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Integrating Multiple Intelligences into Project-Based Learning: Its Potential to Enhance Students' Mathematical Literacy and Curiosity

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Abstract

Mathematical literacy and curiosity have become essential competencies for the increasingly complex and dynamic demands of the 21st century. These competencies can be developed through mathematics learning by selecting an appropriate learning approach. One of the approaches currently recommended is the Project-Based Learning (PjBL) approach. However, effective learning should also consider students' diverse intelligence tendencies, known as Multiple Intelligences (MI). This article employs a Systematic Literature Review (SLR) method. In this review, the researcher systematically collected journal articles from the Scopus, ProQuest, ERIC, and Google Scholar databases. The reviewed articles were limited to publications from 2016 to 2025. From the search results, twenty articles most relevant to the research keywords were carefully selected. These articles were identified and analyzed to examine the potential of mathematics learning through Multiple Intelligences-based Project-Based Learning in enhancing students' mathematical literacy and curiosity. Based on a synthesis of theoretical perspectives and supported by relevant empirical findings, it can be concluded that Multiple Intelligences-based Project-Based Learning has strong potential to improve students' mathematical literacy and foster their curiosity.

Keywords: *Project-Based Learning; Multiple Intelligences; Mathematical Literacy; Curiosity*

Introduction

Education in the 21st century is required to produce generations capable of adapting to increasingly complex and dynamic global challenges. The OECD (2018) emphasizes that education systems must be able to prepare students for jobs that do not yet exist, technologies that have not yet been invented, and problems that are still unimaginable. Therefore, 21st-century education is expected not only to provide knowledge but also to equip students with relevant skills, attitudes, and values so that young generations can adapt and contribute meaningfully in a rapidly changing world. Furthermore, the Regulation of the Minister of Education, Culture, Research, and Technology Number 12 of 2024 states that the Merdeka Curriculum is designed to provide a foundation of knowledge, competencies, and ethics to respond to the realities of the Industrial Revolution 4.0 and Society 5.0 (Kemendikbudristek, 2024).

Mathematics is one of the fields of study that plays an essential role in shaping 21st-century thinking skills. Mathematics learning is not limited to mastering numbers or arithmetic operations but also emphasizes the development of reasoning through logical and systematic steps in solving various mathematical problems. In addition to being a scientific discipline, mathematics is also highly relevant to everyday life. Therefore, efforts to integrate school mathematics learning with real-world contexts have become one of the key priorities in the development of school mathematics curricula.

A competency that enables individuals to understand the role of mathematics in real life is mathematical literacy (OECD, 2023). Mathematical literacy refers to students' ability to formulate, employ, and interpret mathematics in a variety of contexts, including the ability to reason mathematically (OECD, 2023). Mathematical literacy is an essential skill for students; however, it remains a challenge in practice. This issue is reflected in the results of the PISA assessment, where Indonesian students scored 366 in mathematics—well below the OECD average score of 480 (OECD, 2023c).

In addition to developing cognitive abilities, education is also required to pay attention to students' affective development. One of the affective aspects that should be nurtured in mathematics learning is curiosity, which serves as one of the main drivers of meaningful learning (Engel, 2015). Curiosity needs to be continuously fostered to better prepare students to face the challenges of life in the 21st century.

Learning that integrates knowledge with real-world experiences needs to be designed to develop students' mathematical literacy and curiosity. One innovative learning approach that has the potential to enhance students' mathematical learning abilities is Project-Based Learning (PjBL). PjBL emphasizes students' active engagement in investigating interesting and meaningful questions or problems, thereby stimulating their curiosity toward real-world phenomena (Krajcik & Czerniak, 2018).

An effective learning process should also be designed to facilitate students' diverse potentials and intelligence tendencies. This concept is realized through Multiple Intelligences (MI) based learning, a theory pioneered by Howard Gardner. Gardner (2011) stated that intelligence is a trait possessed by all humans, encompassing nine distinct types of intelligences, with each individual exhibiting unique combinations. The application of multiple intelligences in learning provides opportunities to create authentic learning experiences that consider students' needs, interests, and talents (Lunenburg & Lunenburg, 2014).

Thus, the integration of PjBL and MI has the potential to serve as a strategic solution for improving mathematical literacy while fostering students' curiosity. However, previous studies have rarely examined the explicit connection between MI-based PjBL, mathematical literacy, and curiosity. Therefore, the purpose of this study is to explore and synthesize the potential of MI-based PjBL in enhancing students' mathematical literacy and curiosity.

Methods

This study employed a Systematic Literature Review (SLR) as its primary research method. According to Creswell & Creswell (2018), a literature review is an essential component of research because it serves to share relevant findings from previous studies, connect the current research with broader scholarly discourse, and identify potential research gaps for further development. The literature review process in this study was conducted through several stages. First, the researcher collected fundamental theories related to Project-Based Learning (PjBL), Multiple Intelligences (MI), mathematical literacy, and students' curiosity. Second, the researcher examined empirical studies relevant to the implementation of PjBL and MI in mathematics learning. The literature sources were obtained from both national and international journal articles indexed in Scopus, ProQuest, ERIC, and Google Scholar databases.

Based on the search results using the keywords "Project-Based Learning," "Multiple Intelligences," "Mathematics Learning," "Curiosity," and "Mathematical Literacy," a total of 20 articles met the inclusion criteria, namely relevance to the topic, suitability for secondary education level, and publication in reputable journals. The collected literature was then analyzed to explore the relationship between the PjBL and MI approaches and the development of mathematical literacy and students' curiosity. The analysis was conducted descriptively and qualitatively, emphasizing the synthesis of theoretical perspectives and empirical findings that support the potential implementation of MI-based PjBL in improving these two aspects. Therefore, this literature review method is expected to provide a strong theoretical foundation as well as direction for future empirical research.

Findings and Discussion

Project-Based Learning

Project-Based Learning (PjBL) is a comprehensive approach to teaching and learning designed to engage students in the investigation of authentic problems (Blumenfeld et al., 1991). In line with this, Bell (2010) defines PjBL as a learning approach that teaches curriculum concepts through projects based on investigative questions that encourage inquiry and allow students to apply the knowledge they have acquired. Thus, PjBL is a learning approach that emphasizes students' active involvement in exploring authentic problems through project-based investigations. According to the Ministry of Education and Culture (Kemendikbud, 2021), there are six stages of PjBL: (1) identifying problems, (2) designing project plans, (3) developing project schedules, (4) implementing and monitoring the project, (5) testing project results, and (6) conducting evaluation and reflection.

As a learning approach that emphasizes active student engagement in project-based inquiry, PjBL is believed to be effective in developing students' potential. Borich (2017) states that PjBL can promote intrinsic motivation by organizing learning around tasks that are most likely to stimulate and sustain students' interest, effort, and persistence. In PjBL, students are involved in meaningful and relevant problem-solving activities, which simultaneously foster creativity and enhance problem-solving skills (Lee & Galindo, 2021)

Multiple Intelligences

In the field of education, there is a well-known theory called the Multiple Intelligences (MI) theory. This theory was first introduced by Howard Gardner in 1983. Gardner (2011) stated that intelligence is a trait possessed by all humans, in which each individual has nine types of intelligences dimensions that make every human being different from one another and that intelligence serves as a means to achieve certain goals. In line with Gardner, Qiu (2024) explains that in real life, humans must face various problems every day; therefore, they need to use multiple or a combination of intelligences to solve the problems they encounter.

According to Gardner's MI theory, every individual possesses at least nine distinct intelligences. These include verbal-linguistic intelligence, logical-mathematical intelligence, musical intelligence, spatial intelligence, bodily-kinesthetic intelligence, intrapersonal intelligence, interpersonal intelligence, naturalistic intelligence, and existential intelligence (Gardner, 2011; Gouws, 2007). The description of each type of intelligence is presented in Table 1 (Armstrong, 2018).

Table 1. Multiple Intelligences by Howard Gardner

Multiple Intelligences	Description
Verbal-Linguistic Intelligence	the capacity of an individual to use words effectively, both orally and in writing
Logical-Mathematical Intelligence	the capacity to use numbers effectively and to reason well
Musical Intelligence	the ability to perceive, express, and distinguish musical forms and patterns
Spatial Intelligence	the ability to accurately perceive the visual-spatial world and to perform transformations upon those perceptions
Bodily-Kinesthetic Intelligence	the skill in using one's entire body to express ideas and feelings, as well as the facility in using one's hands to produce or transform objects
Intrapersonal Intelligence	the capacity for self-awareness and the ability to act adaptively based on that knowledge
Interpersonal Intelligence	the ability to understand and distinguish among the moods, intentions, motivations, and feelings of other people.
Naturalistic Intelligence	the ability to recognize and classify various species of flora and fauna within one's environment
Existensial Intelligence	the capacity to contemplate deep questions about existence, life, and the nature of reality

Mathematical Literacy

Mathematical literacy is one of the essential skills required by students in the 21st century. Ojose (2011) defines mathematical literacy as the ability to apply mathematical concepts in everyday life. It is further described as an individual's capacity to reason mathematically or to formulate, employ, and interpret mathematics to solve problems in various real-world contexts (OECD, 2023b). Moreover, mathematical literacy is also defined as the ability to use one's mathematical capabilities to better understand the world, its structures, and its events, and to make more informed decisions based on that understanding (Burkhardt et al., 2024). Based on these definitions, mathematical literacy can be understood as the ability to formulate, use, and interpret mathematical knowledge in everyday life to build meaningful understanding and make relevant decisions.

Burkhardt et al. (2024) argue that several factors can enhance students' mathematical literacy skills, including connecting mathematics with real-world situations, training students' abilities in mathematical modeling, improving procedural fluency, encouraging active participation in investigating real-world problems, promoting student discussions, and applying learning approaches that involve authentic situations and active engagement.

In the PISA 2022 assessment, students' mathematical literacy is analyzed through three domains: process domain, content domain, and context domain, as presented in the following table (OECD, 2023a).

Table 2. PISA Mathematical Literacy Assessment Domains

Processes Domain	Content Domain	Context Domain
Formulating	Change and Relationships	Personal
Employing	Quantity	Occupational
Interpreting	Space and Shape	Societal
	Uncertainty and Data	Scientific

Curiosity

One of the affective aspects that should be developed in learning is students' curiosity. Curiosity is a drive to learn and investigate, motivating individuals to explore or discover new things (Manguel, 2015). It is also understood as an attitude driven by the desire to gain new knowledge and experiences, which in turn motivates exploratory behavior (Gottlieb et al., 2016; Litman & Spielberger, 2003; Renner, 2006). Furthermore, Cain (2019) defines curiosity as a trait that stimulates individuals to think critically and find innovative solutions when facing problems. Based on these expert opinions, curiosity can be defined as a phenomenon characterized by the drive and motivation to learn, the desire to acquire new knowledge, to conduct investigations, and to find solutions to problems.

In the context of learning, curiosity has a positive influence on students' learning outcomes (Jirout et al., 2018; Peterson & Hidi, 2019; Shin et al., 2019). It also has a positive impact on mathematical learning outcomes, including creative thinking, mathematical literacy, and critical thinking (Pamungkas & Agoestanto, 2024; Setiawan & Surahmat, 2022; Zetriuslita & Ariawan, 2021).

Shin et al. (2019) explain that several factors influence students' curiosity in learning, including learning content and learning context. The learning content may involve ill-defined problems, collative variables, and tasks with high levels of difficulty. Meanwhile, the learning context encourages students to ask questions, allows them to make mistakes, guides their exploration process, and provides successful problem-solving experiences. In addition, several studies have shown that learning models that require students' active participation can also enhance their curiosity (Liu et al., 2024; Rahayuningsih et al., 2023).

The Relationship between Project-Based Learning Based on Multiple Intelligences and Mathematical Literacy Skills

Project-Based Learning (PjBL) is an instructional approach that emphasizes active student engagement in investigating authentic problems through projects. This approach has been widely studied and applied in educational practice. Teachers must recognize that students possess diverse intelligence tendencies; therefore, integrating Multiple Intelligences (MI) into learning is necessary. When PjBL is integrated with MI, the approach can be designed to be more adaptive to students' diverse potentials.

Mathematical literacy is defined as an individual's ability to reason mathematically or to formulate, employ, and interpret mathematics to solve problems in various real-world contexts. It involves three main processes: formulating, employing, and interpreting (OECD, 2023b). Each stage of MI-based PjBL has the potential to enhance these processes of mathematical literacy.

In the stage where students determine the project based on essential questions with diverse contexts and design project implementation plans in heterogeneous groups according to their intelligence tendencies, students engage in the formulating process. This occurs as students formulate contextual problems into mathematical forms aligned with their dominant intelligences. Research by Asmara & Wardono (2019) and Diego-Mantecon et al. (2021) revealed that PjBL helps students formulate mathematical problems derived from real-world contexts. This is consistent with Blumenfeld et al.

(1991), who stated that projects serve as a bridge between classroom learning experiences and real-life contexts.

The next stages involve arranging project schedules and conducting the project based on students' intelligence tendencies. During these stages, students perform the employing process, as they apply mathematical concepts, facts, and procedures in their project implementation. This aligns with the findings of Rijken & Fraser (2024), who demonstrated that PjBL enhances students' mathematical problem-solving skills.

The following stages in MI-based PjBL involve presenting project results in various forms according to students' intelligence tendencies and conducting project evaluation. These stages develop the interpreting process, as students not only utilize mathematical knowledge but also interpret their project outcomes in relation to real-life contexts. This is consistent with Diego-Mantecon et al. (2021), who noted that project experiences make students more aware of the applicability of mathematics across different fields. Regarding MI implementation, Gouws (2007) stated that considering students' intelligences creates opportunities for them to reflect on how to improve learning processes and to evaluate learning in diverse ways that accommodate different types of intelligence.

Several studies have shown that PjBL positively influences students' mathematical literacy skills. Research by Asmara & Wardono (2019), Sari et al. (2022), Maysarah et al. (2023), Nugroho et al. (2024), and Nasution & Reflina (2025) demonstrated that PjBL effectively enhances students' mathematical literacy. Furthermore, studies on MI-based learning also revealed improvements in mathematical abilities. Research by Kartikasari & Widjajanti (2017) and Finali et al. (2023) found that MI-based instruction positively affects mathematical learning outcomes. Ardani & Widjajanti (2024) concluded that integrating MI into PjBL is effective in improving students' critical thinking and mathematical communication skills. Similarly, Hidayat & Mahmudi (2025) found that MI-based Problem-Based Learning positively affects students' mathematical literacy. Yuwana et al. (2025) also confirmed that MI-based PjBL is effective in improving mathematics achievement. Additionally, Yang et al. (2025) showed that MI-based mathematics learning enhances students' reasoning abilities. Collectively, these findings indicate that the application of PjBL and MI can improve students' mathematical literacy and related mathematical competencies.

Based on the aforementioned studies, implementing Project-Based Learning based on Multiple Intelligences has the potential to enhance components of mathematical literacy, namely formulate, employ, and interpret. Furthermore, the MI theory can serve as a foundation for classroom instruction, where students' activities are designed according to their interests and potentials, making the learning process more adaptive and optimal. Therefore, it can be concluded that the MI-based PjBL approach has the potential to foster students' mathematical literacy skills. The relationship between MI-based PjBL and mathematical literacy skills is illustrated in the following figure.

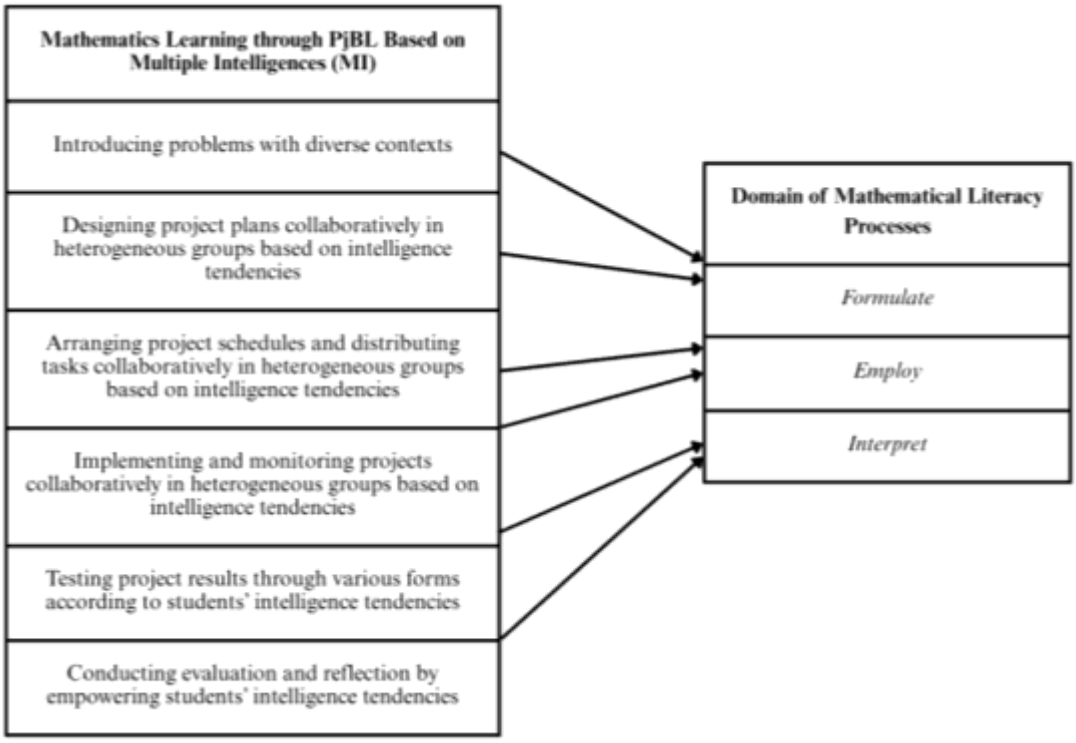

Figure 1. The Relationship between Project-Based Learning Based on Multiple Intelligences and Mathematical Literacy Skills

The Relationship between Project-Based Learning Based on Multiple Intelligences and Curiosity

Project-Based Learning (PjBL) based on Multiple Intelligences (MI) consists of six main stages that can be linked to indicators of students' curiosity. Curiosity is characterized by the drive and motivation to learn, acquire new knowledge, conduct investigations, and find solutions to problems.

First, in the stage of determining essential questions with diverse contexts, students are faced with challenging, real-world problems. This condition stimulates their desire and motivation to learn because the questions are relevant to their daily lives (Zhang & Ma, 2023). This finding is consistent with Zk et al. (2025), who found that project-based learning increases students' learning motivation. The integration of Multiple Intelligences at this stage allows each intelligence to serve as a "delivery route" for personalizing essential cognitive and emotional processes underlying learning, including motivation (Shearer, 2018).

Second, in the stage of designing project plans collaboratively in heterogeneous groups based on intelligence tendencies, students determine problem-solving strategies and identify the information sources needed. This activity aligns with the indicator of acquiring new knowledge, as students are challenged to connect their prior understanding with additional information required to complete the project. Diego-Mantecon et al. (2021) demonstrated that project-based learning encourages students to actively seek new information, while differentiation through Multiple Intelligences ensures that information gathering can occur in diverse ways suited to students' intelligence profiles.

Third, the stages of scheduling and implementing projects collaboratively in heterogeneous groups based on intelligence tendencies provide students with opportunities to explore, collect data, and analyze findings. These stages correspond to the indicator of conducting investigations, as students engage in inquiry-based activities to answer project questions. Thomas (2000) stated that projects involve

students in constructive investigation. Meanwhile, the MI framework allows for role distribution according to each student's dominant intelligence, ensuring meaningful participation in the inquiry process.

Fourth, the stages of presenting project outcomes through multiple modes based on students' intelligence tendencies, and conducting evaluations, allow students to display their products or solutions using different intelligences—whether through verbal presentations, visual models, written reports, or kinesthetic demonstrations. These stages relate to the indicator of finding solutions to problems, as students not only complete their projects but also interpret their results in real-life contexts. Rehman et al. (2024) reported that project-based learning actively involves students in real-world problem solving, enhancing both their understanding and the practical application of knowledge. Similarly, Qiu (2024) asserted that the integration of multiple intelligences or combinations thereof can be used to solve problems effectively.

Several studies have shown that project-based learning positively influences students' curiosity. Research by Wicaksana et al. (2017), Paruntu et al. (2018), Kartika et al. (2019), Rehman et al. (2023), and Zk et al. (2025) demonstrated that PjBL can promote students' curiosity in mathematics learning. Furthermore, studies on MI-based learning also show positive effects on students' attitudes. Benazira et al. (2021) found that mathematics learning based on Multiple Intelligences increases students' motivation and interest in learning mathematics. Similarly, Latifah & Widjajanti (2017) and Yuwana et al. (2025) revealed that MI-based mathematics learning is effective in improving learning outcomes, critical thinking, and curiosity.

Based on these studies, the implementation of Project-Based Learning based on Multiple Intelligences has the potential to foster students' curiosity. The application of MI theory can serve as a foundation for classroom learning, allowing instruction to be tailored to students' interests and fostering their curiosity. Therefore, it follows that the PjBL based on MI approach has strong potential to improve students' curiosity. The relationship between PjBL based on MI and curiosity is illustrated in the following figure.

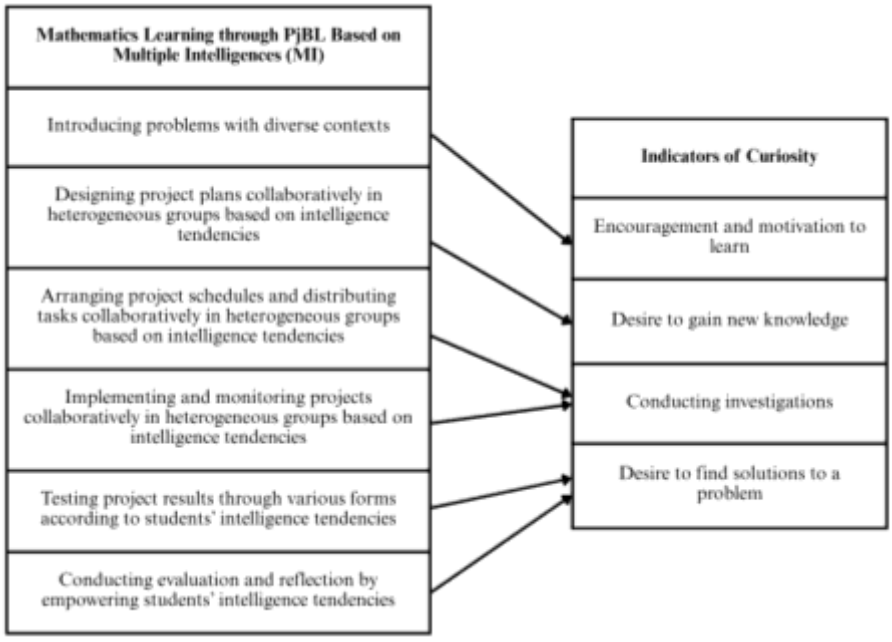

Figure 2. The Relationship Between Project-Based Learning Based on Multiple Intelligences and Curiosity

Conclusion

Based on the studies discussed previously, the Project-Based Learning (PjBL) approach integrated with Multiple Intelligences (MI) theoretically has the potential to foster students' mathematical literacy skills and curiosity. The stages of MI-based PjBL include: identifying problems within diverse contexts; designing projects in heterogeneous groups according to intelligence tendencies; organizing schedules and distributing tasks based on intelligence profiles; implementing and monitoring projects aligned with intelligence strengths; evaluating project outcomes through various modes according to students' intelligences; and conducting reflection activities that empower each learner's intelligence.

Through these stages, students actively develop their mathematical literacy skills, which encompass the abilities to formulate problems, employ mathematical procedures or concepts, and interpret mathematical solutions. Furthermore, the MI-based PjBL stages also have the potential to foster students' curiosity, as reflected in indicators such as the motivation and drive to learn, the desire to acquire new knowledge, the willingness to investigate, and the ability to discover solutions to problems.

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