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Research Article

Inquiry-based learning in action: perspectives from international baccalaureate mathematics Indonesian classrooms

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ABSTRACT
Despite the widespread adoption of inquiry-based learning (IBL) in mathematics education to enhance critical thinking and problem-solving, significant challenges continue to hinder its intended impact, further exacerbating the issue and underscoring the urgent need for in-depth analysis. This study explores the influence of IBL approaches using a phenomenology. Participants included six mathematics teachers, ten students, and seven school administrators who participated in focus group discussions. Essential themes emerged around pedagogical strategies, classroom practices, challenges, and contextual factors, highlighting the complex interplay between inquiry-based learning implementation, teacher facilitation, curriculum demands, and the institutional dynamics of IB Mathematics classrooms.

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Introduction

Inquiry-Based Learning (IBL) approaches in IB Mathematics classrooms refer to teaching and learning methods that emphasize active exploration, investigation, and problem-solving. These approaches invigorate students to do an active role in their learning by asking questions, making connections, and developing their own strategies to solve mathematical problems (Haese et al., 2019). Rather than merely memorizing procedures and formulas, students are urged to develop critical thinking, data analysis, and use mathematical concepts in real-world contexts. IBL approaches promote student engagement, collaboration, and a deeper understanding of mathematical concepts, as students are encouraged to explore multiple solutions and justify their reasoning (Ozdem-Yilmaz & Bilican, 2020; Stoffová, 2020). This learner-centered approach fosters curiosity, creativity, and a growth mindset, empowering students to become independent and lifelong learners in mathematics; however, its effective implementation can be challenging due to varying student readiness levels, the need for extensive teacher guidance, and potential resistance from those accustomed to traditional methods.

Talampas (2024) inquiry-based learning approaches in IB Mathematics classrooms help students to construct their own knowledge and develop a profound understanding of mathematical concepts. Similarly, (Mahmud & Mohd Drus, 2023; Şen et al., 2021) highlight that IBL fosters a collaborative and student-centered environment by allowing students to explore mathematical ideas, make connections, and develop a conceptual understanding of mathematics. Further, they stress that IBL approaches in IB Mathematics classrooms facilitate the development of

communication, reasoning, and mathematical modelling. These findings collectively demonstrate the positive impact of inquiry-based learning on student outcomes in IB Mathematics education; however, its implementation poses challenges, including increased lesson planning time, difficulty in assessing open-ended tasks, and the need for teachers to balance guidance with student autonomy.

Despite the growing recognition and implementation of IBL approaches in IB Mathematics classrooms, there is still a need for further research in this area, particularly from the perspective of teachers, students and school administrators. Existing studies have primarily focused on the benefits and impact of inquiry-based learning on student outcomes, such as problem-solving skills and conceptual understanding. However, there is a gap in understanding how school stakeholders; students, teachers, and administrators, perceive and implement inquiry-based learning in non-Western classrooms, the challenges they face, and the strategies they use to overcome these challenges. Exploring their experiences and perspectives can provide valuable insights into the effective implementation of inquiry-based learning approaches, as well as inform professional development initiatives and support systems.

Method

The study employed a phenomenological approach, collecting non-numerical data through semi-structured interviews. It was conducted at Sekolah Victory Plus in Bekasi, Indonesia. Participants included seven school administrators, ten students, and six mathematics teachers, all directly involved in implementing inquiry-based learning (IBL) approaches and selected through purposive sampling. Thematic analysis, specifically Colaizzi's approach, was used to derive meaningful insights into pedagogical strategies, classroom practices, challenges, perceived impacts, and contextual factors related to the implementation of IBL in IB Mathematics classrooms. In relation to the foregoing, data trustworthiness was ensured through member checking and triangulation. Participants were given transcripts to verify the accuracy of their responses, while triangulation was achieved by supporting the data in in-depth interviews (IDIs) with focus group discussions (FGDs), allowing for a richer and more credible understanding of how IBL is perceived and practiced in the classroom.

Results and Discussion

Figure 1 presents five essential themes that describe the pedagogical strategies and classroom practices employed by IB Mathematics teachers when implementing inquiry-based learning approaches. These themes include guided questioning, collaborative learning and peer interaction, scaffolding and gradual release of learning responsibility, facilitation of student-centered discussions, and the use of diverse assessments that promote self-reflection and critical thinking.

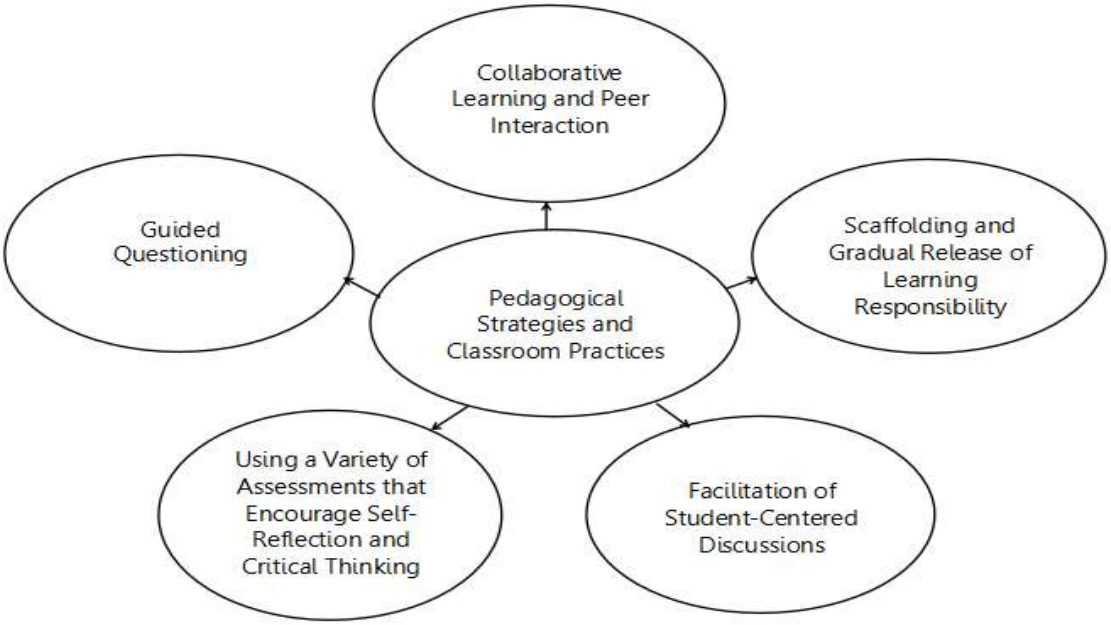

Figure 1. Pedagogical Strategies and Classroom Practices that IB Mathematics Teachers Employ when Implementing Inquiry-Based Learning

The themes highlighted key strategies and practices that support the effective implementation of IBL, encouraging deeper student engagement, promoting autonomy, and fostering critical thinking skills essential for meaningful learning experiences.

During the interviews, the participants highlighted that…

> *"The fact that I am more comfortable to ask questions to easily understand the lesson." S1, L5-6*
>
> *"An active discussion, inquiry games, working together…I started to like inquiry-based learning because I worked better with groups then alone." S8, L13*
>
> *"This is helpful because it practices independence, and it also is a method at which we students can learn from our mistakes. The practice sessions are helpful because the teacher gives us time to work on it ourselves." S10, L18-19, L21-22*
>
> *"I get to see their side (perspective) on things, and we get to exchange thoughts and ideas which benefit both myself and them." S10, L61-63*
>
> *"…exams, worksheets, etc. to foster a learning environment that helps the student refine their knowledge and skills both creatively and critically." S10, L124-125*

Guided questioning and collaborative learning enhance students' problem-solving abilities and engagement in inquiry processes (Lee & Paul, 2023). Similarly, scaffolding and reflective assessment practices significantly improve students' understanding and independence in science-based IBL environments (Qablan et al., 2024) . These studies reinforced the effectiveness of instructional strategies, such as

guided questioning, collaboration, scaffolding, and reflective assessments, that were evident in participants' classroom practices, affirming their value in enhancing IBL across diverse educational contexts.

Figure 2 shows four essential themes that describe the challenges IB Mathematics teachers face when integrating inquiry-based learning approaches into their classrooms, as well as the strategies they use to address them. These themes include student learning behaviours and engagement, teachers' teaching preferences and comfort, time constraints and planning, and class size and classroom management.

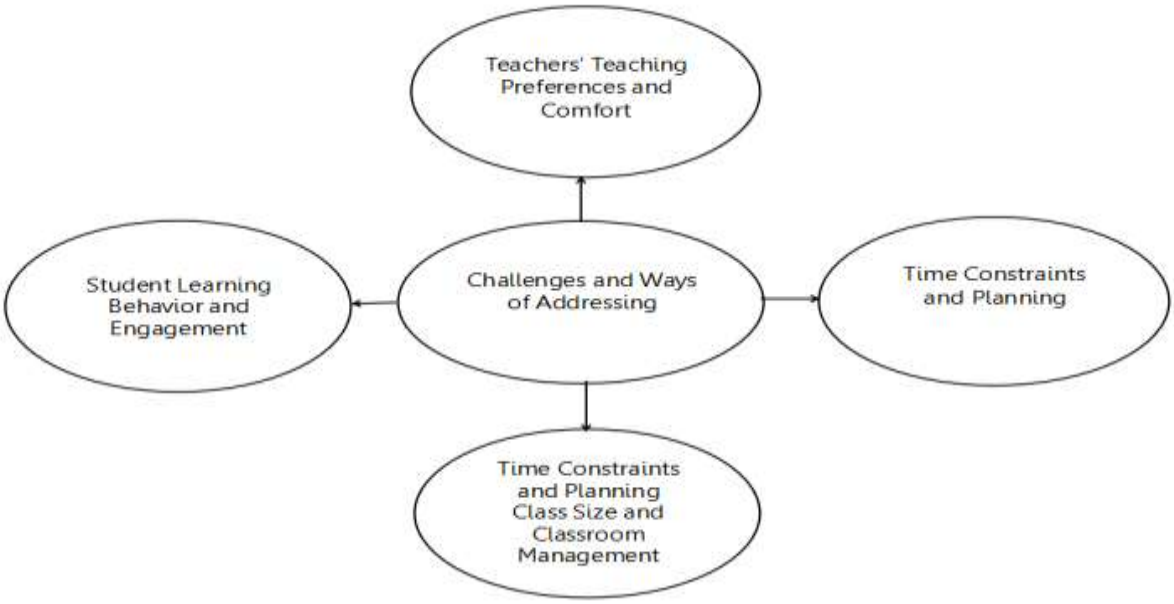

Figure 2. Challenges that IB Mathematics Teachers Encounter when Integrating Inquiry-Based Learning Approaches into their Classrooms, and their Ways of Addressing

The themes revealed that the success of IBL implementation in IB Mathematics classroom is affected not only by pedagogical intentions but also by contextual realities such as student readiness, teacher confidence, and logistical limitations. These challenges highlighted that training and class sizes could have significant impacts on inquiry-driven approaches in an IBL environment.

During the interviews, the participants highlighted that…

> *"…I worked better with groups than alone. I also prefer to communicate with others to get more opinions and perspective from others." S8, L98-99*
>
> *"Yes, I do. If you are a traditional teacher, this strategy would be much of a challenge. If you are somebody who is open and who loves to explore, then this would prove to be challenging yet fun." T1, L168-170*
>
> *"I believe there is. If for example we really do need to cover certain topics in a semester, with the limited time and sometimes with class interruptions due to holidays, the length of inquiry-based learning is shortened." T1, L198-200*
>
> *"The size of the class also matters because some students work better with small groups instead of bigger groups." S8, L40-41*

The success of IBL heavily depends on teacher preparedness and classroom context; inadequate planning time and limited classroom management strategies often hinder effective implementation (Huda et al., 2022). In a similar view, while IBL offers deep learning opportunities, it requires smaller class sizes and a shift in student learning culture, especially in contexts where passive learning is the norm (Mirosavljević & Sablić, 2024). These studies reinforced the idea that systemic factors, such as training, time allocation, and class sizes could hinder the sustainable IBL implementation in mathematics education.

Figure 3 illustrates the five essential themes that highlight the impact of IBL approaches on student engagement, critical thinking, and problem-solving skills. These themes include improved critical thinking and problem-solving abilities, intensified student engagement, development of independent learning and self-regulation, augmented collaboration and communication, and increased ownership of learning.

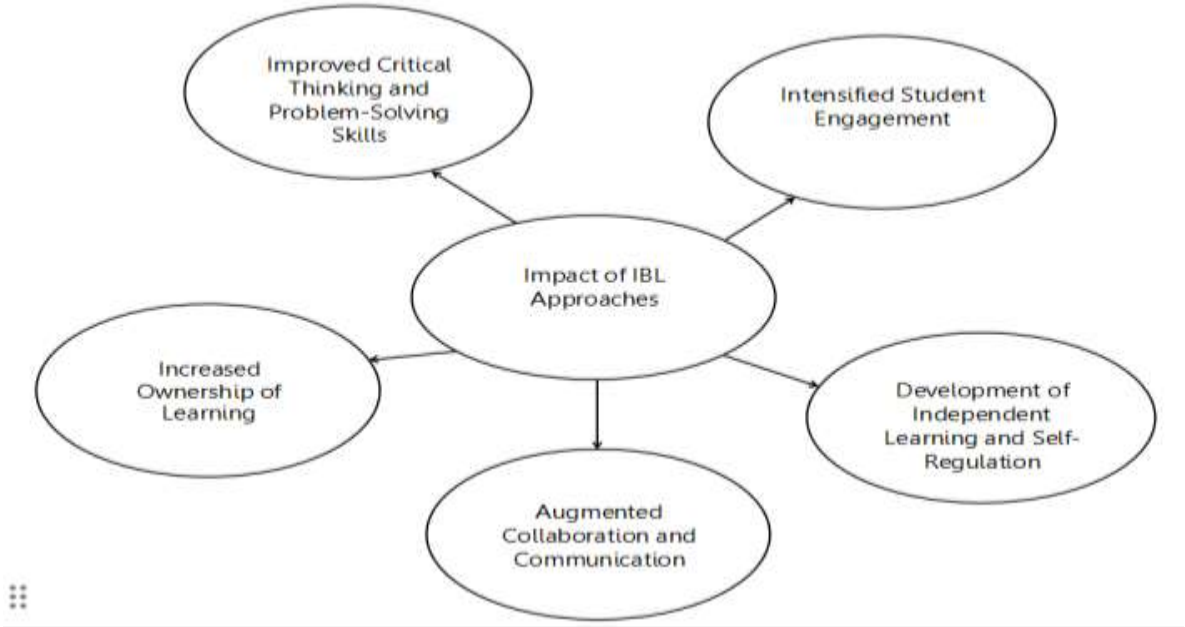

Figure 3. Impact of Inquiry-Based Learning Approaches on Student Engagement, Critical Thinking, and Problem-Solving Skills as Perceived by Mathematics Teachers Based on Their Classroom Experiences

The themes divulged that IBL fosters a dynamic and student-centered environment where learners actively construct knowledge, take ownership of their learning, and engage more deeply in the learning process. These outcomes reflect a shift from passive reception to active exploration, promoting critical thinking, collaboration, and self-directed learning skills essential in 21st-century education.

During the interviews, the participants revealed that…

> *"…foster a learning environment that helps the student refine their knowledge and skills both creatively and critically." S10, L124-125*

"...makes learning more engaging to myself and others." S1, L107-108

"...encourages student-directed inquiry, from teacher-directed inquiry through to student-led inquiry." A2, L306-307

"...students collaborate and explore by providing training on teamwork and inquiry-based teaching." A3, L288-289

"...inquiry activities have encouraged me to study for topics that are even beyond my level...These help me succeed because I get to refine my mathematical skills, while balancing my life in and out of school." S10, L101-102, L85-86

IBL significantly enhanced students' engagement and critical thinking by encouraging them to formulate and investigate their own questions (Hasibuan et al., 2024). Additionally, students exposed to IBL approaches demonstrated stronger problem-solving skills and greater autonomy in managing their learning tasks compared to those taught through traditional methods (Sriyono et al., 2024). These studies emphasized the positive effects of IBL on student engagement, independent learning, and the development of critical thinking and problem-solving skills, mirroring the observed themes from the experiences of the participants.

Figure 4 displays the seven essential themes that describe the factors influencing the success in the implementation of IBL approaches within IB mathematics classrooms. These themes include classroom environment and culture, teacher expertise and professional development, student profiles and readiness, curriculum and assessment framework, time and resource availability, classroom size and demographics, and support from the school and community.

The themes accentuated that the success of IBL in IB Mathematics classrooms is shaped by both internal and external factors, ranging from teacher expertise and student readiness to systemic support and contextual realities like classroom size and time constraints. Furthermore, there is a need for holistic and well-supported educational environment where pedagogical innovation can thrive without being hindered by logistical or institutional limitations.

During the interviews, the participants shared that...

"Flexible seating arrangement, and a safe environment (both physically and verbally, where they can always collaborate freely and voice their opinion or honest input)." T5, L144-145

"The school helps me with inquiry-based learning through training workshops, collaborative planning, and Professional Learning Communities (PLCs)/ Profesional Development." T3, 248-251

"Developing good study habits like staying organized and setting aside time to practice math or other lessons also can help us succeed in inquiry based learning activities." S8, L76-78

"The IB curriculum supports inquiry-based learning by encouraging critical thinking and real-world problem-solving. However, it can also be challenging because of the extensive content that needs to be covered..." T3, L226-228

"I believe there is. If for example we really do need to cover certain topics in a semester, with the limited time and sometimes with class interruptions due to holidays, the length of inquiry-based learning is shortened." T1, L198-200

"...there are enough tools and materials for engaging lessons." A3, L273-274

"The size and makeup of my class affect how I do inquiry. In bigger classes, I might use more group work and tech to keep everyone involved. For smaller classes, it's easier to give everyone personal attention and make sure they're all engaged. Either way, I adjust my plans to fit the class." T3, L152-155

"Supportive policies provide resources and training, while student services offer extra help for those who need it." T3, L205-206

"I will say the parents play very big role. The way they care about their kid's education is very important." T4, L208-209

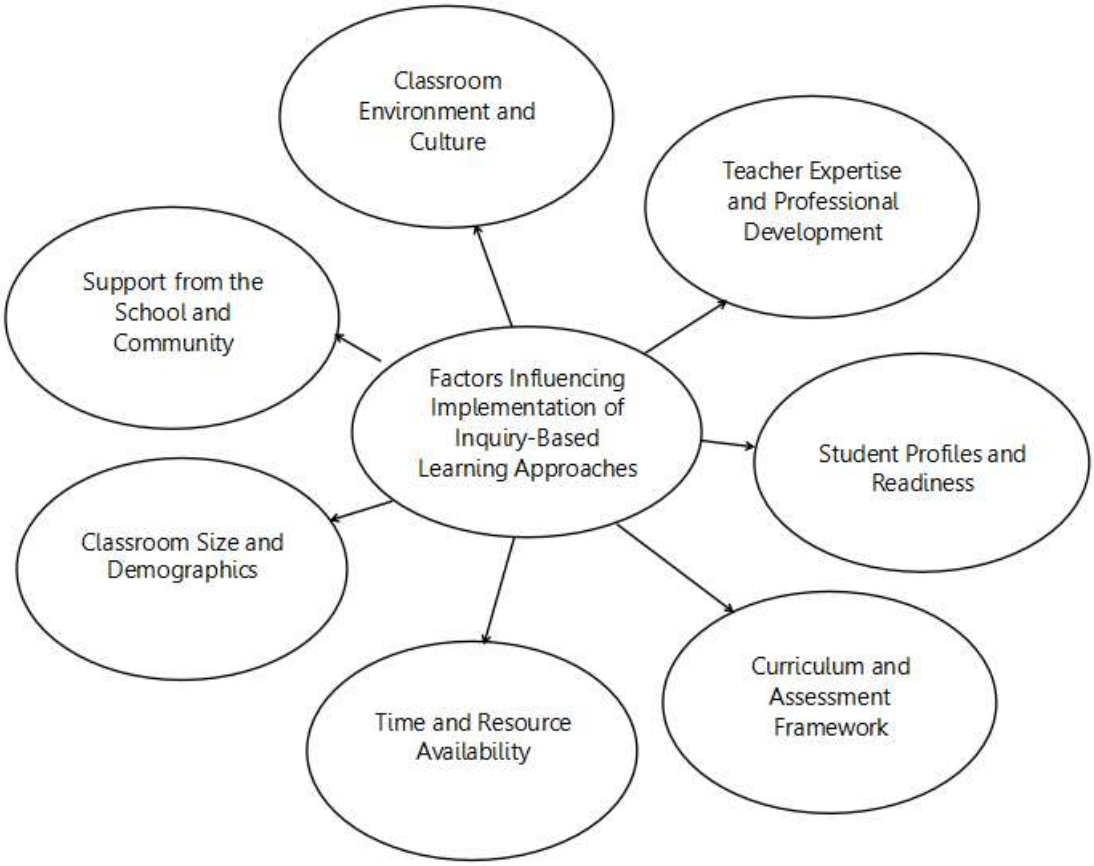

Figure 4. Factors within IB Mathematics Classrooms that Influence the Success in the Implementation of Inquiry-Based Learning Approaches

The sustained professional development and supportive school environments are crucial for fostering teacher confidence and capability in implementing IBL, especially in content-heavy subjects like mathematics (Fry et al., 2025). On the other hand, lack of alignment between curriculum demands and assessment frameworks often discourages teachers from fully adopting inquiry-based approaches, confirming that institutional and curriculum-level support is essential for meaningful IBL integration (Clinkenbeard & Ultan, 2024). These studies reinforced the findings underscoring the importance of structural, pedagogical, and contextual alignment in ensuring successful IBL implementation.

Finally, the study's findings resonate with three key educational theories that highlight the role of active learning, intrinsic motivation, and cognitive balance in shaping effective IB mathematics classroom practices. First, from a constructivist and socio-cultural perspective, learners build knowledge through meaningful experiences and social interaction (Vygotsky, 2020). This view is evident in how students in IB classrooms engaged in problem-solving, collaborative tasks, and reflective thinking which are mirrored in the scaffolding and peer support, where students are guided to achieve more than they could independently. Second, Self-Determination Theory, developed by (Miller et al., 1988) emphasized the psychological needs of autonomy, competence, and relatedness in fostering motivation. The study's themes around increased student initiative, engagement, and ownership of learning align with this theory. When learners are given the space to explore and contribute meaningfully, as seen in inquiry-based instruction, their motivation to learn tends to deepen. Third, Cognitive Load Theory, introduced by (Sweller, 1988), highlighted the need to manage the amount of information learners process at once. The study's insights into how teachers use scaffolding, pacing, and gradual release strategies reflect an awareness of balancing cognitive demands. These approaches help prevent overload and support sustained learning, especially in the cognitively rigorous context of IB Mathematics classroom.

Conclusion

The pedagogical strategies and classroom practices employed by IB mathematics teachers when implementing IBL approaches emphasized the importance of creating a dynamic, student-centered learning environment that actively promotes critical thinking, collaboration, and self-reflection. The challenges IB Mathematics teachers faced when integrating IBL approaches into their classrooms, along with the strategies they used to address them, highlighted the need for teachers to navigate various classroom dynamics and limitations while adapting their practices to ensure successful implementation, emphasizing flexibility, effective time management, and tailored instructional strategies.

The impact of IBL approaches emphasizes the significance of improving students' cognitive and social abilities, creating a more engaging and self-directed learning environment that promotes critical thinking, problem-solving, collaboration,

and independent learning. These approaches are essential for fostering deeper engagement and developing key skills that are crucial for student success.

The success of IBL implementation in IB mathematics classrooms depends on several critical factors, including a supportive classroom environment, well-trained educators, appropriate resources, and the readiness of students. Addressing these factors ensures the diverse needs of students are met and their learning experience is improved.

Conflict of Interest

No potential conflict of interest was reported by the author(s).

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