary level.

Keywords: Project-Based Learning; Educational Board Game; Learning Outcomes; Biotechnology; Classroom Action Research

***Abstrak**: Rendahnya hasil belajar IPA dan kurangnya keterlibatan aktif peserta didik mendorong penerapan strategi pembelajaran inovatif. Penelitian ini bertujuan mengevaluasi efektivitas model Project-Based Learning (PjBL) terintegrasi board game edukatif terhadap hasil belajar peserta didik kelas VIII SMPN 26 Makassar pada materi Bioteknologi. Penelitian menggunakan desain Penelitian Tindakan Kelas model Kemmis dan McTaggart yang dilaksanakan dalam tiga siklus. Subjek penelitian berjumlah 29 peserta didik. Data diperoleh melalui pretest-posttest dan asesmen formatif pada setiap siklus. Hasil penelitian menunjukkan adanya peningkatan hasil belajar peserta didik, dimana nilai rata-rata meningkat dari 67,1 pada Siklus I, menjadi 72,4 pada Siklus II, dan 77,9 pada Siklus III. Peningkatan hasil belajar juga terlihat pada seluruh indikator ranah kognitif, mulai dari kemampuan C1-C4. Model PjBL terintegrasi board game edukatif terbukti efektif meningkatkan hasil belajar serta menciptakan pembelajaran yang aktif dan menyenangkan.*

***Kata Kunci:** Pembelajaran Berbasis Proyek, Board Game Edukatif, Hasil Belajar, Bioteknologi*

INTRODUCTION

Twenty-first-century education demands a fundamental transformation of the instructional process, specifically a shift from teacher-centred towards student-centred approaches oriented to the holistic development of competencies (Nisa et al., 2024). Within this context, active learning has become an essential requirement because it encourages students to think critically, collaborate, communicate, and create as preparation for the challenges of real-world life (Ervina et al., 2025).

These demands are further reinforced by the implementation of the Merdeka Curriculum (Kurikulum Merdeka), which emphasises project-based learning, the strengthening of the Pancasila Student Profile, and the active involvement of students in contextual problem-discovery and problem-solving processes (Nursalam et al., 2023).

The conditions observed during the Field Experience Programme (PPL) at Class VIII-B of SMPN 26 Makassar, however, were in stark contrast to this ideal. Initial observations revealed that the majority of students appeared passive and lacked enthusiasm throughout science learning activities. Classroom interaction was predominantly one-directional, with the teacher dominating learning activities while students assumed a passive listener role devoid of meaningful engagement. This situation directly impacted learning achievement: the class mean score at pretest reached only 64.8, with a mastery rate of 27.5%, equivalent to only 8 of 29 students meeting the minimum completion threshold.

Examining the root causes of these problems, several contributing factors can be identified. First, the instructional models employed by the teacher remained limited to conventional lecturing and individual assignments (Fajra, 2023). Second, the absence of engaging and interactive learning media caused biotechnology content, which is inherently rich in real-world application, to appear overly abstract (Putri & Sugiyanto, 2025). Third, students were insufficiently engaged in the active construction of knowledge, resulting in mechanistic learning that failed to build deep conceptual understanding (Prasetyo, 2020).

Based on these problems, an innovative and contextual learning solution was required. The Project-Based Learning (PjBL) model was identified as a relevant choice because it positions students as active subjects who are directly involved in the planning, execution, and evaluation of real-world projects (Sutarini et al., 2024). Through PjBL, students not only acquire conceptual knowledge but also develop critical thinking, collaboration, communication, and creativity skills that constitute the core 21st-century competency framework (Lubis et al., 2024). To further enhance the effectiveness of PjBL, the researchers integrated it with educational board games as an enjoyable medium for concept consolidation. Game elements such as progressive challenges, rewards, and inter-group competition have been shown to simultaneously increase both extrinsic and intrinsic motivation, with a consequent positive impact on learning outcomes (Nurcahyo, 2025).

Several prior studies have confirmed the effectiveness of comparable learning approaches in improving student outcomes and engagement. Makatita (2024) reported that PjBL implementation in junior secondary science learning demonstrably improved student achievement, with mean scores in PjBL classrooms exceeding those of control classes using conventional methods. Sibarani et al. (2025) found that PjBL combined with game-based media enhanced student engagement and learning outcomes, with game elements enabling students to achieve higher mastery targets than conventional approaches. Furthermore, Sari et al. (2024) demonstrated that interactive project-based learning supplemented by game media fundamentally transformed classroom dynamics from passive activity to an active, collaborative, and enjoyable learning environment.

Although several studies have established the effectiveness of PjBL or educational games independently, relatively few have synergistically integrated both within a structured three-cycle Classroom Action Research (CAR) framework, particularly for Biotechnology content at the junior secondary level. The novelty of the present study rests on three dimensions: (1) the simultaneous pedagogical integration of PjBL with board games as an instrument for concept consolidation and formative assessment; (2) specific application to Class VIII Biotechnology content, which has been consistently regarded as abstract by students; and (3) implementation within a three-cycle CAR framework with a distinct focus per cycle, namely concept reinforcement, project design, and product testing and presentation.

METHODS

This study employed a Classroom Action Research (CAR) approach using the spiral model developed by Kemmis and McTaggart. This model was selected because of its reflective, collaborative, and participatory nature, allowing both researchers and collaborating teachers to jointly identify problems, design interventions, implement actions, observe processes, and reflect on outcomes for continuous improvement (Winarsih, 2022). This approach is particularly appropriate in research contexts aimed at directly improving the quality of classroom learning.

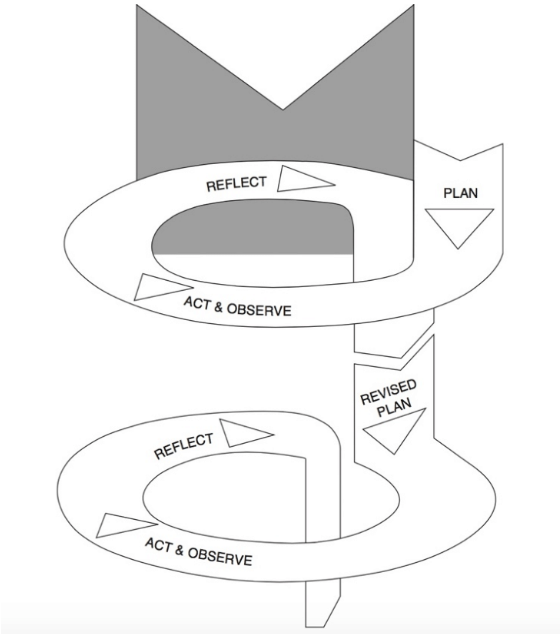

Figure 1. The Kemmis and McTaggart Spiral Model of Classroom Action Research

Each research cycle comprised four interrelated stages: (1) planning, encompassing the development of the Detailed Learning Plan (RPM), the creation of a biotechnology-themed educational board game, and the preparation of research instruments; (2) action, consisting of the implementation of the PjBL model integrated with the board game in the classroom; (3) observation, conducted concurrently with action implementation; and (4) reflection, involving the analysis and evaluation of action outcomes as the basis for subsequent cycle improvements.

Two variables were examined in this study. The independent variable was the implementation of the PjBL model integrated with educational board games, serving as the intervention action across all CAR cycles. The dependent variable was the cognitive learning outcomes of students on Biotechnology content. The study was conducted at UPT SPF SMP Negeri 26 Makassar during the even semester of the 2025/2026 academic year. Participants comprised all 29 students in the selected Class VIII cohort (11 male, 18 female), chosen purposively on the grounds that their science learning outcomes were below the class average and their level of engagement in learning was relatively low.

The study was executed in three cycles. Cycle I focused on explanation of biotechnology concepts and content, covering definitions, types of biotechnology (conventional and modern), applications in everyday life, and societal and environmental impacts of biotechnology. Educational board games were utilised as a concept-consolidation medium at the conclusion of each session. Cycle II continued the PjBL instructional syntax, concentrating on product design: each group designed a biotechnology product, developed a project proposal and working procedures, and received intensive teacher-facilitated mentoring. Cycle III constituted the final stage of the PjBL syntax, focused on product testing and group presentation of biotechnology products before the class.

Data were collected using test instruments. A pretest–posttest instrument comprising 20 multiple-choice items and a 10-item formative multiple-choice assessment administered at the conclusion of each cycle were employed, with items classified according to four levels of Bloom's cognitive taxonomy: C1 (Remembering), C2 (Understanding), C3 (Applying), and C4 (Analysing). Formative assessment was selected because of its orientation towards improving the learning process, enabling the teacher to promptly identify learning difficulties and make appropriate adjustments in subsequent cycles.

Quantitative data were analysed using class mean calculation and the percentage of students achieving the mastery criterion. Analysis was conducted to determine the improvement in learning outcomes following the application of the instructional model, with intervention success defined as: (a) a minimum 15% increase in class mean score, and (b) at least 75% of students attaining a score of ≥ 75. The improvement in student learning outcomes for each indicator was calculated using the normalised gain (N-Gain). N-Gain scores were classified according to the following criteria (Table 1):

Table 1. N-Gain Classification Criteria

N-Gain Score	Interpretation
$0.70 \leq g \leq 1.00$	High
$0.30 \leq g < 0.70$	Moderate
$0.00 < g < 0.30$	Low
$g = 0.00$	No improvement
$-1.00 \leq g < 0.00$	Decline

Source: Sukarelawan, Indratno, & Ayu (2024)

RESULTS AND DISCUSSION

Result

This classroom action research was implemented in Class VIII of SMPN 26 Makassar commencing in April 2026. The study encompassed three cycles, each consisting of one classroom session. Throughout the research process, students responded positively to the instructional model applied. Active engagement, learning enthusiasm, and inter-student collaboration increased progressively from Cycle I to Cycle II, with further development observed in Cycle III.

Descriptive Statistical Analysis

Descriptive statistical analysis of pretest and posttest scores yielded data as presented in Table 2 below.

Table 2. Descriptive Statistical Analysis of Student Learning Outcome Scores

Assessment Stage	Minimum Score	Maximum Score	Mean Score
Pretest	40	80	64.8
Cycle I	40	85	67.1
Cycle II	40	90	72.4
Cycle III	50	95	77.9
Posttest	50	95	76.6

Table 2 reveals that at the pretest stage, the minimum score was 40, the maximum was 80, and the class mean was 64.8. In Cycle I, scores ranged from 40 to 85 with a mean of 67.1. In Cycle II, the minimum score remained at 40 whilst the maximum reached 90, with a class mean of 72.4.

In Cycle III, scores ranged from 50 to 95 with a mean of 77.9. At the posttest stage, scores ranged from 50 to 95 with a class mean of 76.6.

Learning Outcome Development per Cycle

The development of student learning outcomes was analysed through formative test data from Cycles I, II, and III. A summary of mean scores and mastery percentages is presented in Table 3.

Table 3. Summary of Student Learning Outcomes by Cycle

Cycle	Mean Score	Students Meeting Mastery (≥75)	Mastery Rate (%)
I	67.1	13 out of 29	44.8%
II	72.4	17 out of 29	58.6%
III	77.9	20 out of 29	68.9%

Table 3 indicates that student learning outcomes improved progressively across cycles. In Cycle I, which focused on conceptual understanding of biotechnology, the class mean reached 67.1 with a mastery rate of 44.8%, indicating that the learning success indicator had not yet been achieved. In Cycle II, focused on project design and mentoring, the class mean was 72.4 with a mastery rate of 58.6%. In Cycle III, focused on product testing and presentation, the class mean reached 77.9 with a mastery rate of 68.9%. These data clearly demonstrate that student learning outcomes improved progressively across cycles.

Each cycle was implemented through the interrelated stages of planning, action, observation, and reflection, each designed to improve the learning process in subsequent cycles. The following sections present the implementation, observational findings, and reflective analysis for each cycle.

Cycle I

Planning: The researcher collaborated with the co-operating teacher to develop instructional materials for Biotechnology in Class VIII (2 × 40-minute allocation). The focus of this cycle was the reinforcement of foundational biotechnology concepts, including definitions, types of biotechnology (conventional and modern), applications in daily life, and environmental and social impacts. Materials prepared included: (1) a PjBL-based Detailed Learning Plan (RPM); (2) an educational board game; (3) project-based Student Worksheets (LKPD); and (4) a pretest–posttest instrument of 20 multiple-choice items and a 10-item formative assessment per cycle covering C1–C4 cognitive levels.

Action: Learning was opened with contextual questions about biotechnology products in everyday life to activate students' prior knowledge, followed by the formation of project groups of 5–6 members. The teacher provided a comprehensive explanation of biotechnology concepts, covering differences between conventional biotechnology (tempe, tape, yoghurt) and modern biotechnology (transgenic plants, recombinant insulin), applications across various fields, and positive and negative impacts. Each group collaboratively completed the LKPD to identify and classify examples of biotechnology products. The board game session was conducted at the end of the meeting as a concept-consolidation activity.

Observation: Observation was conducted concurrently with action implementation, focusing on: (1) level of student engagement during group discussion and the board game session; (2) student ability to differentiate between conventional and modern biotechnology; and (3) time management of the board game session. Constraints identified included: (a) some students still encountered difficulty distinguishing conventional from modern biotechnology in depth; and (b) the board game session exceeded its time allocation due to high student enthusiasm.

Reflection: The observation results and Cycle I end-of-cycle test (mean 67.1, mastery 44.8%) identified two principal issues as the basis for improvement: (1) student conceptual understanding required further reinforcement through additional scaffolding prior to the project design phase; and (2) board game session time management required more rigorous structuring using an explicit timer.

Cycle II

Planning: Based on Cycle I reflection, three key improvements were prepared: (1) concept cards containing a summary of differences between conventional and modern biotechnology as cognitive scaffolding during the project design phase; (2) explicit integration of a board game timer into the RPM (game allocated to the final 15 minutes with a visible time indicator); and (3) a structured project design guide. The focus of this cycle was the continuation of the PjBL instructional syntax: each group designed a conventional biotechnology product (tempe, tape, or yoghurt) based on a given real-world problem scenario, developed a project proposal and working procedures, and concluded with an intensive teacher-facilitated mentoring session.

Action: Learning was opened with a brief concept card review displayed at each group's table. Students were guided to systematically develop their project designs: selecting the product type based on the assigned problem scenario, specifying required materials, and developing step-by-step production procedures. Product manufacturing took place outside the classroom (at home), with each group required to document project progress and submit periodic updates to the teacher. The board game session was conducted 15 minutes before the lesson concluded, using a timer for concept reinforcement.

Observation: Concept cards proved effective in assisting previously struggling students, and the board game timer successfully maintained the allocated time. The class mean improved from 67.1 to 72.4 with a mastery rate of 58.6%. However, two constraints were identified: (1) some groups continued to require guidance to ensure correct product manufacturing procedures; and (2) some groups failed to submit project documentation consistently, limiting effective teacher monitoring.

Reflection: Following improvements in Cycle II action, two remaining issues were identified: (1) the need for a structured product evaluation instrument to enable students to assess procedural accuracy independently; and (2) the need for targeted guidance or a structured framework for the project production process.

Cycle III

Planning: Based on Cycle II reflection, two new instruments were prepared: (1) a structured product evaluation sheet containing science-based evaluation indicators (colour, texture, aroma, procedural compliance) to guide each group in independently evaluating product success; and (2) a structured presentation guide (background, procedure, test results, impact analysis, conclusion) to enable each group to present their process and results systematically. The board game session was retained as a final consolidation activity.

Action: Cycle III centred on two main sessions. In the product evaluation session, each group evaluated their biotechnology product using the structured evaluation sheet with teacher-facilitated formative feedback. In the presentation session, each group presented their production process, evaluation results, and product impact analysis before the class using the presentation guide. The teacher facilitated an inter-group question-and-answer session that encouraged critical thinking and deeper conceptual mastery. The board game session was again conducted at the conclusion of the meeting as a final consolidation and closing formative assessment.

Observation: The structured product evaluation sheet proved effective in guiding independent evaluation, and the presentation guide successfully assisted all groups in presenting their work coherently and confidently. Inter-group discussion was highly dynamic, reflecting deep conceptual mastery. Cycle III end-of-cycle test results achieved a mean of 77.9 with a mastery rate of 68.9%.

Reflection: All improvement actions formulated since Cycle I were effectively implemented. The three consecutively designed cycles – in which each reflection produced concrete follow-up actions directly implemented in the next cycle – constituted a comprehensive and effective learning strategy.

N-Gain Achievement per Cognitive Indicator

Table 4 presents the N-Gain values for each cognitive learning outcome indicator.

Table 4. N-Gain Achievement per Cognitive Learning Outcome Indicator

No.	Cognitive Indicator	Pretest	Posttest	N-Gain	Category
1	C1 (Remembering)	5.69	7.41	0.40	Moderate
2	C2 (Understanding)	19.48	23.10	0.32	Moderate
3	C3 (Applying)	19.31	23.10	0.32	Moderate
4	C4 (Analysing)	20.34	22.93	0.26	Low
Mean			**16.21**	**19.13**	**0.33 (Moderate)**

Table 4 shows that student learning outcomes improved across all cognitive indicators. The highest improvement was recorded for the Remembering indicator (C1) with an N-Gain of 0.40 (Moderate), whilst the lowest improvement was observed for the Analysing indicator (C4) with an N-Gain of 0.26 (Low). The overall mean N-Gain of 0.33 falls within the Moderate category.

Discussion

The descriptive statistical analysis presented in Table 2 reveals a marked improvement in learning outcomes between pretest and posttest scores for Class VIII students at SMP Negeri 26 Makassar. The pretest mean of 64.8 increased to 76.6 at posttest, a gain of 11.8 points. The initial conditions were characterised by a minimum score of 40 and a class mean well below the Minimum Competency Criterion (KKM = 75), reflecting insufficient conceptual understanding of biotechnology content prior to instructional intervention. This finding is consistent with Putri and Sugiyanto (2025), who report that biotechnology content is frequently perceived as abstract by students when presented without authentic applicative context.

The data in Table 3 reinforce this picture by demonstrating a consistent pattern of improvement across cycles: the class mean increased from 67.1 (Cycle I) to 72.4 (Cycle II) and 77.9 (Cycle III), with classical mastery rates of 44.8%, 58.6%, and 68.9%, respectively. Although the 75% mastery target was not fully achieved by the end of Cycle III, the structured incremental improvement at each stage indicates that the integrated PjBL and educational board game model produced a measurable and sustained positive impact. The PjBL model demonstrably facilitated a gradual shift in instructional orientation from teacher-centred to student-centred learning. When students were involved in the planning and execution of authentic projects, they developed a sense of responsibility for their own learning process. This finding is consistent with Bulkis et al. (2025), who demonstrate that active engagement in authentic projects promotes deep learning and stronger conceptual retention compared with passive learning. In the present study, students who initially struggled to understand fermentation concepts in an abstract manner demonstrated concrete understanding through direct experience in producing tempe, tape, or yoghurt.

In Cycle I, the mean of 67.1 with a mastery rate of 44.8% reflected an adaptation phase in which students were becoming acquainted with the PjBL syntax and the board game mechanism. The constraints identified – difficulty distinguishing conventional from modern biotechnology and challenges with game time management – signalled that the cognitive orientation stage required more explicit scaffolding support. The improvement in Cycle II to 72.4 (mastery 58.6%) was directly attributable to the two follow-up measures derived from Cycle I reflection: the use of concept cards as cognitive scaffolding and the implementation of an explicit timer for the board game session. The process of independently designing biotechnology products compelled students to operationalise concepts in concrete terms, ensuring that students did not merely memorise content but instead actively co-constructed procedural and conceptual knowledge (Bulkis et al., 2025). The highest achievement was recorded in Cycle III with a mean of 77.9 and mastery rate of 68.9%, driven by the product testing and group presentation sessions, which activated the verbalisation of understanding – a mechanism that more effectively reinforces students' internal conceptual connections than re-reading learning materials (Sari et al., 2024).

The integration of educational board games within the PjBL ecosystem provided significant added value. Board games functioned as an enjoyable formative assessment medium in which errors in answering did not generate anxiety but instead prompted discussion and conceptual clarification. Nilasari et al. (2026) explain that game-based learning creates immediate feedback that enables students to promptly identify and correct errors in a non-threatening context. This is consistent with observational findings indicating that students who answered incorrectly during board games demonstrated increased motivation to seek correct answers through group discussion. Furthermore, projects provided meaningful learning experiences, whilst board games helped simplify challenging content through progressively scaffolded questions from C1 to C4, facilitating longer-term retention of learning material.

N-Gain analysis per cognitive indicator (Table 4) reveals a pattern aligned with Bloom's cognitive taxonomy hierarchy. The Remembering indicator (C1) recorded the highest N-Gain at 0.40 (Moderate), followed by Understanding (C2) and Applying (C3) each at 0.32 (Moderate), and Analysing (C4) at 0.26 (Low). The overall mean N-Gain of 0.33 in the Moderate category indicates that the instructional intervention produced a meaningfully standardised impact. The declining N-Gain pattern from C1 to C4 is not indicative of failure; rather, it reflects the inherent characteristics of Bloom's cognitive hierarchy: higher cognitive levels require more complex and extended learning processes. Remembering and understanding (C1–C2) developed relatively rapidly through repeated concept exposure occurring consistently during each board game session, which explains the higher N-Gain values for these indicators. The Low N-Gain for C4 indicates that analytical ability – requiring students to decompose complex information and construct evidence-based arguments – necessitates a more extensive accumulation of learning experience than could be facilitated within three CAR cycles.

The success of this study is also attributable to the effectiveness of the continuous reflection–improvement cycle. Each reflection produced concrete follow-up actions that were directly implemented in the planning of the subsequent cycle: the conceptual understanding problem in Cycle I was addressed through concept cards in Cycle II; the product procedure evaluation problem in Cycle II was addressed through the structured product evaluation sheet and presentation guide in Cycle III. This pattern is consistent with Taabudillah et al. (2025), who emphasise that instructional improvement must be systematic, reflective, and adaptive. The integration of concrete projects (PjBL) and game elements (board games) was thus demonstrated to be mutually complementary: projects provided meaningful and in-depth learning experiences, whilst board games consolidated understanding through enjoyable repetition. Overall, this study confirms that the integrated PjBL and educational board game model constitutes a comprehensive pedagogical innovation that not only enhances cognitive learning outcomes but also positively impacts the affective (motivation, confidence, learning interest) and psychomotor (laboratory and presentation skills) dimensions of student development. This model accordingly merits consideration as an alternative science learning strategy in junior secondary schools in pursuit of meaningful, enjoyable, and impactful learning.

CONCLUSION

Based on the research findings, the implementation of the Project-Based Learning (PjBL) model integrated with educational board games demonstrably improved the learning outcomes of eighth-grade students on Biotechnology content at SMP Negeri 26 Makassar. Improvement was evident in the increase of mean student scores from pretest to posttest, as well as in the progressive improvement of learning outcomes across each cycle. In addition, students' cognitive abilities improved across indicators C1 to C4, with improvements categorised as moderate overall. The integration of projects and educational board games effectively created a more active, enjoyable, and meaningful learning environment through contextual learning experiences, group discussion, and immediate feedback during gameplay. The reflection and improvement process within each cycle also contributed to the sustained enhancement of learning quality. Accordingly, the PjBL model integrated with educational board games merits adoption as an alternative science learning strategy for improving student learning outcomes, motivation, and active engagement at the junior secondary level.

REFERENCES

Bessie, G.W.B., Margarida, F.B.C., Poko, S., & Damnosel, B.P. (2025). Evaluasi efektivitas pembelajaran berbasis proyek di sekolah menengah atas. Jurnal Ilmiah Literasi Indonesia, 1(2). https://doi.org/10.63822/cfyzt016

Bulkis, P., Suriansyah, A., & Harsono, M.A. (2025). Implementasi pendekatan deep learning melalui model pembelajaran project based learning di sekolah 3T. *Jurnal Intelek dan Cendikiawan Nusantara*, 2(6).

Ervina, Fera, E., Vivi, J., & Aidil, P. (2025). Tinjauan teoretis terhadap strategi pembelajaran aktif dalam pendidikan abad 21. *Jurnal Pendidikan Tambusai*, 9(2).

Fajra, R., Ahmad, S., & Siti, R. (2023). Metode pembelajaran aktif untuk meningkatkan keterampilan berpikir kritis siswa sekolah dasar. *Jurnal Dunia Pendidikan*, 4(1).

Lubis, D.C., Fitri, K.S.H., Nadia, S., Namira, S., & Nurhalizah, E.S. (2024). Pembelajaran berbasis proyek: Mengembangkan keterampilan abad 21 di kelas. *Edu Society: Jurnal Pendidikan, Ilmu Sosial, dan Pengabdian kepada Masyarakat*, 4(1).

Makatita, A.L. (2024). Pengembangan perangkat pembelajaran model Project Based Learning (PjBL) materi ekosistem untuk meningkatkan hasil belajar kognitif pada siswa SMA Negeri 4 Ambon. *Dharmas Education Journal*, 5(1).

Nilasari, N.P.L., Made, A.N.T., & Komang, W.W. (2026). Boardgame sebagai media inovatif dalam meningkatkan keterampilan berpikir kritis siswa sekolah dasar. *Jurnal Ilmiah Ilmu Pendidikan*, 9(1).

Nisa, A.K., Tinofa, N.A., Noptario, N., & Abdullah, F. (2024). Transisi pembelajaran teacher centered menuju student centered: Penguatan literasi teknologi siswa sekolah dasar. *Ideguru: Jurnal Karya Ilmiah Guru*, 9(3), 1453–1460.

Nurcahyo, N., Dodi, S.R., Melinda, Y.R., Trisna, R., Loria, W., & Mira, H. (2025). Pengaruh gamifikasi dalam pembelajaran online terhadap motivasi belajar siswa. *Community Development Journal*, 6(3).

Nursalam, N., Sulaeman, S., & Latuapo, R. (2023). Implementasi kurikulum merdeka melalui pembelajaran berbasis proyek pada sekolah penggerak. *Jurnal Pendidikan dan Kebudayaan*, 8(1), 17–34. https://doi.org/10.24832/jpnk.v8i1.3769

Prasetyo, A. (2020). *Partisipasi siswa dalam pembelajaran berbasis konstruktivisme*. Universitas Pendidikan Indonesia.

Putri, S.A., & Sugiyanto, S. (2025). Pengembangan media interaktif berbasis Google Sites materi bioteknologi untuk mendukung kemampuan berpikir kritis siswa. *Jurnal Pendidikan IPA*, 15(2), 142–152. https://doi.org/10.24929/lensa.v15i2.838

Sari, A.M., Rakimahwati, R., Suryana, D., Jamna, J., & Jasrial, J. (2024). Pengembangan model pembelajaran berbasis proyek berbantu game edukasi di taman kanak-kanak. *Aulad: Journal on Early Childhood*, 7(1), 130–140. https://doi.org/10.31004/aulad.v7i1.598

Sibarani, B.N., Afrida, & Febbry, F. (2025). Pengembangan media pembelajaran games based learning menggunakan Wordwall berbasis PjBL untuk mendukung kemampuan kreativitas siswa pada materi sistem koloid. *Jurnal Pengabdian Masyarakat dan Riset Pendidikan*, 4(1), 2184–2191. https://doi.org/10.31004/jerkin.v4i1.1677

Sukarelawan, M.I., Indratno, T.K., & Ayu, S.M. (2024). *N-Gain vs stacking: Analisis perubahan abilitas peserta didik dalam desain one group pretest-posttest*. Suryacahya.
Sutarini, Sutikno, Mimi, R., & Putri, J. (2024). Penerapan model Project Based Learning (PjBL) untuk meningkatkan kreativitas mahasiswa mendesain media. *Jurnal Pendidikan West Science*, 2(2).
Taabudillah, M.H., Masitoh, E.S., & Aura, A. (2025). Refleksi pembelajaran sebagai langkah strategis dalam perbaikan metode mengajar. *Ulumuddin: Journal of Islamic Studies*, 1(2).
Winarsih. (2022). Peningkatan kemampuan pemecahan masalah matematika pada materi vektor menggunakan model Problem Based Learning siswa kelas X MIA SMAN 1 Balai Riam tahun pelajaran 2021/2022. *Meretas: Jurnal Ilmu Pendidikan*, 9(1).