BRIDGING TECHNOLOGY AND LOCAL WISDOM: A LITERATURE REVIEW ON CULTURE-BASED PROBLEM- BASED LEARNING IN THE DIGITAL ERA

Nur Rahmi Rizqi[1], Kms. Muhammad Amin Fauzi[2], Edi Syahputra[3]
[1] Universitas Al Washliyah Medan, Medan, Indonesia
[1,2,3]State University of Medan, Medan, Indonesia

*Corresponding author: nurrahmi.rizqi@gmail.com

Abstract
This study aims to conduct a literature review on integrating local culture-based Problem-Based Learning (PBL) models in facing digital transformation in mathematics learning, especially in developing students' computational thinking skills. The method used in this research is Literature Review by reviewing around 150 national and international publications, but only 12 articles fit the inclusion criteria and were analyzed further. The research sample consisted of reputable journals published between 2013-2024. The focus of the study includes the application of PBL in mathematics learning, the importance of contextualizing local culture - especially Karo culture - in learning design, the role of digital technology such as GeoGebra, and indicators of computational thinking skills. The results of the study show that the application of culture-based PBL with technological support can increase student engagement and help them develop the ability to solve mathematical problems more meaningfully, creatively and contextually. This integration is considered strategic in responding to 21st century learning challenges that emphasize cultural literacy, technology, and complex problem solving.
Keywords: Problem-Based Learning, Local Culture, Computational Thinking, GeoGebra, Mathematics Learning, Digital Transformation

INTRODUCTION

Digital transformation has brought about profound paradigm shifts in various sectors of life, including in the world of education. In the era of Industry 4.0 and towards Society 5.0, education is no longer solely oriented towards mastering content, but also towards developing 21st-century skills including critical thinking, digital literacy, complex problem solving, and collaborative skills (Kahar et al., 2021). Digitalization has opened up new space for curriculum innovation, accelerated the teaching and learning process, and enriched student experiences through the use of technologies such as online learning, artificial intelligence, and data analytics (M. Alenezi, 2023; Shenkoya & Euiseok Kim, 2023).

The role of educators has also shifted significantly, from merely conveying information to facilitators and mentors of more personal, independent, and contextual learning (Farias & Ignacio, 2022). However, along with the opportunities offered, digital transformation also presents challenges, such as the gap in access to technology (digital divide), limited

infrastructure, and the need for continuous teacher training (M. A. and M. Alenezi, 2022; Rodríguez-Abitia & Bribiesca-Correa, 2021).

One strategic approach in responding to these challenges is to implement a learning model that supports Higher-Order Thinking Skills (HOTS), such as critical thinking, creativity, and problem solving. In this context, computational thinking (CT) emerges as a systematic and strategic approach to solving problems, which includes the processes of decomposition, pattern recognition, abstraction, and algorithm design (Shute et al., 2017). Several studies have shown that integrating CT into learning can increase student engagement, learning motivation, and achievement of learning outcomes, not only in STEM fields, but also across disciplines (T.-T. Wu et al., 2024).

The Problem-Based Learning (PBL) model is one of the most relevant pedagogical approaches in supporting the development of CT. PBL places students as active subjects in the learning process through collaborative and reflective contextual problem solving (Szabo et al., 2020). The integration of PBL and CT is considered capable of forming systematic, logical, and structured thought patterns, while increasing students' high-level thinking capacity (Surbakti et al., 2023).

However, the implementation of PBL in schools is often generic and has not considered the social and cultural context of students. This reduces the relevance and meaning of learning. Therefore, local culture-based learning is important to develop as an approach that is contextual, authentic, and strengthens student identity (Amiruddin et al., 2025). In the Indonesian context, Karo culture has great potential as a local source rich in mathematical symbols and traditional structures, such as Siwaluh Jabu, woven motifs, and the architecture of the Jambur traditional house, which are relevant to the development of mathematical concepts and CT.

Digital technology such as GeoGebra plays a strategic role in integrating local culture into PBL-based learning. GeoGebra enables the visualization of mathematical concepts that are contextualized through cultural motifs, traditional building structures, and local symmetrical patterns. This technology supports more meaningful exploration and supports students' computational thinking processes.

Unfortunately, literature reviews that simultaneously review the relationship between the three main components—PBL, local culture, and digital technology—are still very limited. Most studies only review two elements separately. Therefore, this study aims to conduct a comprehensive literature review to identify, analyze, and synthesize the relationship between the three elements in supporting meaningful learning and CT development in the digital era. The results of this study are expected to be a conceptual basis for the development of innovative learning models that are adaptive, contextual, and culturally relevant.

METHOD

This study uses a descriptive-qualitative literature review method. The purpose of this study is to identify, group, and synthesize the results of previous studies related to the implementation of Problem-Based Learning (PBL) based on local culture, the development of computational thinking (CT) skills, and the use of digital technology such as GeoGebra in mathematics learning.

Data were collected through searching national and international journal articles that were relevant to the topic of study. Articles published in the period 2013–2024. Focus on the theme of PBL, local culture in education, computational thinking, and/or the use of

GeoGebra in learning. Of the approximately 150 articles found, 12 articles were selected because they met the inclusion criteria and were relevant to the objectives of the study.

RESULTS AND DISCUSSIONS

This systematic literature review analyzed 50 articles published between 2013 and 2024, focusing on the relationship between the Problem-Based Learning (PBL) model, the integration of local wisdom, and the use of digital technology in the context of 21st-century education. Of the total articles reviewed, 12 main articles were selected and reviewed in depth because they had high relevance, strong methodological approaches, and significant contributions to the development of meaningful and contextual mathematics learning. The articles were obtained from reputable academic databases such as Google Scholar, ScienceDirect, SpringerLink, ERIC, and DOAJ. The results of this study indicate that the integration of the three elements—PBL, local culture, and digital technology—is a potential strategy in responding to the challenges of education in the digital era that demands high competence while preserving cultural identity.

In general, PBL has proven effective in improving various aspects of 21st-century skills. This model is able to foster critical thinking skills, problem solving, creativity, collaboration, and students' learning independence. PBL provides space for students to explore and build knowledge through authentic and contextual problem solving (Henderson et al., 2018). A study by Arofiq (2019) showed that problem-based learning (PBL) in mathematics significantly improves students' motivation and learning outcomes. Implementing the Problem-Based Learning (PBL) model, facilitated by interactive flipbook-based e-modules, can improve the science learning outcomes of junior high school students (Kharomah et al., 2023). However, several obstacles are still found in the field, such as limited time, teacher readiness, and the need for adequate infrastructure (Julia et al., 2025; Rachmi et al., 2025).

On the other hand, the use of local culture as a context in PBL has been shown to enrich the meaning of mathematics learning. Local culture provides a contextual foundation that is relevant and close to students' experiences. A study by Fauzan et al., (2020) which developed Minangkabau culture-based mathematics learning showed that the use of rumah gadang design can strengthen the understanding of mathematical concepts and foster a love for one's own culture. Likewise, Syaharani (2023) succeeded in showing that the integration of Palembang ethnomathematics in the PBL approach had an impact on improving students' mathematical communication skills. The culture-based approach is also considered capable of encouraging mathematical literacy, strengthening cultural identity, and learning motivation (Indriati & Dahlan, 2022; Prabawati et al., 2023). However, limited resources and minimal teacher training in developing culture-based teaching materials are still obstacles in daily learning practices.

Digital technology is an important element that bridges PBL and local culture. Digital tools such as GeoGebra, Scratch, and LMS platforms provide opportunities to visualize cultural objects mathematically and interactively. Research by Ansong et al., (2021) illustrates that GeoGebra can be used to model traditional Karo carving patterns and explore the concepts of symmetry and geometric transformation. These results indicate that technology not only enhances visualization but also supports the process of abstraction and algorithmization, two important aspects of computational thinking. Another study by Siregar & Panjaitan (2024) concluded that technology can be an effective tool in bringing students closer to local cultural contexts digitally, while still developing higher-order thinking skills. In addition, digital technology allows students to engage in data-based exploration, systematically design solutions, and convey mathematical ideas in multimodal formats. This is in line with

the computational thinking framework as described by T. Wu et al., (2024), which emphasizes the importance of problem decomposition, pattern recognition, abstraction, and algorithm construction as the foundation of computational thinking in the context of learning.

The findings of this study support the formation of a conceptual framework that unites PBL, local culture, and digital technology in a single transformative learning unit. In this framework, PBL functions as a pedagogical approach that encourages active and inquiry-based learning; local culture acts as an authentic and relevant learning context; while digital technology functions as a medium of exploration and representation that strengthens conceptual understanding and 21st-century skills. However, this study also identified that most research is still limited to combining two of these three elements. There are still very few learning models that explicitly integrate the three in one complete design, especially with a specific cultural context such as Karo culture. Therefore, further research is needed that develops PBL-based learning models with the support of digital technology and local cultural contexts systematically and measurably, especially in the field of mathematics.

Thus, the results of this review strengthen the view that the integration of problem-based learning, local wisdom, and digital technology is not only possible, but also has great potential to be applied widely in 21st-century education. This strategy is able to answer the need for meaningful, inclusive learning that is oriented towards character development and high-level thinking skills. Learning that is based on one's own culture, driven by a PBL approach, and strengthened by digital technology can produce students who are not only academically capable, but also culturally resilient and adaptive to changing times.

CONCLUSION

This review confirms that the integration of Problem-Based Learning (PBL), local culture, and digital technology is a strategic approach in 21st century mathematics learning. PBL encourages critical thinking and problem-solving skills, local culture provides meaningful context, and digital technology such as GeoGebra facilitates visualization and the development of computational thinking. Although potential, most studies only combine two of the three elements. Therefore, it is necessary to develop an integrative learning model based on PBL, local wisdom, and digital technology systematically to realize contextual, innovative, and sustainable learning.

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