Technical and Vocational Education International Journal
Agustus 2026 | Vol. 6 | No. 02
E-ISSN : 2721-9798
DOI: https://doi.org/10.55642/taveij.v6i02.1370

Technical and Vocational Education International Journal (TAVEIJ)

Evaluating the Effectiveness of Project Based Learning on Higher Order Thinking Skills in Informatics Learning: A Simulation Based Analytical Illustration

Halidi[1*], Abd halim[2], Ratih rosita[3]
[1,2,3]Universitas Muhammadiyah Jambi
e-mail: *[1]hhalidi866@gmail.com, [2]abdh0074@gmail.com, [3]ratihrosita11@gmail.com

Abstract

The low level of students' higher-order thinking skills (HOTS) in Informatics learning is a problem that affects the analytical, evaluative, and creative thinking abilities that can support computational thinking. This article aims to illustrate an analytical procedure for examining the potential effectiveness of the Project Based Learning (PjBL) model in improving students' HOTS in Informatics learning. The analysis is illustrated using a simulated dataset constructed to demonstrate the proposed design and analytical procedure rather than data collected from actual respondents. The illustration is based on a quasi-experimental nonequivalent control group design with pretest and posttest, modeled on a hypothetical cohort of 64 students divided into an experimental group (PjBL) and a control group (conventional learning). A simulated dataset was generated for a HOTS test structured according to the revised Bloom's taxonomy (C4-C6), together with illustrative observation and interview material. Quantitative data were analyzed using independent and paired-samples t-tests, Cohen's d, and N-Gain, while the illustrative qualitative material was examined through thematic analysis. The simulated results show the pattern the analysis would reveal if a real improvement in HOTS occurred in the experimental group relative to the control group, with a large effect size and a moderate N-Gain. In the simulated data the largest gains appear in the creating and evaluating dimensions. The illustration shows how such results, if obtained with real data, could be analyzed to examine whether PjBL is associated with greater improvement in students' HOTS, with potential relevance to computational thinking, and it thereby offers a worked, reproducible analytical template, released with open R and Python code, that researchers can apply directly to actual classroom data on project-based learning in Informatics.

Keywords— Project-Based Learning; HOTS; Informatics; Computational Thinking

INTRODUCTION

Informatics learning at the secondary level plays a strategic role in developing not only technological and programming competence but also higher-order thinking skills (HOTS) such as analytical, evaluative, and creative thinking, which can support the development of computational thinking (Sulaiman & Ismail, 2022; Lyon & Magana, 2022). In the twenty-first century, these competencies have become essential capabilities that enable students to solve complex problems, design digital solutions, and adapt to a rapidly changing technological landscape (Thornhill-Miller et al., 2023; Chalkiadaki, 2022). The national curriculum explicitly mandates the development of HOTS to equip students with analyzing, evaluating, and creating abilities, as reflected in the higher-level cognitive dimensions of Bloom's revised taxonomy (Ichsan & Rahmayanti, 2022; Kamaludin & Ismiatun, 2023). For a discipline as inherently problem-oriented as Informatics, fostering HOTS is not merely desirable but central to authentic disciplinary practice.

Despite these expectations, evidence from educational contexts indicates persistent challenges in developing and assessing students' higher-order thinking skills. Learning tends to emphasize the memorization of concepts and procedural operation of software rather than higher-order tasks such as designing algorithms, evaluating the efficiency of solutions, and creating original digital products (Seit & Herwin, 2022; Setyorini, 2025). This condition is exacerbated by conventional, teacher-centered instruction that provides limited opportunities for students to engage in authentic problem solving and knowledge construction (Sasson et al., 2022; Wijaya, 2024). As a result, students often struggle when confronted with assessment tasks that demand analysis, evaluation, and creation, and their computational thinking remains underdeveloped.

Project-Based Learning (PjBL) has been widely proposed as an effective strategy for cultivating higher-order thinking. PjBL is a student-centered model in which learners engage in extended inquiry around a driving question, design and construct authentic products, and reflect on their process, thereby integrating cognitive, affective, and psychomotor dimensions of learning (Almulla, 2022; Markula & Aksela, 2022). Through the cycle of questioning, designing, building, testing, and presenting, students are naturally required to analyze problems, evaluate alternative solutions, and create tangible artifacts, which correspond directly to the HOTS dimensions of the revised Bloom's taxonomy (Tafakur et al., 2023; Zhang & Ma, 2023). In the context of Informatics, PjBL is particularly well suited because programming and system design are intrinsically project-oriented activities that culminate in a working product.

Several studies have demonstrated the positive effects of PjBL on students' thinking skills across various subjects. Meta-analytic evidence indicates that PjBL produces moderate to large positive effects on academic achievement and higher-order thinking compared with conventional instruction (Tafakur et al., 2023; Zhang & Ma, 2023). In science and mathematics, problem-based learning has been shown to enhance critical thinking, creativity, and problem solving ability (Sasson et al., 2022; Suryanti & Nurhuda, 2022). Nevertheless, most existing studies focus on general academic outcomes or on subjects other than Informatics, and relatively few have examined the specific effect of PjBL on the distinct HOTS dimensions (analyzing, evaluating, and creating) within Informatics learning, nor have they linked these gains explicitly to computational thinking (Zhang & Ma, 2023; Suprapto et al., 2022).

Accordingly, a clear research gap emerges. First, empirical studies measuring the effect of PjBL specifically on HOTS in Informatics learning at the secondary level remain limited. Second, few studies decompose the effect across the individual HOTS dimensions to identify where PjBL contributes most, particularly in the creating dimension that is central to computational practice. Third, the integration of quantitative effect measurement with qualitative evidence of how the project process fosters higher-order thinking is still underexplored. This article addresses these gaps by illustrating how the effectiveness of PjBL in improving HOTS in Informatics could be evaluated through a quasi-experimental design, decomposing the gains across C4-C6, and triangulating the statistical findings with observation and interview data.

The contribution of this article is a transparent, reusable analytical template for evaluating PjBL effects on HOTS in Informatics learning, released together with open, executable code (in R and Python) and a documented data format. Rather than presenting yet another one-off effectiveness study, the article specifies an end-to-end procedure that decomposes HOTS gains across the C4-C6 dimensions of the revised Bloom's taxonomy and integrates assumption checks, within- and between-group testing, effect sizes, and normalized gain into a single reproducible workflow. The template is demonstrated on a simulated data set so that every reported figure can be regenerated and audited, and it is designed to be applied unchanged to empirical student data by substituting the input file. This article aims to illustrate an analytical procedure for examining the potential effectiveness of PjBL in improving students' HOTS in Informatics learning, to compare the modeled improvement between students taught with PjBL and those taught with conventional learning, and to examine how the project-based process fosters analyzing, evaluating, and creating. The findings are expected to provide both conceptual contributions to the study of HOTS and practical recommendations for improving the quality of Informatics learning. Systematically, the conceptual framework of this study is presented in Figure 1.

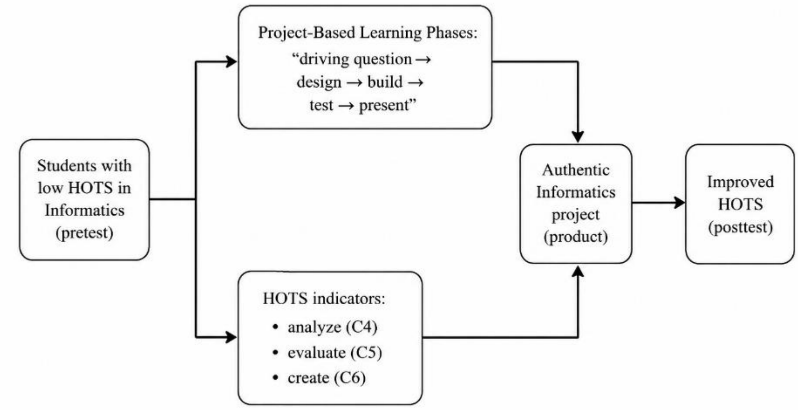

Figure 1. Conceptual Framework of the Study

RESEARCH METHODS

This article presents a simulation-based illustration modeled on a quantitative quasi-experimental nonequivalent control group design using pretest and posttest measurements (Creswell & Creswell, 2023; Miller et al., 2022). It should be noted that the data reported in this article are simulated data, generated to illustrate the research design and the statistical analysis workflow; they do not represent measurements obtained from real students, and the numerical results should therefore be interpreted as a methodological illustration rather than empirical evidence. This design was selected because it allows the researcher to compare the improvement of HOTS between an experimental group taught with Project-Based Learning (PjBL) and a control group taught with conventional learning, without random assignment of individual students, which is not feasible in an intact-classroom school setting. To illustrate how qualitative evidence could complement the numerical results, hypothetical observation and interview materials were constructed as supporting examples, so that the illustration could show both the magnitude and the process of a possible improvement.

The illustration is modeled on a hypothetical cohort of 64 tenth-grade students in the Informatics subject, organized as two intact classes with comparable initial characteristics. One class (n = 32) is modeled as the experimental group receiving instruction with the PjBL model, and the other (n = 32) as the control group receiving conventional, teacher-centered instruction on the same material. Both groups are assumed to be taught by the same teacher over six meetings covering an authentic Informatics project, such as designing and building a simple application or information system. In this modeled design, the PjBL implementation follows five instructional phases: formulating a driving question, designing a plan, building the product, testing and monitoring, and presenting and evaluating the outcome, as summarized in Table 1.

Table 1. Phases of Project-Based Learning Implementation

PjBL Phase	Learning Activities and Targeted HOTS
Driving question	Students are presented with an authentic problem and formulate the project goal, activating analysis of the problem (C4).
Designing a plan	Students design an algorithm or system plan, comparing alternative approaches and justifying choices (C4–C5).
Building the product	Students construct the digital product (program/prototype), applying and creating solutions (C6).
Testing & monitoring	Students test, debug, and evaluate the efficiency and correctness of the product (C5).
Presenting & evaluating	Students present the product, evaluate peers' work, and reflect on the process (C5–C6).

The primary instrument was a HOTS test consisting of 12 essay and problem-solving items constructed according to the revised Bloom's taxonomy, covering the analyzing (C4), evaluating (C5), and creating (C6) dimensions within Informatics content. The test was administered as both pretest and posttest to the two groups. For the purpose of this illustration, the validation stage is represented with plausible values of the kind such a procedure would yield: content validity assessed by three expert validators rating the items on a five-point scale, with Aiken's V coefficients of 0.79 to 0.82, and reliability from a pilot test of 30 students giving a Cronbach's alpha of 0.86. These validation figures are illustrative and would need to be obtained from a real expert panel and pilot sample in an empirical application. Observation sheets were used to record students' engagement in higher-order activities during the project. In this design, semi-structured interviews would be conducted with about eight students from the experimental group, selected purposively to represent a range of achievement levels, after the posttest, each lasting approximately 20 to 30 minutes, and would be analyzed thematically following the six-phase approach of Braun and Clarke (2023). The interview material used below is constructed for illustration rather than drawn from real respondents. The validity and reliability of the HOTS test are summarized in Table 2.

Table 2. Validity and Reliability of the HOTS Test

Dimension	Indicators	Aiken's V
Analyzing (C4)	Tracing algorithms; identifying errors; comparing data structures	0.82
Evaluating (C5)	Assessing efficiency; judging solutions; critiquing designs	0.79
Creating (C6)	Designing algorithms; building programs; constructing systems	0.81
Overall reliability		Cronbach's α = 0.86

Data analysis was conducted in two complementary ways. The quantitative data were analyzed using descriptive statistics (mean, standard deviation, and category). Within this analytical procedure, the assumptions of normality and homogeneity of variance are checked using the Shapiro-Wilk and Levene tests before the parametric comparisons. For the simulated data used here, the gain scores did not depart significantly from normality (Shapiro-Wilk $p = .39$ for the experimental group and $p = .57$ for the control group) and the posttest variances were homogeneous (Levene $p = .79$), so the parametric comparisons were appropriate. All statistics reported below are produced by the accompanying analysis script (see the Data and code availability statement), so that the same procedure can be re-run on empirical data. A paired-samples t-test was used to examine the difference between pretest and posttest scores within each group, and an independent-samples t-test was used to compare the posttest scores and the gain between the experimental and control groups, with the alpha level set at 0.05. Effect sizes were calculated using Cohen's d, and the magnitude of improvement was measured using the normalized gain (N-Gain), categorized as low (< 0.30), moderate (0.30–<0.70), or high (≥ 0.70). The constructed qualitative material was thematically interpreted following the six-phase approach of Braun and Clarke (2023). In an empirical application of this procedure, data triangulation would integrate the quantitative and qualitative findings to provide a holistic understanding of the effectiveness of PjBL, and the study would be conducted in accordance with applicable research ethics, including informed consent and assured confidentiality. As this article uses simulated data, no human participants were involved. The entire procedure described in this section is implemented as a single, ordered analysis script so that it functions as a reusable template: each step, from descriptive statistics and assumption checks to t-tests, effect sizes, and normalized-gain categorization, is executed by the same code and can be reproduced or applied to new data without modification.

RESULTS AND DISCUSSION

Results

In the simulated dataset, the modeled groups have comparable baseline HOTS scores, with pretest means in the low category and no statistically significant baseline difference detected between them ($p > .05$), suggesting comparable baseline scores. After the modeled intervention, the experimental group associated with PjBL shows a substantially greater improvement than the control group. The comparison of the pretest and posttest scores of the two groups is presented in Table 3.

Table 3. Pretest and Posttest HOTS Scores by Group

Group	Pretest (M ± SD)	Posttest (M ± SD)	Gain	N-Gain	Category
Experimental (PjBL)	48.6 ± 7.8	82.3 ± 9.2	33.7	0.66	Moderate
Control (conventional)	47.9 ± 8.1	66.4 ± 9.4	18.5	0.36	Moderate

Note. The values in this table are simulated data generated to illustrate the analytical procedure; they are not derived from actual student measurements.

As shown in Table 3, the experimental group's mean HOTS score increased from 48.6 to 82.3, yielding a moderate N-Gain of 0.66, whereas the control group increased from 47.9 to 66.4, yielding a moderate N-Gain of 0.36. The paired-samples t-test showed a significant improvement from pretest to posttest in the experimental group, $t(31) = 24.74$, $p < .001$, and in the control group, $t(31) = 13.23$, $p < .001$. The independent-samples t-test showed that the experimental group had significantly higher posttest scores than the control group, $t(62) = 6.84$, $p < .001$, Cohen's $d = 1.71$. A separate independent-samples t-test on the gain scores likewise favored the experimental group, $t(62) = 7.79$, $p < .001$, Cohen's $d = 1.95$. In this illustration, while both modeled approaches show improved HOTS, the effect associated with PjBL is substantially larger. The comparison is visualized in Figure 2.

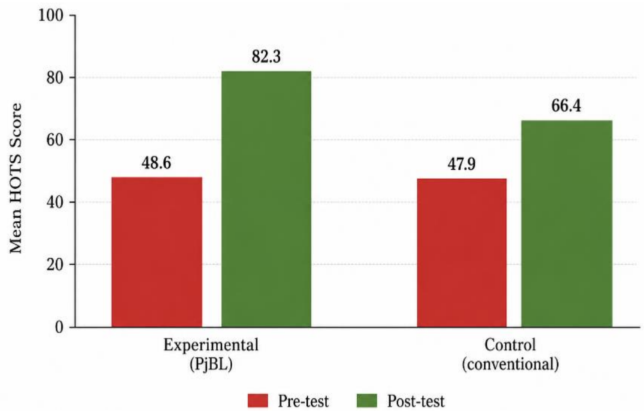

Figure 2. Simulated Pretest and Posttest HOTS Scores by Group

In the simulated data, the modeled improvement in the experimental group appears across all three HOTS dimensions. The largest raw gains appeared in the creating and evaluating dimensions, with both increasing by 33.8 points (creating: 45.3 to 79.1; evaluating: 47.8 to 81.6), while analyzing increased by 33.5 points (52.7 to 86.2). This simulated pattern illustrates how authentic project activities could be hypothesized to support the development of the creating and evaluating dimensions. The improvement across the three HOTS dimensions is illustrated in Figure 3.

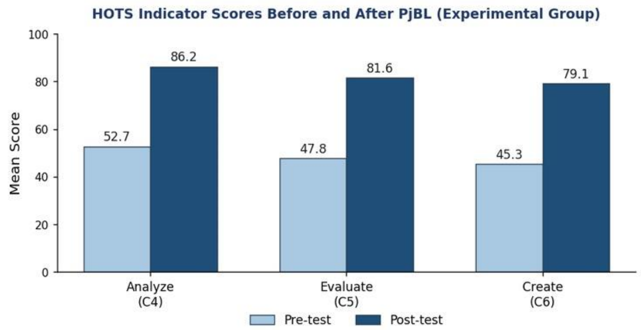

Figure 3. Simulated HOTS Indicator Scores Before and After PjBL (Modeled Experimental Group)

To illustrate how qualitative evidence would complement the quantitative analysis, the following observation and interview material is presented as constructed, illustrative examples rather than records of real classroom events. In such a design, observation notes would be expected to capture how, during the driving-question and design phases, students in the experimental group engage in analyzing the problem and comparing alternative solutions, whereas the control group primarily receives explanations and works on routine exercises. In the building and testing phases, students would collaboratively debug their programs and evaluate the efficiency of their solutions, showing evaluating and creating behaviors less common in the control group. By the presentation phase, students would be expected to justify their design choices and critique peers' products, indicating how higher-order thinking could become an integral part of the learning process rather than an isolated task.

A thematic reading of the illustrative interview material points to three themes that such a study might surface. The first, ownership through authentic products, reflects a sense of engagement arising from building something real, as in the following constructed example:

"When I had to actually build the program myself, I had to think about why each part worked and how to fix it when it failed. It was harder than just answering questions, but I understood much more." (illustrative example, not a real respondent)

The second theme, learning through iteration and failure, reflects how a testing and debugging cycle could foster evaluative thinking through repeated assessment and refinement of solutions. The third, collaborative reasoning, reflects how group work might encourage students to explain, defend, and revise their ideas, strengthening both analysis and evaluation, as in this constructed example:

"In my group we argued about which algorithm was faster, and to convince each other we had to test both. That made me really think about efficiency, not just whether it worked." (illustrative example, not a real respondent)

Taken together, the simulated quantitative results and the illustrative qualitative material show how the two strands of evidence would be integrated in a real study: the moderate N-Gain, the large effect size, and the comparable gains in the creating and evaluating dimensions would be interpreted alongside evidence of engagement in authentic, iterative, and collaborative problem solving.

Discussion

In the simulated illustration, the analysis points to a pattern in which Project-Based Learning is associated with greater improvement in students' HOTS in Informatics learning. The modeled experimental group's moderate N-Gain (0.66) and the large effect size ($d = 1.71$) in favor of PjBL over conventional learning correspond to substantial and practically significant differences within the constructed data; they demonstrate what the analytical procedure would report rather than establishing an empirical effect. These results align with and extend previous research documenting the positive effects of PjBL on higher-order thinking across subjects (Tafakur et al., 2023; Sasson et al., 2022; Zhang & Ma, 2023), while illustrating how its effectiveness could be examined within the distinct context of Informatics, where programming and system design are intrinsically project-oriented. The simulated pattern in which both modeled groups improved, with the PjBL group improving more substantially, illustrates how the authentic, student-centered, and iterative nature of the project process, rather than mere exposure to the content, could be associated with greater development of higher-order thinking.

The decomposition of the gains across the three HOTS dimensions offers a more nuanced contribution. The creating dimension (C6) showed one of the largest gains, comparable to that of evaluating, which is consistent with the theoretical premise that PjBL culminates in the construction of an authentic product and therefore most directly exercises the highest-order cognitive processes (Almulla, 2022; Zhang & Ma, 2023). This is particularly significant for Informatics, since creating (designing algorithms and building programs) is the dimension most closely aligned with authentic computational practice and is often the least developed under conventional, procedure-oriented instruction (Setyorini, 2025; Lyon & Magana, 2022). The substantial gains in evaluating and analyzing further indicate that the testing, debugging, and design phases of the project could engage students in assessing efficiency and comparing alternatives, competencies that are central to computational thinking.

The illustrative qualitative material points to the mechanisms that could underlie such gains. A sense of ownership over authentic products, learning through iteration and failure, and collaborative reasoning would together help explain how a project process might foster higher-order thinking. These themes are consistent with the constructivist foundations of PjBL, in which knowledge is actively constructed through meaningful, situated activity rather than passively received (Markula & Aksela, 2022; Almulla, 2022). In such a design, evidence that students engaged in evaluative and creative behaviors rarely seen in the control group would support interpreting any improvement as a change in the quality of thinking rather than a mere increase in test familiarity.

If confirmed with real data, a pattern of this kind would carry practical implications for Informatics education, supporting the integration of project-based, product-oriented learning as a strategy for developing HOTS in the context of computational thinking rather than relying on procedural instruction and low-order assessment. Teachers should design authentic, appropriately scaffolded projects that deliberately target analyzing, evaluating, and creating, and should allocate sufficient time for the iterative testing and reflection phases that appear most responsible for the simulated gains. For curriculum and policy, such results would reinforce the value of embedding project-based approaches within the Informatics curriculum to prepare students for the higher-order demands of twenty-first-century digital work (Chalkiadaki, 2022; Haryani et al., 2022).

Several considerations qualify what this illustration can show. The foremost is that the results are based on simulated rather than empirically collected data; the values are intended to demonstrate the analytical design and must be replicated with real student data before any substantive conclusion about the effectiveness of PjBL can be drawn. The quasi-experimental design that the illustration models does not, on its own, permit full causal attribution, because it lacks random assignment of individual students; an empirical application would need to address this through its design and analysis. When the template is applied to real data, further constraints would apply: a single-school sample over a short period would restrict generalizability and would not capture the long-term durability of any gains, and reliance on a single teacher, while controlling for teacher effects, would limit external validity. Empirical applications should therefore employ larger, multi-site samples, extend the intervention over a longer period, incorporate delayed posttests to assess retention, and examine the differential effectiveness of PjBL across different Informatics topics and student characteristics.

CONCLUSION

This article has presented a worked, simulation-based illustration of how the effectiveness of Project-Based Learning in improving students' higher-order thinking skills in Informatics learning can be designed and analyzed. Using a constructed dataset, the illustration shows how a quasi-experimental comparison, effect-size estimation, N-Gain categorization, and thematic reading of qualitative material can be combined to examine whether PjBL is associated with greater improvement than conventional learning. In the simulated data, the modeled experimental group displays a moderate N-Gain and a large effect size, with the largest gains in the creating and evaluating dimensions. These results are illustrative of the analytical procedure only and do not constitute empirical evidence that PjBL is effective; such a claim would require the same procedure to be applied to data from real students. The article is therefore offered as an analytical template that researchers and practitioners can adopt when evaluating project-based approaches to higher-order thinking in Informatics education.

REFERENCES

1. Almulla, M. A. (2022). The effectiveness of the project-based learning (PBL) approach as a way to engage students in learning. SAGE Open, 12(3), 1–14. https://doi.org/10.1177/21582440221126566.

2. Braun, V., & Clarke, V. (2023). Toward good practice in thematic analysis: Avoiding common problems and be(com)ing a knowing researcher. International Journal of Transgender Health, 24(1), 1–6. https://doi.org/10.1080/26895269.2023.2047392.
3. Chalkiadaki, A. (2022). A systematic literature review of 21st century skills and competencies in primary education. International Journal of Instruction, 11(3), 1–16. https://doi.org/10.12973/iji.2018.1131a.
4. Creswell, J. W., & Creswell, J. D. (2023). Research design: Qualitative, quantitative, and mixed methods approaches (6th ed.). SAGE.
5. Guo, P., Saab, N., Ren, D., & Admiraal, W. (2023). The community of inquiry perspective on students' social presence, cognitive presence, and academic performance in online project-based learning. Journal of Computer Assisted Learning, 39(5), 1481–1494. https://doi.org/10.1111/jcal.12817.
6. Haryani, E., Cobern, W. W., & Pleasants, B. A. S. (2022). Fostering students' 21st century skills through project-based learning in science education. Journal of Turkish Science Education, 19(3), 862–882. https://doi.org/10.36681/tused.2022.155.
7. Ichsan, I. Z., & Rahmayanti, H. (2022). Higher order thinking skills and Bloom's taxonomy in education: A systematic review. Jurnal Penelitian dan Pembelajaran IPA, 8(2), 145–162. https://doi.org/10.30870/jppi.v8i2.14889.
8. Kamaludin, A., & Ismiatun. (2023). Pengembangan Buku Teks bermuatan Higher-Order Thinking Skills (HOTS). Journal of Tropical Chemistry Research and Education, 5(2), 34–42. https://doi.org/10.14421/jtcre.2023.52-04.
9. Lyon, J. A., & Magana, A. J. (2022). A review of mentoring and computational thinking: Fostering problem solving in computer science education. Computer Applications in Engineering Education, 30(3), 895–914. https://doi.org/10.1002/cae.22488.
10. Markula, A., & Aksela, M. (2022). The key characteristics of project-based learning: How teachers implement projects in K-12 science education. Disciplinary and Interdisciplinary Science Education Research, 4(1), 2. https://doi.org/10.1186/s43031-021-00042-x.
11. Miller, C. J., Smith, S. N., & Pugatch, M. (2022). Experimental and quasi-experimental designs in implementation research. Psychiatry Research, 283, 112452. https://doi.org/10.1016/j.psychres.2019.06.027.
12. Sasson, I., Yehuda, I., & Malkinson, N. (2022). Fostering the skills of critical thinking and question-posing in a project-based learning environment. Thinking Skills and Creativity, 44, 101003. https://doi.org/10.1016/j.tsc.2022.101003.
13. Seit, S., & Herwin, H. (2022). Teachers' understanding and implementation of higher-order thinking skills in learning. Cypriot Journal of Educational Sciences, 17(9), 3231–3243. https://doi.org/10.18844/cjes.v17i9.7376.
14. Setyorini, R. (2025). The Dominance Of LOTS In Summative Assessment: The Challenge Of Improving HOTS. EDUCATIONE, 3(1), 33–42. https://doi.org/10.59397/edu.v3i1.44.
15. Sulaiman, J., & Ismail, S. N. (2022). Teacher competence and 21st century skills in transformation schools. Universal Journal of Educational Research, 10(1), 71–80. https://doi.org/10.13189/ujer.2022.100108.
16. Suprapto, N., Sunarti, T., & Wulandari, D. (2022). Enhancing students' critical thinking skills through problem-based learning: A meta-analysis. International Journal of Instruction, 15(4), 621–638. https://doi.org/10.29333/iji.2022.15436a.
17. Suryanti, S., & Nurhuda, N. (2022). The effect of problem-based learning on students' higher-order thinking skills. Jurnal Pendidikan Progresif, 12(2), 578–590. https://doi.org/10.23960/jpp.v12.i2.202213.
18. Tafakur, T., Retnawati, H., & Ismail, S. (2023). Effectiveness of project-based learning for enhancing students' critical thinking skills: A meta-analysis. JINoP (Jurnal Inovasi Pembelajaran), 9(2), 191–206. https://doi.org/10.22219/jinop.v9i2.26467.
19. 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. https://doi.org/10.3390/jintelligence11030054.

20. Wijaya, H. Z. P. (2024). Analyzing Levels, Factors and Students' Strategies in Learning. SALEE: Study of Applied Linguistics and English Education, 3(2), 318–338. https://doi.org/10.35961/salee.v3i2.507.
21. 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. https://doi.org/10.3389/fpsyg.2023.1202728.