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A systematic review of technology-enhanced problem-based learning in the 21st century

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Abstract

Problem-based learning and innovation are instruments that help the abilities expected to foster 21st-century abilities. This has set off enormous advancements in instructive exploration connected with Problem-based learning and innovation. This content examination concentrates on plans to efficiently dissect research patterns in problem-put-together learning and innovation-based concerning articles distributed in global diaries. In light of the laid-out consideration rules, 20 articles were gathered for examination utilizing the Paper Arrangement Structure (PCF) instrument. The aftereffects of the examination showed the strength of acquiring and moving abilities points, oddity-themed, with experimental plan strategies. The most widely recognized reconciliation designs were connected with consensus. Consequently, it is important to lead different problem-put-together learning and innovation studies concerning other possible issues to assist instructive organizations with creating HR that can contend in the 21st.

Keywords: Problem-Based Learning, technology, 21st century

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1. INTRODUCTION

The rapid advancement of technology accelerates cultural transformation in the learning process and changes in the organizational framework of the classroom (Su, 2024). As a result, educators are forced to look for appropriate strategies to effectively navigate these changes according to the rapid development of the times. PBL can be a more appealing methodology in conveying content and furnishing training with better learning, hypothetically and socially, and laying out associations among hypothesis and social settings (Servant-Miklos et al., 2019; Tursynkulova et al., 2023). It makes learning more free, significant, and pertinent, and builds the rule of social responsibility (Kwan, 2019; Wijnia et al., 2024). Since its beginning, PBL systems have been situated to connect with understudies in their way of learning and as a methodology for connecting certifiable circumstances as a beginning stage for the procurement and mix of new information (Ghani et al., 2021). PBL was then broadly embraced in different disciplines, including design, sociologies, business, and regulation. With regards to advanced education, PBL has been broadly acknowledged as one of the approaches working on understudies' abilities and, consequently, working on the employability of graduates (Zhao et al., 2023; Jabarullah &; Hussain, 2019; Okolie et al., 2020).

Problem-based learning (PBL) is an understudy-centered (understudy-focused) instructing approach (Santos et al., 2019), through genuine critical thinking encounters in worked with meetings (Jabarullah & Hussain, 2019). As educated by hypothetical constructivists, PBL is an autonomous growing experience (Kwan, 2019). Past examination found that PBL can further develop understudy learning, inspiration, parallel thinking skills (Mustofa & Hidayah, 2020), decisive reasoning abilities, collaboration, group-based critical thinking abilities, critical thinking abilities, and decisive reasoning abilities (Kurniawan & Sofyan, 2020). The improvement of innovation has made it conceivable to integrate different apparatuses into conventional educating and learning techniques. Viable coordination of innovation ought to urge educators to participate in understudy-focused exercises. Many creators demonstrate their requirement for additional examination that uncovers the significance of innovation for educating and growing experiences in various fields (Kmecová, 2020).

Accordingly, innovation can be integrated into the learning of different regions like learning the board frameworks (LMS), data perception, and multimodal materials that make sense of complicated peculiarities. For this situation, PBL permits the joining of adaptable advancements in the growing experience. Modern undergraduate education is evolving rapidly with the integration of digital technology (Century et al., 2020). Learning activities led by educators are increasingly crucial in helping students deepen their understanding and stimulate active learning, driven by constructivist principles in which knowledge is constructed through interaction rather than imitation or repetition (Srikan et al., 2021). Engaging in classroom activities catalyzes self-knowledge development. Papert suggests that computational thinking emerges from foundational educational approaches, where emotional and social dimensions hold as much significance as technical content within lessons (Efendi & Yulastri, 2019). Instructive foundations started to search for top-notch helping strategies to ingrain the soul and positive collaboration of understudies. To work on instructive results, the Assembled Countries has suggested instructing techniques that ought to be applied by instructors. Joining customary schooling with different e-learning advancements and electronic developments inside and outside the homeroom is an illustration of such a technique (Nuangchalerm, 2020). Understudies can likewise communicate straightforwardly with educators taking part in online exercises like gathering conversations, understanding tasks, and composing tasks that help mixed learning targets. It

consolidates the best parts of conventional classes and is web-based on figuring out how to support self-review while diminishing the time customary classes spend.

1.1.Purpose of study

Deliberate audits that investigate Problem-based learning and innovation-explicit topics have become typical in instructive exploration, for example, orderly writing surveys of pattern number sense research (Hernández-Ramos et al., 2021). Nonetheless, a precise writing survey that joins Problem-based learning and examination and innovation in Indonesia has not been led. Accordingly, this study aims to methodically dissect research drifts that can increment information about problem-based learning (PBL) coordinating innovation in the 21st hundred years. In light of articles distributed in worldwide diaries. The subtleties of the exploration questions that guide the interaction examination are as per the following: (1) what points are generally investigated by research on innovation-based issue-based learning?; (2) What strategies are most broadly utilized ordinarily utilized in problem-based learning research?; (3) What are the most widely recognized topics utilized in research on problem-based learning?; (4) how is the example of innovation-based problem-based learning; (5) What research points have the most potential to be created from now on?

2. METHODS AND MATERIALS

This qualitative research uses a content analysis approach with systematic literature review techniques to analyze technology-based problem-based learning (PBL) research trends. A systematic literature review is a secondary study that combines findings from various primary studies to answer research questions (Newman &; Gough, 2020).

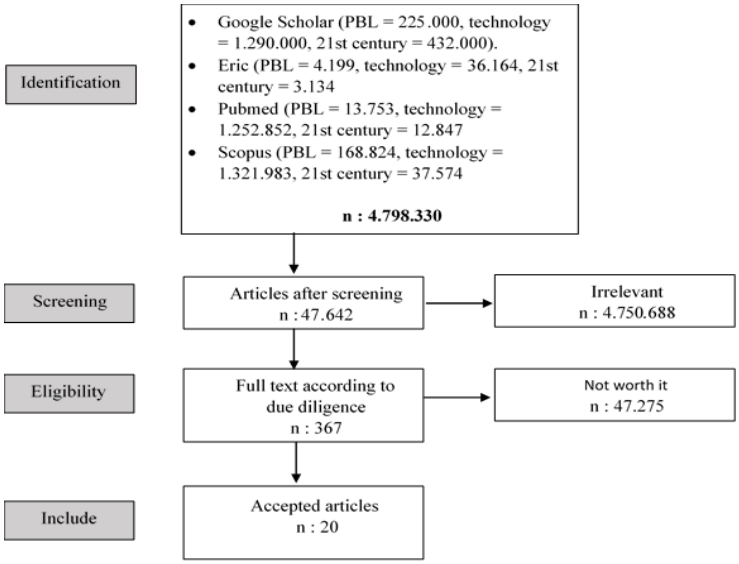
The factors in this study are Problem-based learning (PBL), Innovation, and 21st Hundred years. Problem-based learning (PBL) is a methodology that underscores the openness of issues as a trigger for learning so that learning is not generally compartmentalized by the area of science, yet the same incorporated all in all. Science innovation concentrates on abilities to make devices to handle techniques to assist with finishing different human tasks. The 21st century is a century where innovation is growing so quickly. After running for a very long time, innovation has become a piece of our regular routines. In this century likewise started to be known the term web-based entertainment, like Friendster, Facebook, Twitter, Instagram, and numerous others. Indeed, it additionally affects the learning framework. In this way, the term 21st-century learning arose.

This research adopts a review process by Ardwiyanti et al., (2021), which is portrayed as follows: (1) figuring out research questions; (2) laying out incorporation models (Table 1); (3) searching articles in different data sets (Google Unhitched male, ERIC, Pubmed, Scopus) by composing the watchwords "problem-based learning", "innovation", "21st 100 years"; (4) coding articles utilizing Paper Order Structure (PCF); (5) recognize designs all through the article; (6) orchestrate these examples to address research questions.

The gathered articles are sifted utilizing the PRISMA outline displayed in Figure 1; A sum of 4,798,330 articles was obtained from different data set sources. After Screening, there were 47,642 comparable exploration articles. After refining the titles and abstracts, 377 articles were obtained, while 47,275 did not meet the criteria, leaving 20 articles that were further revised according to the established standards.

Figure 1

Diagram PRISMA



The PCF-adjusted coding instrument was created by Kizilaslan. The instrument has met the necessities of legitimacy and dependability. The gathered information is dissected utilizing rate computations.

Table 1

Inclusion criteria

Category	Inclusion Criteria
Types of publications	Logical articles distributed in journals
Journal specifications	International peer-reviewed journals
Year Published	2019 - 2023
Research settings	Indonesia
Nationality of the researcher	Foreigner
Free variables	Problem-Based Learning, Technology, and the 21st Century
Field	Common
Types of Studies	Empiris dan theoritis
Research subjects	Common

3. RESULTS

Table 2

Article distribution based on journal identity

Researcher Name (Year)	Research Title (Country of Origin)	Journal name
(Mulaudzi et al., 2023)	Hybrid problem-based learning in Technology teacher preparation: Giving students a voice in their learning process	Journal of Education
(Fukuzawa & Cahn, 2019)	Technology in problem-based learning: helpful or	The International

	hindrance?	Journal of Information and Learning Technology
(Humpe & Brehm, 2020)	Problem-based learning for teaching new technologies	IEEE Global Engineering Education Conference (EDUCON)
(Ünal, 2019)	Web 2.0 Technologies Supporting Problem-Based Learning: A Systematic Literature Review	Journal of Problem-Based Learning in Higher Education
(Ugli, 2020)	Problem-Based Learning Technology in Teaching Auxiliary Projection Techniques	Journal of Critical Reviews
(Lufri et al., 2021)	The Effect of Problem-Based Learning Model in Information Technology Intervention on Communication Skills	Jurnal Ta'dib
(Dermentzi et al., 2022)	Using the problem-based learning method and educational technologies to teach open data: A design-based research approach	Education and Information Technologies
(Lin & Wang, 2023)	Enhancing students' online collaborative PBL learning performance in the context of coauthoring-based technologies: A case of wiki technologies	Education and Information Technologies
(Iwatsuki et al., 2021)	Problem-Based Learning in Child and Adolescent Psychiatry: A Perspective from Japan	Advances in Medical Education and Practice
(Muhammad et al., 2021)	Comparing project-based learning and problem-based learning to foster 21st-century learning skills in agricultural seaweed product	Cypriot Journal of Educational Sciences
(Rogers et al., 2021)	Problem-based Learning in Institutional and Curricular Design at the New Model Institute for Technology and Engineering (NMITE)	Journal Problem-Based Learning in Higher Education
(Tanjung et al., 2022)	Problem-Based Learning (PBL) Model with Technological, Pedagogical, and Content Knowledge (TPACK) Approach	International Journal of Education in Mathematics, Science and Technology
(Liu et al., 2022)	Creating An Interactive Dashboard to Support Middle School Teacher's Implementation of A Technology-Supported Problem-Based Learning Program	International Journal of Designs for Learning
(Nugroho & Hermasari, 2023)	Using online flipped classroom in problem-based learning medical curriculum: A mixed method study.	Journal of Education and Learning
(Lee-Cultura et al., 2022)	Children's play and problem-solving in motion-based learning technologies using a multi-modal mixed methods approach	International Journal of Child-Computer Interaction
(Louw & Deacon, 2020)	Teaching Industry 4.0 technologies in a learning factory through problem-based learning: case study of a semi-automated robotic cell design	Procedia Manufacturing
(Maidan et al., 2020)	Impact of Problem-based Learning (PBL) model through Science Technology Society (STS) approach on Students'	Journal of Physics

	interest	
(Jiang et al., 2022)	Application of 3D printing technology combined with PBL teaching method in clinical teaching of cerebrovascular disease an observational study	Medicine
(Zhao & Cong, 2019)	Effect of Problem and scripting-based Learning Combining Wearable Technology on Orthopedic Operating Room Nurses' Learning Outcomes	Nurse Education Today
(Hernández-Ramos et al., 2021)	The Effects of Using Socio-Scientific Issues and Technology in Problem-Based Learning: A Systematic Review	Education sciences

Given Table 2, the review included 20 articles distributed in worldwide diaries. This writing survey utilizes PRISMA (Preferred Reporting Item Diagram Systematics and Meta-investigation). Scientists got the information base by perusing Google Researcher (5), ERIC (5), Pubmed (5), and Scopus (5), with a scope of 2019-2023. Find articles connected with catchphrases: "problem-based learning", "innovation", and "21st hundred years". Related articles are taken for additional investigation.

3.1.Research topics on PBL and technology

Research into PBL and technology is conducted on a variety of topics. For example, table 3 shows the topic of learning and transfer skills (45%) dominates PBL and technology research, followed by creativity and motivation (25%). On the other hand, the general benefits of education (15%), professional development (10%), and diversity and expansion of participation (10%) are still minor topics. This finding is in line with the research trend of STEM Education: from various angles based on technology-based learning models (Darmawansah et al., 2023). This study's findings are consistent with global research trends from 1999 to 2019, as reported in the Hiroshima Journal of Mathematics Education, highlighting a predominant focus on abilities and characteristics as key subjects (Pang, 2020).

Table 3

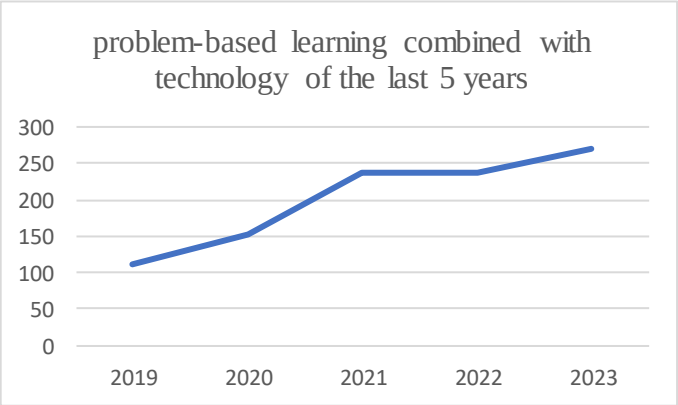
Trends in PBL and technology research topics

Research Topics	Percentage (%)
Study and Transfer Skills	40
Creativity and motivation	25
General benefits of education	15
Professional development	10
Diversity and expanded participation	10

Figure 2 shows that research into PBL and mindfulness technology will be widely conducted in 2022-2023. This is in line with technology-based PBL which will intensify in 2020 (Darmawansah et al., 2023). As a result, it is not surprising that PBL research started from a basic topic that focuses on medical education and has now been widely used at all levels of education.

Figure 2

Distribution of PBL and technology articles published annually.



3.2.PBL research methods and technology

An ongoing methodical writing audit uncovers Experimental Plan (55%) and Poll or Study (20%) as PBL and innovation patterns (Table 4). The pattern of technique research pursues the direction of the subject. The expansive subjects examined are connected with reinforcing PBL and innovation in different areas which are broadly helped out through experimental design.

Table 4

Trends in PBL research methods and technology

Metode penelitian	Percentage (%)
Mixed Method	10
Questionnaire Or Survey	20
Experimental Design	55
System Development	15

Another examination connected with PBL and innovation is created through framework improvement strategies and blended techniques. This viewing requires analysts inspired by generally high examination, for example, experimental configuration research. Thus, particularly in the advancement of PBL and technology in Indonesia which started to be created in 2013, it is normal to begin with an examination of the unique situation and cycles connected with hypothetical issues that are at present being considered to be pertinent to the qualities of creating research. This study's findings are consistent with global research trends from 1999 to 2019, as reported in the Hiroshima Journal of Mathematics Education, highlighting a predominant focus on abilities and characteristics as key subjects (Pang, 2020).

3.3.PBL and technology research themes

Reality and audio/video dominate the themes of PBL and technology research in the 21st century. Table 5 shows novelty (55%) and audio/video (25%) trends in PBL and technology research in the 21st century. This applies to the consequences of examination that show that oddity in innovation isn't new and is constantly worked on in different things, one of which is mechanical technology (Darmawansah et al., 2023). Furthermore, ongoing research in technology and learning continually incorporates innovations aligned with

the times, making research trends on PBL and technology themes increasingly relevant to the rapid pace of development and its evolving characteristics.

Table 5

PBL research theme trends and technology

Trending Themes	Percentage (%)
Audio/video	25%
Obstacle	20%
kebaharuan	55%

One of the themes that has become a novelty in PBL and Technology research is Virtual learning. Learning environments that combine technology with this environment are often of particular interest to researchers (Hernández-Ramos et al., 2021). Studies conducted in the last 5 years always provide novelty for technology that collaborates with PBL so that it can be a reference for other researchers.

3.4.PBL pattern trends and technologies

Technology-based PBL models are extensively applied across general topics, particularly among college (35%), high school, and elementary school students, with a predominant application in general settings (45%) as shown in Table 6. This aligns with Ankiewicz (2021), who explains that many educators face challenges in mastering subject content or possess limited knowledge of effective pedagogical approaches. Consequently, they often adopt teaching and learning strategies that are misaligned with the innovative, problem-based methodologies fundamental to technology-enhanced education. Accordingly, instructor instructors at colleges should prepare ready-planned educators for innovation training by utilizing techniques that will be receptive to these logical prerequisites and expert assumptions by considering the advancing requirements and advancement of students during the educational experience. It is therefore recommended that teacher educators implement active learning strategies, such as problem-based learning (PBL), in teacher education programs (Mulaudzi et al., 2023). Teachers have always been important in providing knowledge; therefore, it is not surprising that training must continue to be given to teachers so that education continues to float following the times, especially technology every 8 hours continues to change.

Table 6

Technology-based PBL pattern trends

Trends Pola	Percentage (%)
Common	45
Student	35
High School Students	15
Elementary Students	5

4. DISCUSSION

Strengthening PBL and technology at the general level and students has been empirically proven effective (Nugroho &; Hermasari, 2023; Louw & Deacon, 2020; Jiang et al., 2022). Students find it helpful to improve their abilities through daily activities or familiar objects. Therefore, it makes sense to undertake the integration of PBL with training technology or in learning.

Alluding to the patterns distinguished in problem-based learning and examination innovation in general, there are a few subjects that poor people worked on ideally. Given these discoveries, the accompanying

proposals are proposed: First, it is essential to initiate both quantitative and qualitative research aimed at designing programs that enhance motor skills among elementary school students, considering their cognitive development stages. Additionally, conducting problem-based learning (PBL) research that incorporates technology for children with special needs will ensure they benefit from contemporary advancements in education. Furthermore, integrating local cultural arts as elective subjects in PBL and technology initiatives can promote the preservation of cultural heritage, particularly in countries like Indonesia. It is also crucial to focus on developing technology-based educational materials to align with emerging research trends in PBL and technological integration during the digital era. Finally, a shift in research emphasis from traditional collaborative factors to 21st-century competencies such as critical thinking, collaboration, creativity, emotional intelligence, complex problem-solving, leadership, and decision-making is necessary. This transition, coupled with training that connects cultural understanding with rapid technological advancements, will ensure that academic institutions remain relevant and impactful in society.

5. CONCLUSION

The pattern of problem-based learning and innovation research is overwhelmed by acquiring and moving abilities with the topic of curiosity of experimental plan techniques. The most moving example of the review is the general example of society. A few existing issues have not been taken care of ideally, including the connection between problem-based learning and innovation, reinforcing projects to the local area, the utilization of workmanship and culture in picking up fortifying problem-based learning with innovation for youngsters with extraordinary necessities, creating showing materials and learning media given data innovation, and further developing 21st-century abilities (for instance, computational reasoning).

A few restrictions in this study are that it doesn't include articles distributed in public diaries. By utilizing global articles completely in this manner, the survey can be revamped to ensure the exactness of the examination results.

Conflict of Interest: The authors declare no conflict of interest.

Ethical Approval: The study adheres to the ethical guidelines for conducting research.

Funding: This research received no external funding

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