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The development of a project-based, technology-enhanced science module to promote social interaction for preschool children through blended learning

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ABSTRACT
Early science learning has the potential to enhance children's social interaction development, but a lack of resources in schools requires well-structured activities and a supportive learning environment. In a project aimed at helping children develop an interest in science education from an early age, this describes a Project-Based, Technology-Enhanced Science Module (PTBLM) for preschool children, fostering their interest in science through collaborative activities. This study employs a multi-method design, utilising the ADDIE module based on five phases. In the first phase, the needs analysis phase, nine experienced early childhood education educators were interviewed, and thematic analysis revealed the necessity of developing a science learning module for preschool children. During the second and third phases, the design and development phases, the module content was validated by six different experts, with the Content Validity Index (CVI) indicating unanimous agreement on the module's design and development (k = 1). In the fourth phase, the implementation phase, an 8-week intervention was conducted with 25 preschool children, and the mean scores showed a significant increase, with post-test scores being higher (m = 66.0) than pre-test scores (m = 33.00). In the final evaluation phase, an educator was interviewed, and content analysis indicated that the learning module was highly positive in enhancing children's social interaction development through engaging science projects. In summary, this learning module provides educators with more opportunities and resources to enhance science education in preschool, thereby expanding children's exposure to the world of science.

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Introduction

The social interaction development of children is significantly affected by various factors such as personalities (Monninger et al., 2023), gender (Friebel et al., 2021), parental roles (Zhu et al., 2024), and preschool settings (Aya & Shigeki, 2022). A strong correlation exists between social skills and happiness in childhood (Rossano et al., 2022). The capacity of a child to adjust and conform to their surroundings. Accepting and respecting the environment, along with feeling positive emotions during social activities, are crucial for a happy and successful future. When children take care of their surroundings and enjoy social interactions, it helps them build a better life (Mayar, 2013). The early stages of children's social development exhibit variations between girls and boys (Sjöman et al., 2021). Research suggests that girls tend to demonstrate faster development compared to boys (Mohamed, 2018; Tan, 2018). However, it is worth noting that the preschool setting can offer a fair and equitable environment that provides children with opportunities for development through positive engagement in social activities (Sjöman et al., 2021). The incorporation of engaging interactive social activities, such as the utilisation of interactive teaching materials, can effectively facilitate positive interpersonal relationships among preschool educators during learning and facilitating sessions (Chee Luen, 2017; Chee Luen; 2015).

The Project-based Learning (PBL) approach is widely acknowledged as a viable substitute for conventional, educator-centred pedagogy (Maros et al., 2022). According to Chen and Yong (2019), PBL exhibits a moderate to substantial favourable impact on children's academic performance in comparison to conventional educational methods. PBL is an efficient way for the acquisition of twenty-first century skills because it encourages interpersonal communication, teamwork and leadership (Chu et al., 2017). Mohamed and Jaafar (2020) examined the impact of the PBL approach on preschool activities. They found that PBL fosters peer-to-child interaction and promotes collaboration engagement. Additionally, PBL enhances children's motivation and creative thinking by incorporating inquiry elements. Besides, Setyowatiet al. (2023) indicated that the implementation of PBL activities in group settings can enhance children's communication skills through hands-on activities. This can be reinforced by research findings from Mohd Saad et. al (2024) in which educators feel that the implementation of projects in preschool can improve the motivation of children to ask diverse questions about the topics demonstrated to them. From the current study's standpoint, although educator initially struggled to effectively implement projects, children exhibited a strong desire for further exploration due to the engaging nature of the projects.

Problem Statements

Educators in the preschool context have the responsibility of implementing science instruction in preschool. However, few educators consider themselves to be able to take on the duty. A study conducted by Ramli et al. (2017) revealed that preschool educators continue to exhibit inadequate readiness in implementing science instruction. Ghazali et al. (2024) have elucidated that educators experience significant apprehension when it comes to conducting early science activities. This is primarily due to their limited teaching proficiency and inadequate grasp of scientific concepts. This can be backed by the findings of Daud's study (2019) where she has mentioned that the knowledge of early childhood education educators is at the moderate level to undertake high-impact activities, and this situation poses challenge for them to delve deeper into new knowledge such as doing research on more complex science concepts such as understanding physics topics. In addition, Nilsson and Elm (2017) reported that preschool educators struggled with planning and reflecting on their science teaching due to a lack of specific content knowledge. Similarly, Özsırkıntı and Akay (2024) found that in Turkey, teachers often faced difficulties with inadequate knowledge of science content, which impeded their ability to teach science concepts effectively to young children.

Aside from educators' lack of comprehension, there are some other factors that explicitly contribute to science education in preschool not being implemented effectively. Winarni (2017) found that the activity of teaching science to preschool children through examples and explanation remains glued to the examples in preschool science textbooks, making it difficult for children to learn science. Undoubtedly, textbooks are an important educational tool that transmit knowledge to the next generation (Palló, 2006), but Mupa and Chinooneka (2015) discovered that using textbooks solely will make learning less active and results in negative consequences for children as well as will be adversely affected by being forced to learn in an unfavourable and hostile. In addition, Kember and Gow (1994) highlighted that teaching using textbooks tends to discourage a deep approach to learning. Instead, these methods often lead to a surface approach where students concentrate on memorizing material for exams rather than understanding the underlying meaning. Moreover, the results of an analysis conducted by Hardin et al. (2019) revealed that even when utilised by highly qualified educators, traditional textbooks do not guarantee improved academic performance of learners. These findings could be further supported by Singh's (2023) explanation, which argues that using traditional resources such as textbooks in learning hinders the amount of inquiry that children are going to do because textbooks often provide information in a structured, linear manner that limits exploration and critical thinking. Instead of engaging in hands-on activities, asking questions, and exploring concepts through experimentation, children may passively absorb information without fully understanding or questioning it. This explanation underscores the necessity of allocating resources towards educator training and support in the utilisation of various tools, including science-related equipment (Taşdemir & Yıldız, 2024) and technological tools (Dore & Dania, 2020). Positively, Zhang et al. (2024) demonstrated that incorporating technological aspects into project activities do not only enhances children's understanding in their learning, but it also promotes greater involvement and collaboration during the learning process.

The lack of tangible resources in schools, such as lab equipment, science kits, and hands-on materials, limits the ability of preschool teachers to provide engaging and practical science experiences. Without these resources, children miss out on opportunities to explore scientific concepts through direct experimentation and observation (Barenthien & Dunekacke, 2022; Çiftçi, A., & Topçu, 2022). A study conducted by Han et al. (2022) revealed that rural schools in particular have serious problems in implementing practical science activities when compared to urban schools because they do not have access to materials to implement practical science activities in Malaysia. Abdul Rashid (2022) revealed that educators are unable to deliver optimal instruction due to their belief that available resources are insufficient, making it challenging to offer children opportunities for collaborative and transparent exploration of their learning. Ghazali et al. (2022) noted that in order to ensure that children's learning about science concepts is successfully implemented, the use of hands-on activities such as the application of PBL by incorporating TBL is critical because it can increase concentration and focus on children and encourage them to acquire new experiences. Ghazali et al. (2023) underscored that the principal application of technological tools in the classroom is to equip children with instructive video displays. These displays help children understand concepts more thoroughly and accurately.

This study will focus on five research questions arising from the problems highlighted until the development of a Project-Based, Technology-Enhanced Science Module (PTBLM), including:

1. What are the needs for developing PTBLM in early childhood education?
2. What are the key aspects that must be included in the design of PTBLM to support the social development of children's interactions?
3. What are the contents that must be included in the development of PTBLM to improve the social development of children's social interaction?
4. What is the difference between the mean scores for the social interaction development of children before and after using the PTBLM?
5. Is PTBLM effective in improving the social interaction development of children?

Literature Review

In early childhood education, the implementation of teaching and facilitation activities needs to be creatively implemented by educators to ensure that children can improve their development holistically. To flourish and attain professional satisfaction, a preschool educator needs to acquire knowledge about teaching approaches for children to grasp basic skills before entering the mainstream (Abdullah et al.,2021). One of the most effective strategies is to include the PBL approach into preschool scientific instruction. Previous studies have revealed that PBL is an effective approach for immersing children in the real world of the twenty-first century (Bell, 2010; Doppelt, 2003; Kaldi et al., 2011; Tamim & Grant, 2013). A prior study by Ilangko (2014) discovered that the PBL that he carried out helped children develop and enhance their capacity for creative thought. From these findings, it could be surmised that PBL is a systematic learning strategy that allows young learners to enhance their abilities and receive in-depth knowledge through the execution of the project, collaboration and 'hands-on' procedures (Du & Han, 2016). Children can also cooperate with the educator by applying what they have learned to create an outcome that addresses the investigated issue or solves the desired problem (Kavanagh & Rainey, 2017; Reisman et al., 2018; Shukri et al., 2019). As demonstrated by Sumarni et al, (2022), PBL has the potential to enhance children's understanding as they work through educator-prepared projects. It can also foster cooperation, interaction, and communication between learners and educators as well as between learners and peers. Finally, PBL can help children develop compassionate and understanding friendships through the completion of projects together.

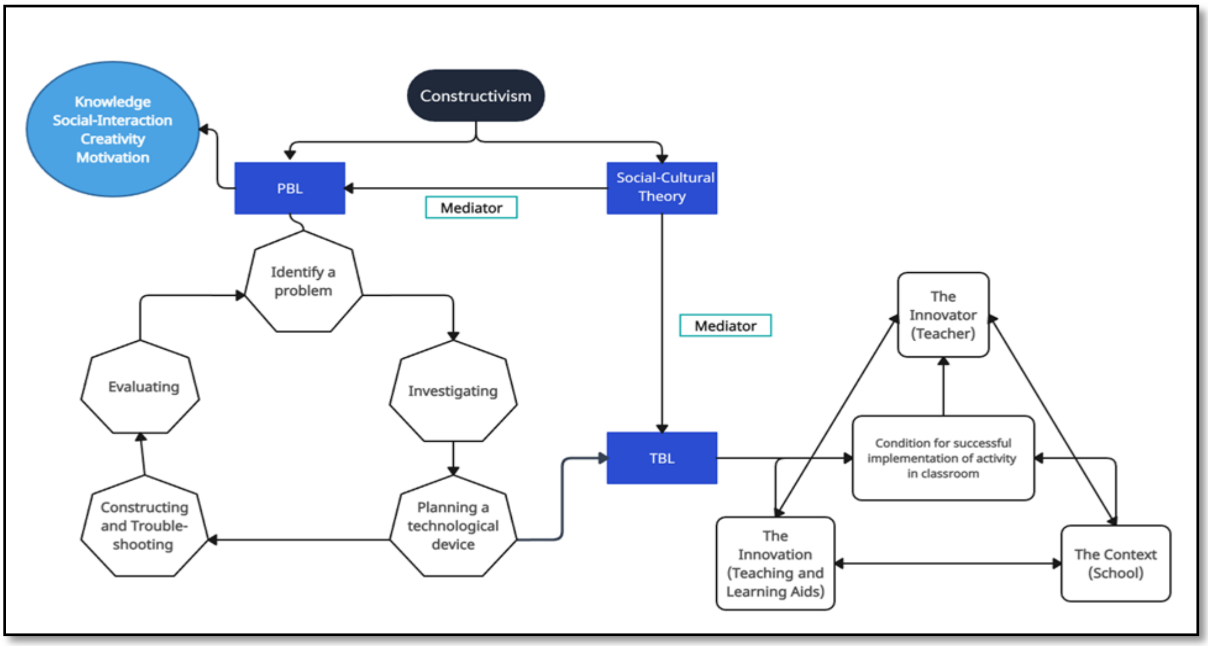
With regard to the use of technology in educational settings, several researchers have demonstrated that it is a platform to produce the elements of 21st century learning (Tripati et al., 2023). The experience of the children in the prior study shows that the lack of technology tools in the classroom causes science learning to become more boring. By utilising digital tools in the classroom, educators and children can acquire new information, abilities and experiences (Demir & Akpinar, 2018; Ramaila & Molwele, 2022). Furthermore, exposing children to Technology-based Learning (TBL) will help them learn about things that are outside of their assumptions and thinking box. When juxtaposed with the impact of technological innovation on the transformation of society and the social lives of individuals outside the classroom, the change in learning through the incorporation of technology has gained traction (Ilomäki & Lakkala, 2018). Tomar and Sharma (2021) elaborated that this approach may reduce educators' costs by experience, offering children a tech-centred world, fostering better relationships between children through collaborative behaviour, and keeping children interested and engaged. As a result, the integration of PBL and TBL, known as PTBL in science classrooms is not only enabling children to gain new knowledge related to the concepts of science, but it is also can enhance the collaboration of child-peers (Markula & Aksela, 2022). Blended learning is a viable option for implementing PTBL. According to Irwanto and Setyo Rini (2024), children's interest in learning about science can be greatly boosted through the use of blended learning. This discovery is in line with the research of Yıldız Taşdemir and Gürler Yıldız (2024), which highlights the importance of providing children with chances to investigate subjects through interesting activities, such integrating technological tools into educational pursuits (Yıldız & Selvi, 2015).

Conceptual Framework

In the context of the current study, PTBL approach plays a crucial role in order to improve children's social interaction development. To observe the impact of PTBL on children's learning, educators would first deliver PTBL activities to the children, culminating in the execution and assessment of a sequence of instructional actions conducted at the preschool (Safitri et al., 2018). Cunningham et al., (2009) emphasised that in order to properly mediate children's development, educators need to have a broad range of content knowledge. Educators in particular must be aware of the traits and competencies of the 21st century, which include information, media and technology skills, learning and innovation skills, and life and career skills, in order to successfully carry out a project intended for children (2019). In current study, to create an effective learning module for children, researchers created the PBL Process Model, which outlines five major stages that educators must take to scaffold children when adopting PBL activities at preschool that were adopted from Barak (2020). Furthermore, to ensure that classroom settings may be converted into child development in accordance with the use of technology in the classroom, researchers have followed fundamentals provided by Zhou et al. (2002). Furthermore, the study will examine Vygotsky's (1978) sociocultural learning theory to provide theoretical guidance for educators in the mediation process. By synthesising these theoretical perspectives, the study aims to establish a structured and comprehensive framework for implementing PBL in early childhood education.

Figure 1

The implementation of PTBL in preschool through blended learning



Educators play a crucial role as mediators in early science discussions, shaping how children engage with and explore scientific concepts. According to Barnes (1969), education should not be about accepting a single authoritative voice but rather fostering an environment where multiple perspectives can be explored. In this context, educators act as collaborators and guides, initiating discussions while allowing children to navigate their own learning paths. To effectively implement PBL, educators must understand the natural mediation process. Barak's (2020) PBL model outlines key steps that facilitate this approach (see Figure 1). The first step involves encouraging children to identify a relevant problem within the topic they are studying. While early learners may have limited reading skills, structured guidance and interactive activities can help them engage with the material in meaningful ways. Engaging in explanations allows children to reconcile conflicting information, construct new hypotheses, and refine their understanding (Bursh & Legare, 2019). In second step, to ensure that children can investigate the problem earlier, the educator's role is to encourage them to get information related to the topic from various sources such as books, videos, pictures and the internet (Yusop et al., 2018). Educators do not need to be an encyclopedia to the children in order to convey answers clearly, but there are various types of teaching techniques that can be employed, such as informing children, "I don't know the real answer, let's explore together" (Lan, 2022). From here, children will show enthusiasm to continue to search and find real answers. The next step is that educators need to guide children to find deeper answers to problems that arise through the provision of technological devices through the integration of TBL. This is primarily due to the rising number of novel experiences attempting to integrate technological tools to teaching in order to improve children learning quality (Wang & Hoot, 2006).

In the current study, there are 3 elements related to TBL that need to be clearly understood by the educator. Firstly, educators should be ready to serve as pedagogical innovators in the classroom (Alvarado & Voy, 2006) by making topics and projects more engaging. Secondly, the content provided by the tools should be appropriate for children's development (Lentz et al., 2014). Thirdly, educators should understand explicitly the role of children as "innovators". When individuals refer to "innovation," they are not limited to the use of computers or other technology-based teaching tools. While technological improvements are a part of innovation, innovation involves much more than just technology (Childhood Education International, 2023). The following step for the mediation process in PBL is to construct and troubleshoot the problem after they have a firm understanding of the three components of TBL. This step is frequently applied in producing any project in order to identify the root cause of faulty completed projects. This step is also taken to fix rejected goods and identify the underlying causes of issues so that unsuccessful goods can be repaired and used once again (Mahmood et al., 2016). In early childhood education, troubleshooting should be guided by structured problem-solving rather than relying solely on trial and error. While Cowles (2015) described trial and error as a natural way for children to explore solutions, troubleshooting in a PBL framework involves systematic reflection, hypothesis testing, and iterative improvements.

Finally, the evaluation phase plays a critical role in the learning process. Ahea et al. (2016) emphasised that feedback is essential for learning and facilitation. Encouraging peer dialogue between educators and children, as well as among children themselves, enhances understanding of learning goals and fosters a collaborative learning environment. By integrating structured feedback within the PBL framework, educators can ensure that children actively engage in self-assessment and continuous improvement.

Methods

Please An approach to research known as a mixed-methodologies design is one that incorporates both qualitative and quantitative research methods into a single investigation that is being conducted (Timans et al., 2019) was employed in this current study. The ADDIE Model (Shakeel et al., 2022) was selected as a supplementary framework for instructional design and development. It represents five phases: Analysis, Design, Development, Implementation, and Evaluation. During the first phase, known as the needs analysis phase, researchers conducted a series of interview protocols to gather qualitative data on educators' perspectives regarding the significance of designing a PBL science learning module for preschool settings. Furthermore, in the second phase, known as the module design phase, researchers distributed a survey to experts to solicit crucial components that should be incorporated into the learning module. In the third phase, experts were also provided with a questionnaire to assess the efficacy of the module in promoting the social development of children's interactions. Data was obtained via an online platform, with researchers interviewing participants via Google Meet in the first phase, and each expert receiving a set of questionnaires through their official institutional email in the second phase. The rationale for adopting an online platform is its ease of access and the ability for all participants and experts to respond quickly (Toivonen et al., 2019). Additionally, in the fourth phase, which is the implementation phase of the learning module, data was collected using pre- and post-tests through an experimental method involving 25 children. Subsequently, in the fifth phase, the evaluation phase, an educator was interviewed using a series of interview protocols to identify the effectiveness of the module on children's social interaction development. The constructs and items of each instrument can be referred to in Table 1 - 5.

Table 1

Constructs and items for research instrument in Phase 1

Phase / Instrument	Construct	No. of Items
Phase 1: Needs Analysis (Interview Instrument: The Perception of Preschool Educator towards Integrating PTBL in Science Activities)	Challenges in teaching early science	1
	Integrating National Preschool Curriculum Standard (KSPK) 2017 with PBL Activities	1
	The Best Approach could be utilised to teach early science	1
	The importance of PBL approach for social interaction	1

Table 2

Constructs and items for research instrument in Phase 2

Phase / Instrument	Construct	No. of Item
Phase 2: Module Design (Questionnaire Instrument: Designing PTBL based Science Learning Module in improving Children's Social Interaction)	Activity Implementation	2
	Types of Activity	1
	Learning Objective	1
	Use of Worksheet	1
	Use of Technology Tools	1
	Time Allocation	1
	Challenge of Activity	1
	Guideline in Classroom	1

Table 3

Constructs and items for research instrument in Phase 3

Phase / Instrument	Construct	No. of Item
Phase 3: Module Development (Questionnaire Instrument: Evaluation of PTBL based Science Learning Module in improving Children's Social Interaction)	Technological Needs	2
	Learning and Facilitation Objective	2
	Module Contents	2
	Activities Slots	2

Table 4

Constructs and items for research instrument in Phase 4

Phase / Instrument	Construct	No. of Item
Phase 4: Module Implementation (Pre-Post Tests Instrument: Assessment of Social Interaction Development of Children)	Cooperation	5
	Self-Control	5
	Assertiveness	5

Table 5

Constructs and items for research instrument in Phase 5

Phase / Instrument	Construct	No. of Item
Phase 5: Module Evaluation	Appropriateness	1
(Interview Instrument: The Effectiveness	Effectiveness	1
of PTBLM)	Usability	1

A total of 47 study participants were selected for data collection from the first phase until the fifth phase. For the appointment of study participants in all phases, researchers employed purposive sampling technique where it signifies a collection of non-probability sampling procedures in which units are selected because they have qualities that researchers need in your sample (Palinkas et al., 2015). Furthermore, the second sampling technique employed in Phase 1 is snowball sampling (Heckathorn, 2011), which is a recruitment approach in which study participants are invited to help researchers identify new possible subjects. To provide a general overview of the backgrounds of all of the participants and experts chosen for this study, it can be referred to in Table 6.

Table 6

Background of study participant

Phase	Participant	Position	Experience in Education
Phase 1 (Needs Analysis)	1, 2, 3, 4, 5, 6, 7, 8, 9	Preschool Educator	More than 5 Years
Phase 2 (Module Design)	1	PhD., Lecturer	More than 15 Years
	2	PhD., Lecturer	More than 5 Years
	3	PhD., Child Consultant	More than 15 Years
	4	PhD., Lecturer	More than 5 Years
	5	Excellent Preschool Educator	More than 15 Years
	6	Preschool Excellent Educator	More than 5 Years
Phase 3 (Module Development)	1	PhD., Lecturer	More than 15 Years
	2	PhD., Lecturer	More than 5 Years
	3	PhD., Lecturer	More than 10 Years
	4	PhD., Lecturer	More than 5 Years
	5	PhD., Child Partitioner	More than 15 Years
	6	PhD., Lecturer	More than 5 Years
Phase 4 (Module Implementation)	1	Preschool Educator	More than 5 Years
	2	25 Preschool Children aged 5 – 6 years old	
Phase 5 (Module Evaluation)	1	The Same Educator as Mentioned in Phase 4	

In this current study, researchers selected participants, including experienced preschool educators, preschool children, and experts in the field, through an official appointment process facilitated by the University of Technology Malaysia. Regarding the participation of preschool children, consent forms were signed by their parents or legal guardians, ensuring voluntary participation in the interview sessions and the eight-week intervention. The study followed a structured five-phase process:

1. Needs Analysis Phase (June–July 2023): This phase involved gathering insights from preschool educators to understand their experiences and needs.
2. Module Design Phase (January–February 2024): Experts collaborated to develop a framework for the educational module.
3. Module Development Phase (March–April 2024): The module was refined and finalised based on expert input.

4. Module Implementation Phase (July–September 2024): The module was tested in preschool settings, involving both educators and children.
5. Module Evaluation Phase (End of September 2024): The effectiveness of the module was assessed based on educator and child engagement.

Additionally, appointed experts were provided with an official appointment form bearing the reference number UTM.J.53.01.00/13.11/1/4/2 Vol. 16. To accurately analyse the data gathered, the following software packages were used:

Table 7

Software used for analysing the data

Phase of Research	Software	Technique
Phase 1: Needs Analysis	ATLAS.ti version 8	Thematic Analysis
Phase 2: Design	Microsoft Excel	Content Validity Analysis
Phase 3: Development	Microsoft Excel	Content Validity Analysis
Phase 4: Implementation	SPSS version 26	Paired Sample T-Test
Phase 5: Evaluation	Microsoft Word	Content Analysis

Findings

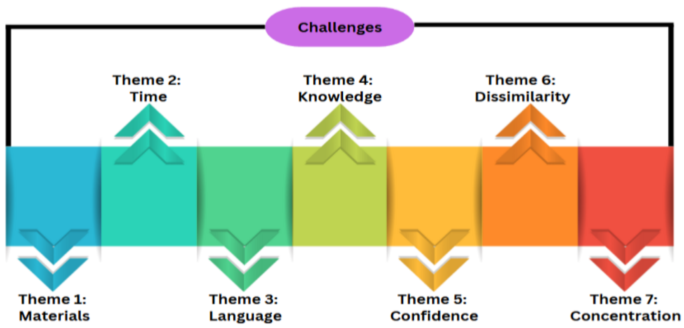
The Needs for Developing PTBLM in Early Childhood Education

a. Construct 1: Challenges in Teaching Early Science

Preschool educators confront a variety of challenges when ensuring that science teaching is handled in an appropriate manner, as noted by 21st century education. Educators' challenges have been influenced not just by their personal convictions, but also by external factors. Figure 2 depicts seven themes that were identified by the researchers.

Figure 2

Challenges in teaching science in preschool



Seven topics have been successfully documented in order to understand the challenges faced by educators and preschool children in ensuring that early science learning is implemented effectively. The first theme that was most commonly reported was that four participants (P) stated that they were not provided with or did not have adequate equipment to conduct quality science activities at preschool. The following interview findings support this study. The data was originally collected in Bahasa Malaysia, then translated into English, and subsequently reviewed by a language expert to ensure accuracy and clarity.

P1: "Furthermore, I intend to instruct on the topic of balloon bursting at my location tomorrow. However, acquiring enough materials is a significant challenge for me. This is a remote location, and it is rather distant if I wish to depart from here.". - 1:1 ¶ 65

P3: "In my perspective, the materials we offer are limited and the children must collaborate with us to prepare for projects, such as botanical science.". - 3:2 ¶ 55

P4: "And the other is related to the material used. The majority of individuals, uh, this is a common occurrence. The majority of my acquaintances from the preschool division heavily rely on paper-based modules for teaching. They abstain from utilizing any form of substance. That is the issue I perceive. That is all.". - 4:2 ¶ 57

P8: "The biggest challenge is in terms of preparing materials. If we want to perform an inquiry, we use things that are not in the classroom. We must locate it by ourselves". - 8:1 ¶ 61

The second successfully recorded theme was a shortage of time to conduct high-quality scientific activities. P8 and P3 reported that they must participate in other activities, which limits their ability to focus on science activities. The third theme recorded was language, with P4 stating that the use of terminology in science differs from the terms used in common language at home, which prompts children to struggle with such terms. The fourth successfully documented theme was lack of knowledge, with P1 and P7 arguing that it was about the best approach to offer PBL activities while incorporating parts of 21st century education. The sixth theme was lack of confidence, in which P2 states that children felt afraid in attempting to solve issues in science activities, resulting in inability to complete the activity. The sixth theme was age inequality among children, and P6 stated that it is difficult to execute the same activities for all children because she must monitor the growth of each child individually. The final theme was the children's lack of concentration, as P5 and P9 described how difficult it was to regulate the children and ask them to focus when doing science tasks in class.

b. Construct 2: Integrating National Preschool Curriculum Standard (NPCS) 2017 with PTBL Activities

All study participants (P1-P9) expressed positive agreement on the integration of KSPK 2017 with PBL activities. However, only two of the nine participants agreed that KSPK 2017 should be conditionally integrated with PBL activities as shown in the table as Table 8.

Table 8

The agreement of the integration of NPCS 2017 with PBL approach in science activities

Participant	Theme 1: Agree Unconditionally	Theme 2: Agree Conditionally
1.	✓	
2.	✓	
3.	✓	
4.		✓
5.	✓	
6.		✓
7.	✓	
8.	✓	
9.	✓	

According to the Table 8, P1, P2, P3, P5, P7, P8, and P8 believe that introducing PBL activities in preschools through the use of KSPK 2017 content is appropriate due to the importance of this PBL approach (see construct 4) for the development of children's social interactions as they participate in impactful classroom activities. However, P4 and P6 emphasized in the interviews that this integration should be performed conditionally for the following reasons:

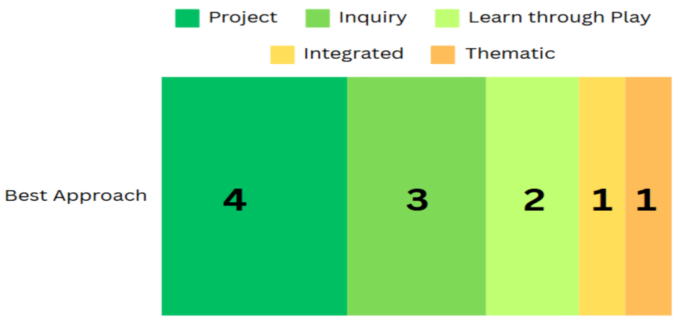
P4: "That's all right, but it depends on the circumstances. It will take some time, just like me and the preparation doing the project. It's recommended that we take our time.". - 4:5 ¶ 103
P6: "To be honest, I believe that it is sometimes relevant to be implemented and sometimes it is not. According to the first viewpoint, the children's level varies. Perhaps the integration of PBL with KSKP 2017 can be carried out directly in the urban environment but not in rural areas.". - 6:4 ¶ 102

C. Construct 3: The Best Approach Could Be Utilised to Teach Early Science

Before designing the module, researchers have to figure out which approach should be favoured so that educators can generate quality learning. There were five themes that emerged as indicated as in the figure below:

Figure 3

Best approach to implementing early science activities



Four participants namely P5, P7, P8, and P9 confidently claimed that the integration of science education is consistent with the PBL approach. This is because this approach has its own advantages compared to other approaches such as debates as below:

P5: "Typically if I want to carry out a project, I would love to use existing, real materials. For example, if I wish to undertake an experimental activity, the teaching aids utilized must be interesting. We must provide them engaging material and our voice must be absolutely clear". - 5:3 ¶ 92

P7: "So, the approach I chose in my project is the 3E approach, which I will encourage my learners to reveal to explore, experiment, and experience". - 7:4 ¶ 77

P8: "In our preschool, I have not been limited to follow the timetable, so I will be using a project approach entirely. So, when using the full project approach in my instruct session, I guess this approach could provide an investigation. So, this time is when educator,,,, urmmm,, children do an investigation in a project approach". - 8:4 ¶ 78

P9: "Example of making a project. Project. The simplest for preschool children is to plant seeds. Right? The process is the easiest, materials are easily available, and they can see progress day by day. The peanut seeds germinated". - 9:2 ¶ 85

The second theme was the inquiry approach, where P1, P8, and P9 agreeing that inquiry is a key component in ensuring early science learning can be implemented through hands-on experiences. They claimed that this method will pique children's interest in completing a task. The third theme was the approach of learning through play, where P2 and P6 stating that allowing children to play in science learning increases their motivation to learn. The fourth and fifth themes were thematic approach and integrated approach, respectively. P4 explained that the fourth theme is important because children must understand a concept in accordance with appropriate themes, while P3 stated that the third theme is also important to ensure that the activities implemented produce high-impact learning outcomes.

d. Construct 4: The Importance of PBL Approach for Social Interaction

To assess preschool educators' perceptions of previous experiences and their abilities to evaluate the value of the PBL approach in early science activities, they were asked about the strength of this approach to the social development of children's interaction. Four themes emerged, as shown in Table 9.

Table 9

The benefits of PBL approach in early science activities

Participant	Theme 1: Two Ways Communication	Theme 2: Joyful in Learning	Theme 3: Many Ways Interaction	Theme 4: Increasement of Socialisation
1.	✓			
2.		✓		
3.		✓		
4.				
5.	✓		✓	
6.				✓
7.	✓			
8.	✓			
9.	✓	✓		

For theme one, two-way communication, P1, P5, P7, P8, and P9 emphasised that in science activities using the PBL approach, children's engagement with educators or peers becomes more active. This can be demonstrated by P 5's experience, which follows:

> P5: "When I do project with my preschool children, they would love to keep talking. I mean he or she is eager to speak up. Everyone wants to talk to educator and want to tell what they see in front of their eyes. Meaning, if we ask, they will share their opinion". - 5:8 ¶ 185

For the second theme, joyful in learning, P2, P3, and P9 demonstrated that implementing projects in the classroom can assist children in acquiring fun and burden-free learning. Besides, only P3 and P4 commented on the third and fourth theme which in many ways deal with interaction and increase in socialisation. P3 believes that theme 3 arises when learners socialise with others in their group while engaging in collaborative learning. Furthermore, P4 claimed that theme 5 is significant to children because the PBL approach itself can improve children's motivation to interact more openly with their friends. This can be proven by the dialogues as below:

Key Aspects that Should be Included in The Design of PTBLM to Support the Social Development of Children's Interactions?

In the second phase, six experts (E) were provided with an evaluation instrument, a prototype of the Project-Based, Technology-Enhanced Science Module (PTBLM), and a prototype of the educator's guideline. Based on the researchers' findings, all experts provided highly positive feedback on the module's design. The evaluation used a response scale limited to Agree (A), Agree Strongly (AS), and Agree Very Strongly (AVS), indicating unanimous agreement across all constructs and items, as detailed in Table 10. As a methodological note, the approach used to address this research question was identical to that used for the third research question, as both followed the same process for implementing the research instrument and measuring agreement.

Table 10

Constructs, items and experts' agreement in Phase 2

No	Construct/Item	Expert Agreement					
		E1	E2	E3	E4	E5	E6
	Construct 1						
1.	Item 1: Variety of Activities through Learn by doing.	AS	AS	AS	AVS	AS	A
	Item 2: Teaching and facilitation scheduled and formatted.	AS	A	AS	AVS	AS	A
	Construct 2						
2.	Item 1: State the type of project clearly.	AS	AS	AS	AVS	AS	A
	Construct 3						
3.	Item 1: Appropriateness of earning objective.	AS	A	AS	AS	AS	A
	Construct 3						
4.	Item 1: Appropriate Worksheet	AS	A	AS	AVS	AS	A
	Construct 5						
5.	Item 1: Technology accessible to use the module in the classroom	AS	A	AS	AS	AS	A
	Construct 6						
6.	Item 1: Appropriate time to implement the activity within .40 minutes	AS	A	AS	AS	A	A
	Construct 7						
7.	Item 1: Appropriate challenge with child development.	AS	AS	AS	VAS	AS	A
	Construct 8						
8.	Item 1: Provide guideline to implement the activity.	AS	AS	AS	VAS	AS	A

To assess agreement levels among experts, researchers categorised responses into two groups: Agreement and Disagreement, as suggested by Yusoff (2019) as shown in Table 11.

Table 11

Expert agreement scale classification

	Instruction	
Agreement	Scale	Category
Disagree Very Strongly (DVS)	1	0
Disagree Strongly (DS)	2	0
Disagree (D)	3	0
Agree (A)	4	1
Agree Strongly (AS)	5	1
Agree Very Strongly (AVS)	6	1

Following this classification, agreement scores for each item were grouped into two categories: relevant or irrelevant. This categorisation was determined using the Item Level-Content Validity Index (I-CVI). The Scale Level-Content Validity Index (S-CVI) was then calculated by determining the proportion of experts who agreed on each item. The results, as summarised in Table 12, indicate strong consensus among the experts, with all items classified as relevant.

Table 12

I-CVI (Item Level-Content Validity Index) and S-CVI (Scale Level-Content Validity Index)

Item	Expert 1	Expert 2	Expert 3	Expert 4	Expert 5	Expert 6	I-CVI	Category	S-CVI
1	5	5	5	6	5	4	1	Relevant	1
2	5	4	5	6	5	4	1	Relevant	1
3	5	5	5	6	5	4	1	Relevant	1
4	5	4	5	5	5	4	1	Relevant	1
5	5	4	5	6	5	4	1	Relevant	1
6	5	4	5	5	5	4	1	Relevant	1
7	5	4	5	5	4	4	1	Relevant	1
8	5	5	5	6	5	4	1	Relevant	1
9	5	5	5	6	5	4	1	Relevant	1

To determine the overall validity of the module, the Modified Kappa Coefficient (K) was calculated using the formula proposed by Polit and Beck (2007). These calculations, originally intended for the Methods section, yielded a coefficient value of $K = 1$, indicating full agreement among experts. The results are summarised in Table 13**.**

Table 13

Modified Kappa Coefficient (K) obtained based on Content Validity Indexing

Sum of I-CVI	9	Sum of S-CVI	9
Sum of I-CVI/Ave: (Total I-CVI/Total of Item	1	Sum of I-CVI: (Total I-CVI/Total of Item	1
Category	Accepted		Accepted

Based on expert feedback, a consensus was reached on refining the module to better align with preschool education settings. The final version of PTBLM ensures age-appropriate activities, clear guidelines for educators, and a well-structured methodology for fostering children's social interaction skills.

The Development of PTBLM to Improve Children's Social Interaction

In the third phase, six experts (E) were provided with an evaluation instrument, a fully developed Project-based, Technology-Enhanced Science Module (PTBLM), and a comprehensive educator's guideline. The feedback indicated that all experts evaluated the module positively, using the response scale of Agree (A), Agree Strongly (AS), and Agree Very Strongly (AVS) for each item. The consensus across all constructs and items are detailed in Table 14.

Table 14

Constructs, items and experts' agreement in Phase 3

No.	Construct/Item	Expert Agreement					
		E1	E2	E3	E4	E5	E6
	Construct 1	AS	A	AS	AS	A	A
1.	Item 1: Laptops and LCDs in the classroom.						
2.	Item 2: Internet facility.	AS	A	AS	AS	AVS	AVS
	Construct 2	AS	AS	AS	AS	AVS	AVS
3.	Item 1: Objectives focus on the 2017 National Preschool Standard Curriculum (NPSC 2017)						
4.	Item 2: Objectives that can assess the assessment based on the level of the child.	AS	AS	AS	AS	AVS	AS
	Construct 3	A	AS	AS	AS	AVS	AVS
5.	Item 1: The content is suitable according to the level of knowledge of children.						
6.	Item 2: Content relevant to children's development.	A	AS	AS	AS	AVS	AS
	Construct 4	AVS	AS	AS	AS	AVS	AVS
7.	Item 1: Interactive activities help children communicate with each other.						
8.	Item 2: Activities can help group problem solving.	AS	AS	AS	AS	AVS	AVS

To assess expert agreement on each item, responses were categorised into two groups: Agreement and Disagreement, following the method outlined in Table 11.

Table 15

I-CVI (Item Level-Content Validity Index) and S-CVI (Scale Level-Content Validity Index)

Item	Expert 1	Expert 2	Expert 3	Expert 4	Expert 5	Expert 6	I-CVI	Category	S-CVI
1	5	4	5	5	4	4	1	Relevant	1
2	5	4	5	5	6	6	1	Relevant	1
3	5	5	5	5	6	6	1	Relevant	1
4	5	5	5	5	6	5	1	Relevant	1
5	4	5	5	5	6	6	1	Relevant	1
6	4	5	5	5	6	5	1	Relevant	1
7	6	5	5	5	6	6	1	Relevant	1
8	5	5	5	5	6	6	1	Relevant	1

To determine the overall content validity, the Modified Kappa Coefficient (K) was calculated using the formula suggested by Polit and Beck (2007). The results, shown in Table 16, indicate that the overall coefficient value for S-CVI reached $K = 1$, demonstrating full agreement among experts.

Table 16

Modified Kappa Coefficient (K) obtained based on Content Validity Indexing

Sum of I-CVI	8	Sum of S-CVI	8
Sum of I-CVI/Ave: (Total I-CVI/Total of Item	1	Sum of I-CVI: (Total I-CVI/Total of Item	1
Category	Accepted		Accepted

The expert evaluations confirm that PTBLM is a suitable and effective tool for enhancing children's social interaction in preschool settings. The unanimous agreement among experts highlights the module's alignment with early childhood education standards, relevance to children's developmental needs, and ability to foster interactive learning.

The Difference between the Mean Scores for the Social Interaction Development of Children before and After Using the PTBLM?

Table 17

The difference between pre and post-tests scores of social interaction variable

Construct	Item	Question	Mean Score (Pre)	Mean Score (Post)
1	1.	Encouraging a friend who is struggling to complete the science task.	2.00	4.28
	2.	Applauding a friend who has done well on their science task.	2.64	4.08
	3.	Praising the achievement of a group member who successfully completed the science activity.	2.00	4.40
	4.	Praising the achievement of a friend from another group who successfully completed the science activity.	2.12	4.52
2	5.	Helping group members complete the task without being prompted by others.	1.96	4.04
	6.	Listening to the educator's explanation before starting the activity.	2.00	4.40
	7.	Sharing items with others during the science activity.	2.00	4.44
	8.	Postponing personal activities when asked.	2.64	4.56
	9.	Behaving appropriately according to the situation.	2.00	4.16
	10.	Waiting for your turn to complete the assigned science task.	2.60	4.12
3	11.	Showing joy when group members help in completing the science activity.	2.48	4.68
	12.	Participating by giving answers during the group science activity.	2.52	4.20
	13.	Using appropriate words when interacting with friends during the science activity.	2.08	4.56
	14.	Making eye contact when interacting with others during the science activity.	1.92	4.96
	15.	Showing clear reactions when communicating during the science activity.	2.04	4.60
Cumulative Mean Score			33.0	66.0

The researcher conducted a study of the mean scores for both the control group and the treatment group using a pre-test (administered prior to the intervention) and a post-test (administered subsequent to the intervention). The following part would address the mean score for the 15 items related to the social interaction variable from the questionnaire. Figure 17 presents the pre-test and post-test mean scores for children’s social interaction development during science classes. Overall, the post-test scores indicate a marked enhancement in social interaction. Conventional learning recorded a cumulative mean score for children's social interaction development of (m = 33.0). However, after an 8-week intervention, the children's social interaction development increased to (m = 66.0), showing a mean score difference of (m = 33.0). In summary, the use of PTBLM is often more impactful than conventional learning because it is an active, child-centred approach that enhances understanding, engagement, and skill development. The module involves teamwork, requiring students to collaborate, share responsibilities, and communicate effectively. Additionally, it can be inferred that the eight projects developed in PTBLM were highly effective in the teaching and facilitation sessions conducted by the educator.

The Effectiveness of PTBLM in Improving the Social Interaction Development of Children

Based on the interview findings analysed from the interview transcripts, three key constructs were highlighted by the researchers. Examining the appropriateness of the PTBLM for children's social interaction development, Participant 10 (P10) expressed that the content developed in the module appropriate and aligns with the educational context outlined in the main curriculum proposed by the Ministry of Education Malaysia. This is evidenced by the following excerpt from the transcript:

> "I guess that PTBLM module is highly appropriate for preschool-aged children. The projects presented in this module are exemplary. It provides children with early science activity experiences aligned with the competencies of the National Preschool Standard Curriculum, coordinated at the preschool level." – P10

Furthermore, considering the effectiveness of the module on children's social interaction development through the P10's experiences, the educator explained that the designed projects not only help children communicate but also encourage them to learn collaboratively. This is evidenced by the following excerpt:

> "Based on my experience, this module is highly conducive to enhancing the development of social interaction. This module also promotes interaction and collaboration among children in groups created during early projects related to science." – P10

Additionally, regarding the educators' perception of the module's usability, P10 believes that the developed projects are suitable for preschool children aged 5 to 6 years. This perception is also reflected in the content related to the appropriateness of the module. This is evidenced by the following excerpt:

> "It is very suitable because the content and topics produced are in accordance with the elements formed in the National Preschool Standard Document 2017. In my view, this module is very suitable for use at all levels of kindergarten and preschool." – P10

P10 affirmed that the PTBLM aligns with the National Preschool Standard Curriculum established by the Ministry of Education Malaysia. This alignment ensures that the module provides developmentally appropriate early science activities tailored for preschool children. Furthermore, P10 highlighted that the module actively fosters communication and collaboration among children during science-based group activities, reinforcing its role in enhancing social interaction skills. This observation is supported by the structured learning approach embedded in the module, which incorporates hands-on, inquiry-driven tasks that encourage peer engagement. Additionally, P10 emphasised that the module is highly suitable for preschoolers aged 5 to 6, as its content and topics are specifically designed in accordance with the National Preschool Standard Document 2017. The structured progression of activities ensures age-appropriate cognitive and social development, making the module adaptable for various preschool and kindergarten settings. The module's alignment with established national educational frameworks underscores its validity as a structured tool for fostering both scientific understanding and social skill development in young learners.

Discussion

Through the views of the educators in this present study, the PBL module is essential in preschool education today since it can enhance children's social development through their engagement in early science activities inside or outside the classroom. This is supported by the findings of Mohamed and Mohamad Jaafar's (2020) study, which stated that providing PBL learning modules to educators in science education in preschool allows children to socialise and communicate with educators, friends, and those activities more openly and transparently because the topics introduced are based on 21st century learning elements. Moreover, Ompok et al. (2020) argue that introducing science learning modules through the PBL approach in preschool not only increases children's curiosity about new concepts, but it also increases children's confidence in questioning and answering critical problems initiated by the educator. Furthermore, Aziz and Bakar (2021) discovered that the PBL science module is appropriate for promotion in the early childhood environment because collaborative learning in the classroom can help children develop their creativity. Otherwise, Hsin and Wu (2023) discovered that the educator's function as a facilitator and role model in the classroom encourages children's experimentation since the educator becomes a resource for children to socialise in meaningful activities. By integrating these perspectives, this study not only supports previous research but also provides empirical evidence demonstrating that a PBL-based science module can serve as a practical tool for fostering children's social interaction, confidence, creativity, and problem-solving skills in preschool settings.

Next, keeping in consideration the success of PBL features in early childhood education, experts have expressed their belief that a learning module based on PTBL will assist children in improving their social development through group activities. However, Elviana et al. (2022) noted that the educator's knowledge of applying these two ways is critical to ensuring that the children understand the content to be presented. Cooperative work in PBL has the potential to enhance children's communication and teamwork skills, leading to considerable improvements in their overall development (Parrado-Martínez & Sánchez-Andújar, 2020). Upon further synthesis, these two approaches greatly facilitate social interactions that hold immense importance for children. It is helpful to consider the PBL approach first where Apriyanti and Diana (2016) and Aulia et al. (2024) explained that PBL can allow children to learn cooperatively with peers. Otherwise, Kim and Kim (2021) discovered that when children start doing projects in groups, their social interaction becomes passive. Hence, the findings imply that the responsibilities of individuals within a group should be modified to accommodate the specific attributes of problem-based learning (PBL) and the nature of the work. Furthermore, when considering the significance of incorporating technology into education, independent of the specific technologies employed in the classroom, it can provide support for students' comprehension and learning during science-based activities that include inquiry (Devolder et al., 2012; Rutten et al., 2012). Therefore, to achieve success in science education classes, educators must adopt a more systematic approach by incorporating technology tools, such as utilising proper models and guidelines (Zahner, 1998). From the perspective of this study, the use of science education videos can enhance children's understanding of concepts and encourage them to share ideas when responding to teachers' questions related to their learning.

In general, introducing attractive and interactive learning modules into the education system attracts children to learn (Sirisuthi & Chantarasombat, 2021). In addition to improving children's communication and interaction skills, using learning modules incorporating PBL and TBL in the classroom will assist children in grasping the concepts taught to them (Artiniasih et al. 2019). Furthermore, Oksa and Soenarto (2020) noted that educators' efforts to implement learning utilising electronic media in conjunction with the execution of science activities at school can stimulate children to take out activities with greater confidence. Next, to explain why PTBL in blended learning is important, the results of this study also confirmed the findings of the current study, in which one of the experts indicated that the existence of this PTBLM can assist children develop an interest in science subjects. Considering the percentage of secondary school students in Malaysia last year, a Malaysian academician, Ahmad (2023), stated that only about 15.2 percent of the total number of 415000 thousand chose the science stream, which is still far from the country's target of 40 percent of students in science, also known as STEM. Thus, the introduction of this blended learning module is the

Malaysian Ministry of Education's best attempt to preserve science education for future generations, as the learning module's guidelines can help educators create more meaningful activities (Wijaya & Vidianti, 2021). More profoundly, Yustina et al. (2020) argued that incorporating PBL into a blended learning environment has a significant impact on educators' capacity for creative thought and has demonstrated to be a more successful approach than traditional methods for fostering this kind of thinking in science classrooms. Hence, by integrating both of these approaches, blended learning has the potential to enhance both the social development of children's relationships and the overall quality of the learning environment (Dziuban et al., 2018; Graham et al., 2023; Tonbuloğlu & Tonbuloğlu).

Finally, the analysis of PTBL activities conducted with children over the 8-week intervention reveals that the positive impact on children's social interaction is demonstrated by a higher mean score in the post-test compared to the pre-test. A study by Hoesny et al. (2022) indicates that learners' experiences with PTBL not only enhance children's collaborative learning attitudes but also foster their willingness to communicate confidently in public. The findings from the educator in the final evaluation phase of the study indicate that the eight activities developed in PTBLM enhanced children's collaboration in problem-solving tasks. Consequently, the results of this study indicate that the projects implemented in PTBLM enhance the social development of children's interactions in a more transparent environment.

Conclusion

In recognition of the challenges encountered by educators in carrying out activities due to a lack of knowledge in planning quality early science activities in preschool, experts agreed that designing a comprehensive science PBL learning module would greatly benefit educators in planning engaging and effective activities for children. Furthermore, by providing children with real-world experiences to solve problems related to various scientific concepts in a blended learning environment, the approach not only allowed them to learn collaboratively but also enhanced their motivation to participate in science activities. It encouraged them to use their creativity and critical thinking skills in problem-solving based on the activities conducted. The implementation of this learning module in science education improved children's abilities to solve problems in a more collaborative learning environment, resulting in enhanced critical thinking skills, increased engagement, and better academic outcomes. Additionally, children exhibited more positive attitudes towards learning, demonstrating a deeper understanding of science concepts through hands-on activities and teamwork. This positive shift highlighted the significant impact of the PTBL approach in early childhood education, ultimately fostering a more effective and engaging learning experience for young learners.

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Conflict of Interest

The authors declare that there are no conflicts of interest related to this research, authorship, or publication of this article.

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