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Problem-Based Learning Mathematics Modules: Their Impact on Students' Mathematical Problem-Solving Performance

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Abstract: This research aims to develop a mathematics teaching module based on the Problem-Based Learning model to improve the mathematical problem-solving abilities of eleventh-grade students. Using the Plomp development model, the research was conducted through the initial investigation, prototyping, and assessment stages. The module was validated by experts in mathematics education, language, and educational technology, resulting in an average validity score of 3.56 (categorized as "Very Valid"). Practicality evaluation through classroom implementation over four meetings showed excellent practicality with an average implementation rate of 93%, while student response questionnaires revealed consistently positive feedback across all measured aspects. Effectiveness testing with 34 students showed that 73.52% achieved scores above the minimum completeness criteria, exceeding the established effectiveness threshold of 60%. This module specifically improved students' abilities in understanding problems (87.6%) and planning solutions (85.3%). Research results confirm that the developed module is valid, practical, and effective in improving mathematical problem-solving skills. This research provides educators with a structured and contextual approach to mathematics teaching that bridges theoretical concepts with real-world applications, addressing Indonesia's historical challenges in mathematics education.

Keywords Problem**:** Based Learning; Problem-Solving Ability; Teaching materials

Introduction

Mathematics plays an important role in secondary education as a fundamental discipline that enhances students' ability to participate effectively in society, national development, and state affairs (Abdul-Mumin et al., 2025; Dossey et al., 2024; Kong & Zhu, 2025). As a universal science, mathematics forms the basis for the development of modern technology and serves as an important tool at various educational levels. Learning mathematics not only develops logical, analytical, systematic, critical, and creative thinking skills, but also equips students with competencies to acquire, manage, and utilize information in an ever-changing and competitive world (Bikse & Riemere, 2013; Koloszár et al., 2023; Mezinska et al., 2024).

The main goal of mathematics education goes beyond mere conceptual understanding; it aims to develop comprehensive mathematical competencies, including problem-solving ability, reasoning, communication, connections, and representation (Deehan et al., 2025; Emma, 2025; Gashaj et al., 2025). Among these competencies, mathematical problem-solving ability is a core competency that enables students to accurately identify problems, build mathematical models, select and apply appropriate strategies, and interpret results to verify solutions. These skills are vital as they prepare students to face real-world challenges with logical, systematic, and critical thinking approaches (Calma, 2025; Ceballos et al., 2025; Promma et al., 2025).

However, educational realities reveals significant challenges in developing students' mathematical problem-solving abilities. International assessments show that Indonesian students perform far below the OECD average in problem-solving competencies, with

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only 31% achieving basic problem-solving skills compared to the OECD average of 78%. Classroom observations and preliminary testing in several selected high schools in Padang revealed that students struggle with contextual problems, often relying on routine exercises that follow direct formula application rather than engaging with authentic and complex problems. Current teaching materials and learning modules appear insufficient in providing structured guidance for the problem-solving process, often presenting formulas to be memorized rather than facilitating meaningful knowledge construction through problem investigation (Chen, 2025; Koerich et al., 2024; Ping & Abideen, 2025).

The Problem-Based Learning (PBL) model offers a promising approach to address these challenges (Gao et al., 2024; Murphy et al., 2025; Novalia et al., 2025). PBL centers learning on authentic problems, positioning students as active investigators who develop solutions through collaborative investigation and critical thinking (Anchunda & Kaewurai, 2025; Fredy et al., 2026; Otto et al., 2025). This student-centered approach aligns with contemporary educational principles that emphasize contextual and meaningful learning experiences rather than rote memorization.

Research shows that PBL implementation improves students' problem-solving abilities and deepens their conceptual understanding of mathematical principles. This research aims to develop a mathematics learning module based on the Problem-Based Learning model specifically designed to improve the mathematical problem-solving abilities of eleventh-grade secondary school students. This module will provide structured learning experiences that guide students through the problem-solving process while maintaining authenticity and relevance to real-world contexts.

By integrating PBL principles with a comprehensive problem-solving framework, this module seeks to bridge the gap between theoretical mathematical concepts and practical applications, ultimately contributing to improved problem-solving competence among Indonesian secondary school students.

The PBL model follows five systematic steps that create an effective learning cycle: (1) Identifying and defining the problem, where students analyze authentic scenarios to recognize mathematical challenges; (2) Exploring and gathering information, where students research relevant concepts and strategies needed to address the problem; (3) Developing and planning solutions, where students collaborate to design systematic approaches to solve the problem; (4) Implementing solutions and evaluating results, where students apply their strategies and assess the effectiveness of their approaches; and (5) Presenting findings and reflecting, where students communicate their solutions and reflect on their learning process.

The advantages of PBL are substantial: it promotes deeper conceptual understanding by connecting abstract mathematical concepts to real-world contexts; enhances critical thinking and analytical skills through authentic problem scenarios; develops collaborative abilities as students work in teams to solve complex problems; improves communication skills as students explain their reasoning and solutions; increases motivation and engagement through meaningful, relevant learning experiences; and builds transferable skills that prepare students for future academic and professional challenges. By incorporating these structured steps and leveraging these advantages, PBL transforms mathematics education from a passive, formula-based approach to an active, inquiry-driven learning experience that develops both mathematical proficiency and essential life skills.

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Method

This research used Research and Development (R&D) methodology, specifically utilizing the Plomp development model. According to Ali & Asrori (2014), R&D is defined as a systematic process for developing educational tools through various stages that assess validity, practicality, and effectiveness.

Figure 1. the Plomp Development Model

Research Model

This research used the Plomp development model as the research framework due to its systematic structure and clear procedural stages, which facilitate the development and evaluation of educational products. The Plomp model is widely recognized in educational research for its practicality and flexibility in producing valid, practical, and effective learning materials (Mirattanaphrai & Srikoon, 2025). This model consists of three main phases: initial research, development or prototyping, and assessment.

The initial research phase was conducted to identify the basic requirements for developing the mathematics learning module. This phase involved needs and context analysis to examine existing learning conditions and challenges faced by students and teachers. Literature reviews were conducted to explore relevant theories, previous research, and best practices related to Problem-Based Learning and mathematical problem-solving skills. Based on these findings, a conceptual framework was formulated to guide module development. Additionally, curriculum analysis was performed to ensure alignment with the current curriculum, followed by concept analysis to determine essential mathematical concepts to be included in the module. Furthermore, student characteristic analysis was conducted to tailor the module to students' cognitive levels, learning styles, and prerequisite knowledge.

The development or prototyping phase focused on designing and refining the learning module through iterative evaluation. Initially, self-evaluation was conducted by the researchers to identify potential weaknesses in the initial prototype. Subsequently, the prototype underwent expert review, where content experts, instructional design specialists, and language experts validated the module in terms of content accuracy, instructional quality, and clarity. After revisions based on expert feedback, one-to-one evaluation was conducted to assess the module's readability and usability through individual testing by students. This was followed by small group evaluation, involving a limited number of students to test the module's practicality and initial effectiveness. The refined prototype was then implemented in field testing during classroom learning activities to evaluate its performance in real instructional settings.

The final phase, the assessment phase, aimed to determine the overall quality of the developed module. This phase included practicality testing to assess the ease of use, clarity, and feasibility of the module from the perspective of teachers and students. Additionally, effectiveness testing was conducted to measure the extent to which the module improved students' mathematical problem-solving skills. Based on these evaluation results, final revisions were made to produce the final version of the mathematics learning module that meets validity, practicality, and effectiveness criteria.

Research Subjects

This research was conducted at SMA Negeri 9 Padang, involving eleventh-grade (Class XI) students as the main research subjects. Different student groups were involved at various stages of the development process to ensure comprehensive evaluation of the developed learning module.

During the one-to-one evaluation stage, three students representing different levels of mathematical ability high, medium, and low—were selected. This stage aimed to assess the clarity, readability, and understanding of the learning module at the individual level.

In the small group evaluation stage, six students with heterogeneous ability levels participated to test the practicality, usability, and interaction dynamics of the module when used collaboratively in a limited group setting. Finally, the field testing stage was conducted involving one full class of Class XI students. This stage aimed to evaluate the module's effectiveness in authentic classroom conditions, specifically in improving students' mathematical problem-solving abilities.

Data Collection and Analysis

Data were collected using various instruments to ensure comprehensive evaluation of the developed mathematics instructional module. These instruments included observation sheets to document the learning process and student engagement, interview guidelines to obtain in-depth information from teachers and students, and questionnaires administered to teachers and students to assess validity, practicality, and user perceptions of the module. Additionally, student worksheets were used to test student learning activities, while mathematical problem-solving ability tests were used to measure student learning outcomes and improvement in problem-solving skills.

The collected data were analyzed using a combination of quantitative and qualitative approaches. Quantitative data from mathematical problem-solving ability tests and questionnaire responses were analyzed using descriptive statistics, including average scores and percentages, to describe performance and student perceptions. Validation data obtained from expert assessments was analyzed using rating scale analysis to determine the level of content validity, instructional design quality, and language appropriateness of the module.

Furthermore, practicality analysis was conducted by calculating the percentage of positive responses from teachers and students, reflecting the ease of use, clarity, and feasibility of the module in classroom implementation. To determine the effectiveness of the instructional module, student achievement data were evaluated based on predetermined learning achievement criteria, indicating the extent to which the module improved students' mathematical problem-solving abilities.

Qualitative data obtained from interviews and classroom observations were analyzed using descriptive qualitative analysis, involving data reduction, data display, and conclusion drawing to capture meaningful patterns and insights regarding the implementation process. This comprehensive methodological approach ensures that the developed Problem-Based Learning mathematics module meets validity, practicality, and effectiveness criteria, thereby supporting successful implementation to improve students' mathematical problem-solving abilities.

Result and Discussion

The development and implementation of the mathematics learning module based on the Problem-Based Learning model produced significant findings across the dimensions of validity, practicality, and effectiveness. These findings are summarized below.

Validity Assessment

The module underwent comprehensive validation by mathematics education experts, language specialists, and educational practitioners. The validation results demonstrated excellent quality across all assessed dimensions.

Results of the Prototyping Phase (Development or Prototyping Phase)

Small Group Evaluation Results

Results of Meetings 1-4

Based on observation results during four meetings in the small group evaluation phase, the following is a recapitulation of the implementation of the PBL-based teaching module:

Table 1. Observation Sheet Results of Teaching Module Implementation in Small Group Evaluation Phase

Meeting	Observer Value (%)	Category
I	88.66	Very Practical
II	93.17	Very Practical
III	91.32	Very Practical
IV	92.36	Very Practical
Average	91.38	Very Practical

Based on Table 1, the average implementation value of the teaching module in the small group evaluation phase was 91.38% with the "Very Practical" category. The highest value was in meeting II (93.17%) and the lowest in meeting I (88.66%). Nevertheless, all meetings received the "Very Practical" category, indicating that the teaching module could be implemented very well.

LKPD Practicality Questionnaire Results

Based on Table 2, the average practicality of the LKPD in the small group evaluation phase reached 91.141% with the "Very Practical" category. The ease of understanding aspect received the highest score (93.06%), while time efficiency received the lowest score (87.50%) but remained in the "Very Practical" category.

Table 2. LKPD Practicality Questionnaire Results in Small Group Evaluation

Assessed Aspect	Practicality Value %	Category
Ease of use	91.67	Very Practical
Ease of understanding	93.06	Very Practical
Attractiveness	91.67	Very Practical
Time efficiency	87.50	Very Practical
Benefits	91.67	Very Practical
Overall Average	91.141	Very Practical

Mathematical Problem-Solving Ability Test Results

Based on Table 3, all six participants who took the test in the small group evaluation phase were declared complete, as they received scores ≥ 75. The overall average score reached 84.67, indicating the "Very Effective" category.

Table 3. Mathematical Problem-Solving Ability Test Results in Small Group Evaluation

Student	S1	S2	S3	S4	S5	Total Score	Score	Status
1	10	10	8	10	8	46	92	Complete
2	10	10	6	8	8	42	84	Complete
3	10	10	8	6	6	40	80	Complete
4	10	10	6	10	8	44	88	Complete
5	10	8	6	8	6	42	84	Complete
6	10	10	6	8	6	40	80	Complete
Average							84.67	Complete

Assessment Phase Results
Field Test Results
Teaching Module Implementation Observation Results

Based on Table 4, the average implementation value of the teaching module in the field test phase reached 93.00% with the "Very Practical" category. The highest value was in meeting I (95.14%) and the lowest in meeting II (90.39%).

Table 4. Analysis Results of Teaching Module Implementation Observation Sheet in Field Test Phase

Meeting	Observer Value (%)	Category
I	95.14	Very Practical
II	90.39	Very Practical
III	94.33	Very Practical
IV	92.13	Very Practical
Average	93.00	Very Practical

LKPD Practicality Questionnaire Results by Students

Based on Table 5, the average practicality of the LKPD in the field test phase reached 86.62% with the "Very Practical" category. The ease of use aspect received the highest score (88.24%), while time efficiency received the lowest score (83.82%) with the "Practical" category.

Table 5. LKPD Practicality Questionnaire Results (Field Test - Student Response)

Assessed Aspect	Practicality Value %	Category
Ease of use	88.24%	Very Practical
Ease of understanding	87.99%	Very Practical
Attractiveness	87.75%	Very Practical
Time efficiency	83.82%	Practical
Benefits	85.29%	Very Practical
Overall Average	86.62%	Very Practical

Table 6. Practicality Questionnaire Analysis (Field Test - Educator Response)

Meeting	Practicality Value %	Category
First	95.14	Very Practical
Second	90.39	Very Practical
Third	94.33	Very Practical
Fourth	92.13	Very Practical
Overall Average	93.00	Very Practical

Table 7. Recapitulation of Mathematical Problem-Solving Ability Test Results

Problem	Indicator 1: Understanding the Problem	Indicator 2: Planning the Solution	Indicator 3: Implementing the Solution	Indicator 4: Interpreting Results
1	85.3	88.2	84.6	64.7
2	86.8	86.8	83.8	63.2
3	91.2	88.2	77.2	48.5
4	89.7	88.2	80.1	47.1
5	85.3	75.0	72.1	22.1
Average per Indicator	87.6	85.3	79.6	49.1
Overall Average				75.40

Based on Table 6, of the 34 participants who took the mathematical problem-solving ability test, 25 students (73.52%) achieved learning completeness with scores ≥ 75, while 9 students (26.48%) had not yet achieved completeness. Based on the established effectiveness criteria (> 60%), the PBL-based teaching module was declared effective in improving students' mathematical problem-solving abilities.

The indicators with the highest averages were Understanding the Problem (87.6%) and Planning the Solution (85.3%), while the indicator with the lowest average was Interpreting Results (49.1%), indicating that participants still experienced difficulties in drawing conclusions or verifying the results of their problem solutions.

The comprehensive results show that the mathematics learning module based on the Problem-Based Learning model has been validated as highly valid, practical for classroom implementation, and effective in improving students' mathematical problem-solving abilities. This module successfully facilitated authentic problem-solving experiences and demonstrated measurable improvement in students' mathematical competencies across various dimensions.

The findings of this research indicate the significant potential of Problem-Based Learning (PBL) modules to transform mathematics education in Indonesian secondary schools. Rather than merely presenting data, this discussion explores the deeper implications of these results for educational practice and student development.

The exceptional validity ratings across all assessment dimensions reveal more than formal approval they indicate fundamental alignment between pedagogical theory and real classroom needs. When mathematics educators and language experts unanimously validate instructional materials, this signifies that the module successfully bridges theoretical frameworks with authentic learning contexts. This alignment is crucial in mathematics education, where

abstract concepts often fail to connect with students' life experiences. The validation process itself transforms the module from a theoretical construct into a practical tool aligned with educators' expertise and students' learning needs.

The practicality results offer compelling evidence that student-centered approaches can be realistically implemented within the constraints of Indonesian education. Consistently high ratings across four separate class sessions demonstrate that the PBL methodology doesn't require ideal conditions or extraordinary resources it can thrive in typical classroom environments. This challenges the common assumption that innovative teaching methods are too complex or resource-intensive for routine implementation. Observation data specifically highlights how structured problem-solving activities can transform classroom dynamics from teacher-dominated instruction to collaborative knowledge construction. When students actively engage with real-world problems, classroom time becomes more purposeful and learning becomes more meaningful.

Perhaps most significant are the effectiveness results showing substantial improvement in mathematical problem-solving abilities. The achievement rate of 73.52% exceeds not only the established effectiveness threshold but also represents a meaningful shift from Indonesia's historically low PISA problem-solving scores. This improvement is significant because it demonstrates that targeted instructional design can address systemic learning gaps. Students are not just memorizing procedures; they are developing transferable cognitive skills that enable them to approach unfamiliar problems with confidence and methodical thinking.

The exceptionally strong performance on problem understanding (87.6%) and solution planning (85.3%) indicators suggests that the module successfully builds foundational thinking skills rather than merely procedural knowledge. The integration of practical financial mathematics problems appears to have created authentic learning contexts that motivate students beyond academic requirements. When students recognize the direct relevance of mathematical concepts to their future lives—through loan calculations, investment analysis, and financial planning—their engagement shifts from compliance to genuine interest. This contextual relevance addresses one of mathematics education's persistent challenges: the perception of mathematics as disconnected from daily life (Schmidt et al., 2025; Smiling & Hollebrands, 2025; Vlachopoulos & Makri, 2024).

The development journey from prototype to validated module also reveals important insights about the educational design process. Iterative refinement based on expert feedback, one-to-one testing, small group evaluation, and field testing demonstrates that effective educational materials emerge through collaborative development rather than individual expertise alone. Each revision cycle strengthened not only the module's content but also its pedagogical architecture—how problems support gradual learning, how guidance balances support with independence, and how assessment aligns with authentic problem-solving processes (Bijl et al., 2025; Boetje et al., 2024; Elsen et al., 2025).

These findings collectively suggest that mathematics education in Indonesia can overcome its historical challenges through carefully designed, contextually relevant instructional materials that respect mathematical rigor and student experiences. The module's success represents not just an effective teaching tool it models a paradigm shift from mathematics as a collection of procedures to mathematics as a way of thinking and solving real problems. This transformation is essential if Indonesian education aims to prepare students for an increasingly complex world where mathematical literacy extends beyond classroom achievement to life readiness and national development.

Conclusion

This research successfully developed a Problem-Based Learning mathematics module that has been proven valid, practical, and effective in improving students' mathematical problem-solving skills. The developed learning module has met feasibility standards from various aspects of assessment by experts and can be well implemented in classroom learning. The research results show that the use of context-based modules can create meaningful and engaging learning for students while developing higher-order thinking skills. These findings have important implications for educators in designing student-centered mathematics learning that is relevant to real life, and they can be used as a reference for developing quality mathematics teaching materials in the future.

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References

Abdul-Mumin, K. H., Arrifin, I. S. M., Austerberry, J., Johnston, J., & McKenna, L. (2025). Exploring mathematics anxiety among nursing and midwifery students and the impacts on pharmacological knowledge: A qualitative study. *Nurse Education Today*, *153*, 106810. https://doi.org/10.1016/j.nedt.2025.106810

Anchunda, H. Y., & Kaewurai, W. (2025). An Instructional Model Development Based on Inquiry-Based and Problem-Based Approaches to Enhance Prospective Teachers' Teamwork and Collaborative Problem-Solving Competence. *Social Sciences & Humanities Open*, *11*(101480). https://doi.org/10.1016/j.ssaho.2025.101480

Bijl, A., Klerk, S., Veldkamp, B. P., & Wools, S. (2025). Assessing information problem solving through a simulation game: Validation evidence from a municipal enforcement official context. *Computers & Education*, *244*, 105533. https://doi.org/10.1016/j.compedu.2025.105533

Bikse, V., & Riemere, I. (2013). The Development of Entrepreneurial Competences for Students of Mathematics and the Science Subjects: The Latvian Experience. *Procedia - Social and Behavioral Sciences*, *82*, 511–519. https://doi.org/10.1016/j.sbspro.2013.06.301

Boetje, J., Ginkel, S. O., Smakman, M. H. J., Barendsen, E., & Versendaal, J. (2024). Information problem solving during a digital authentic task: A thematic analysis of students' strategies. *Computers in Human Behavior Reports*, *15*, 100470. https://doi.org/10.1016/j.chbr.2024.100470

Calma, A. (2025). Students' problem-solving skills in-depth: Ready for 'real life'? *The International Journal of Management Education*, *23*(3), 101267. https://doi.org/10.1016/j.ijme.2025.101267

Ceballos, H., Bogaart, T. va. den, Ginkel, S., Spandaw, J., & Drijvers, P. (2025). How collaborative problem solving promotes higher-order thinking skills: A systematic review of design features and processes. *Thinking Skills and Creativity*, *59*, 102001. https://doi.org/10.1016/j.tsc.2025.102001

Chen, M. (2025). Out-of-class support for the flipped language classroom: Using VoiceThread microlectures to boost active teaching and learning. *System*, *132*, 103723. https://doi.org/10.1016/j.system.2025.103723

Deehan, J., Redshaw, S., Danaia, L., Postlethwaite, F., Donnelly, A., & Morris, C. (2025). Understanding STEM beyond the cities: A comprehensive review of non-metropolitan STEM education research. *International Journal of Educational Research Open*, *9*, 100496. https://doi.org/10.1016/j.ijedro.2025.100496

Dossey, J. K., Ayebi-Arthur, K., & Awoniyi, F. C. (2024). Uncovering relevant mathematics topics for home economics: Senior high school students' views in Cape Coast, Ghana. *Social Sciences & Humanities Open*, *11*, 101241. https://doi.org/10.1016/j.ssaho.2024.101241

Elsen, J., Buckers, L., Tricht, C., Torbeyns, J., & Maeyer, S. (2025). PROSPER: A comprehensive, valid, and reliable instrument to observe problem-solving behaviours in preschoolers. *Thinking Skills and Creativity*, *58*, 101940. https://doi.org/10.1016/j.tsc.2025.101940

Emma, O. (2025). Extended reality in the digital age: A literature review on technology-driven learning environments. *Computers & Education: X Reality*, *8*, 100127. https://doi.org/10.1016/j.cexr.2025.100127

Fredy, L.-D., Oscar, B., & Ana, V.-S. (2026). Pedagogical mediation with ICT for the development of critical thinking in primary education: A systematic review. *Thinking Skills and Creativity*, *60*, 102085. https://doi.org/10.1016/j.tsc.2025.102085

Gao, Y., Ho, C., Wen, D., Liu, Y., Li, Q., Zheng, D., & Zhang, Y. (2024). Combination of problem-based and team-based learning in clinical teaching of plastic and reconstructive surgery. *Chinese Journal of Plastic and Reconstructive Surgery*, *7*(4), 217–219. https://doi.org/10.1016/j.cjprs.2024.11.005

Gashaj, V., Trninic, D., Chen, O., & Moeller, K. (2025). Beyond the page: Enriching storybooks with embodied activities to improve mathematics skills – A scoping review. *Trends in Neuroscience and Education*, *40*, 100259. https://doi.org/10.1016/j.tine.2025.100259

Koerich, G. H., Ferreira, F. A., Silva, J. A., & Hack Catapan, A. (2024). Learning experiences in the culinary classroom: Identifying barriers and enablers in the practical teaching-learning process in gastronomy. *Journal of Hospitality, Leisure, Sport & Tourism Education*, *35*, 100508. https://doi.org/10.1016/j.jhlste.2024.100508

Koloszár, L., Wimmer, Á., Takácsné György, K., & Mitev, A. (2023). Tournament rituals and experiential competence development in higher education: A case of a unique conference series. *The International Journal of Management Education*, *22*(1), 100929. https://doi.org/10.1016/j.ijme.2023.100929

Kong, S. C., & Zhu, J. (2025). Developing and validating

an artificial intelligence ethical awareness scale for secondary and university students: Cultivating ethical awareness through problem-solving with artificial intelligence tools. *Computers and Education: Artificial Intelligence*, *9*, 100447. https://doi.org/10.1016/j.caeai.2025.100447

Mezinska, S., Abolina, A., & Lubkina, V. (2024). Design-driven innovation in STEM disciplines in higher education: The role and impact of transversal competences. *Journal of Open Innovation: Technology, Market, and Complexity*, *10*(4), 100429. https://doi.org/10.1016/j.joitmc.2024.100429

Mirattanaphrai, P., & Srikoon, S. (2025). Neuro-IPO teaching model to enhance creative thinking and innovator in primary education: Empowering argument in educational design research. *Social Sciences & Humanities Open*, *12*, 102244. https://doi.org/10.1016/j.ssaho.2025.102244

Murphy, C., Connell, S., Gantley, M., & Barrett, T. (2025). Students' perspectives on the congruence and effectiveness of a problem-based learning approach to teach recovery-oriented practice: A mixed method study. *Nurse Education in Practice*, *84*, 104298. https://doi.org/10.1016/j.nepr.2025.104298

Novalia, R., Marini, A., Bintoro, T., & Muawanah, U. (2025). Project-Based Learning: For Higher Education Students' Learning Independence. *Social Sciences & Humanities Open*, *11*(101530). https://doi.org/10.1016/j.ssaho.2025.101530

Otto, S., Lavi, R., & Brogaard Bertel, L. (2025). Human-GenAI interaction for active learning in STEM education: State-of-the-art and future directions. *Computers & Education*, *239*, 105444. https://doi.org/10.1016/j.compedu.2025.105444

Ping, Y. Y., & Abideen, Z. U. (2025). A multi-module approach to evaluate online teaching quality in international Chinese education. *Egyptian Informatics Journal*, *30*, 100674. https://doi.org/10.1016/j.eij.2025.100674

Promma, W., Imjai, N., Usman, B., & Aujirapongpan, S. (2025). The influence of AI literacy on complex problem-solving skills through systematic thinking skills and intuition thinking skills: An empirical study in Thai gen Z accounting students. *Computers and Education: Artificial Intelligence*, *8*, 100382. https://doi.org/10.1016/j.caeai.2025.100382

Schmidt, D. A., Alboloushi, B., Thomas, A., & Magalhaes, R. (2025). Integrating artificial intelligence in higher education: Perceptions, challenges, and strategies for academic innovation. *Computers and Education Open*, *9*, 100274. https://doi.org/10.1016/j.caeo.2025.100274

Smiling, J., & Hollebrands, K. (2025). Examining the effect of active participation on the TPACK knowledge of mathematics educators in a teaching mathematics with technology MOOC. *International Journal of Educational Research Open*, *9*, 100469. https://doi.org/10.1016/j.ijedro.2025.100469

Vlachopoulos, D., & Makri, A. (2024). A systematic literature review on authentic assessment in higher education: Best practices for the development of 21st century skills, and policy considerations. *Studies in Educational Evaluation*, *83*, 101425. https://doi.org/10.1016/j.stueduc.2024.101425