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DEVELOPMENT AND EFFECTIVENESS OF THE E-SKY MODULE BASED ON PBL IN THE TEACHING AND FACILITATION PROCESS OF EARLY SCIENCE

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Abstract. *In recent years, there has been a growing concern in science education on the enhancement of preschoolers' knowledge and motivation for concepts by implementing efficient teaching methods. This study explored the development and effectiveness of the E-sky Module in increasing the development of preschoolers in Project-based Learning (PBL) activities conducted both within and outside of preschool. This study employed the Design and Development Research (DDR) approach, incorporating many research methods. During the qualitative interviews conducted in the needs analysis phase, three different themes related to the difficulties encountered by teachers when conducting early science projects were meticulously recorded and analysed. Based on a quantitative analysis completed by three experts in the field, this E-sky Module has been determined to have a substantial level of validity and a satisfactory level of reliability. This is evidenced by a Cronbach's alpha coefficient of ($p < .82$) observed. Moreover, throughout the evaluation phase, four distinct themes were effectively reported, suggesting that this module significantly contributed to the comprehensive development of preschoolers. Hence, future studies should explore the potential of enhancing knowledge acquisition through promoting motivation and the emergence of conducive learning environments in the context of PBL.*

Keywords: *project-based learning, teaching pedagogical, facilitation process, learning module, scaffolding*

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Introduction

The nation and society encounter several challenges as they strive to embrace modernisation to progress and remain pertinent. A plethora of technological breakthroughs and scientific revelations occur almost daily. This phenomenon has affected individuals and transformed conventional social conventions to align with contemporary lifestyles. Furthermore, scientific advancements have led to the evolution of various things, including the consumption of products and the use of technological instruments. And this matter has also had a good impact on the education of the 21st century where it has increased the competence of educators in offering higher-quality and accessible educational resources (Haleem et al., 2022). In Malaysia basically, science education is progressing in line with the National Science Education Philosophy, which prioritises the cultivation of individuals who possess a deep understanding of science and technology. This contributes to the advancement of a science-based civilisation (Division of Curriculum Development, 2012). Science plays a crucial role in developing well-rounded persons, as stated by the National Education Philosophy (Ariffin et al., 2022). It is widely known that many countries are competing to achieve modernity through education. Therefore, it is crucial to focus on the holistic development of individuals in order to effectively travel the path of growth and work towards constructing a developed nation (Ramli & Lee, 2023).

In order to enable all preschoolers to gain self-empowerment via education, it is imperative for the school, specifically the teachers, to carefully contemplate the most effective methods of fostering preschoolers' growth and development. The teacher's proficiency in employing suitable teaching approaches, strategies, techniques, and procedures enhances the effectiveness and enjoyment of the preschoolers' learning process (Che Noh et al., 2018). Hence, the implementation of Project-based Learning (PBL) is highly regarded as crucial in science education, particularly in early science activities. The findings of Balemen and Özer Keskin (2018) provided support for the assertion that PBL has a substantial influence on all science areas.

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Conversely, Kurt and Akoglu (2023) discovered that the PBL approach is the most efficient method for improving individuals' science education. In addition, the use of PBL activities in the early childhood science learning model requires refinement and introduction of a model. According to Barak (2020), the PBL model is commonly referred to as a standard teaching approach used in schools globally, with modifications made to suit different subject areas. Preschoolers usually work collaboratively with their teachers on projects that showcase their acquired knowledge. Alternatively, they may be assigned projects related to specific subjects to complete independently. Furthermore, Zhang and Ma (2023) have demonstrated in their meta-analysis study that the incorporation of PBL activities in education enhances learners' motivation and cognitive abilities, leading to significant improvements in their academic performance. More significantly, Zhou's study (2023) also suggested that PBL is the most effective learning strategy for learners and the best teaching strategy for educators.

Additionally, it is vital for teachers to utilise a guideline that aligns with the cognitive and emotional growth of preschoolers in order to effectively implement the PBL-based model during the Learning and Facilitation Process (LFP). One effective method to foster preschoolers' curiosity and enhance their comprehension of science subjects is integrating a science learning module into the LFP (Asmaryadi, 2023). To support this statement, a study conducted by Ariffin and Siew (2023) has determined that the utilisation of a learning module is highly effective in enhancing preschoolers' creative thinking abilities. The PBL-based learning module in early science is an effective guideline aimed at enhancing preschoolers' learning via hands-on activities conducted with teachers and peers at school (Hsin & Wu, 2023). Thus, providing preschoolers with suitable activities that allow them to engage in meaningful and purposeful projects can enhance their problem-solving abilities, as well as their capacity for critical and creative thinking when making decisions (Chistyakov, 2023). Moreover, Leng et al. (2023) have demonstrated that incorporating learning modules related to science education not only enhances preschoolers' motivation to learn but also serves as a valuable resource for preschool teachers in science education settings. The module can be utilised as directive materials and provide guidance to meet the requirements of national standards for preschool education, ensuring the preparation of future generations with internationally recognised educational standards.

Moving on to the roles of preschooler-teacher, open, effective, enjoyable, and conducive learning during LFP must be promulgated between teachers and preschoolers. Teachers can employ multiple strategies to enhance learning in the classroom. Teachers are responsible for figuring out how to encourage preschoolers to learn (Chand, 2022). In LFP, it is crucial for teachers to increase preschoolers' participation in early science activities. Thus, Alharbi (2023) proposed the integration of the Zone of Proximal Development (ZPD) and scaffolding (Vygotsky, 1988) into LFP to accelerate preschoolers' development more comprehensively. Furthermore, teachers should be well-versed in the most effective means of environmental communication with preschoolers in order to facilitate enhanced autonomy among learners. These include rewarding preschoolers who demonstrate a positive attitude toward learning (Aliabadi & Weisi, 2023), fostering autonomy in learning (Moreira & Lee, 2020), empowering learners by valuing their oral contributions (Pineda-Báez et al., 2019), and the active involvement of teachers in promoting engagement (Reeve & Shin, 2020). While these efforts may appear gradually, teachers have the ability to shape preschoolers' creative thinking in the classroom. By providing encouragement, teachers can yield favourable outcomes. Smolucha and Smolucha (2020) discovered that Vygotsky's approach to Early Childhood Education (ECE) introduces a novel method of evaluating a preschooler's learning potential. Therefore, by leveraging the guidance of a more knowledgeable individual, preschoolers can make significant advancements in their activities.

Utilising science education, programs, and activities is an excellent method to offer preschoolers novel prospects for acquiring life skills. This emphasis extends to various fields, including engineering and the development of machines. Notably, countries such as Japan (Vogt, 2023), South Korea (Jung, 2023), and the People's Republic of China (Zhao et al., 2022) have actively implemented projects in this domain. To ensure parity with other countries, it is imperative to enhance the early science education process, beginning at the preschool level. Hence, it is imperative to enhance the LFP in early science education to optimise preschoolers' comprehension and learning outcomes. Early science education necessitates hands-on learning and relies on the utilisation of available resources. In addition, preschool teachers must possess extensive knowledge and expertise in the early science-LFP to ensure that the transmission of knowledge and skills to preschoolers is more efficient and thorough. By incorporating PBL activities into science education, a learning environment can be created that aligns with the prospect of 21st-century education (Corbano-Reyes, 2023) that has been discussed by many countries (Amadi, 2023; Fitria, 2023).

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Literature Review

Preschooler-Teacher Engagement of PBL in Early Science Education

Integrating PBL concepts into early science activities is one of the most interesting ways preschools teach preschoolers nowadays (Apostolou, 2023; Lee et al., 2023). PBL, often called the project approach, is a method of teaching that involves delving deeply into real-world subjects in order to captivate preschoolers. Using this approach in the classroom, teachers and preschoolers can generate significant educational opportunities that align with 21st-century education (Saduakassova et al., 2023). Furthermore, this approach can help individuals prepare to conduct studies in the fields of science and social science since most of the projects are of a scientific character. Teaching preschoolers from four to six years old can involve a wide range of initiatives. Moreover, this approach has to be put into place in stages. The platform of this approach must also conclude with the preschoolers' evaluation of their work. Santos et al. (2023) suggested that within the proposed learning scenarios in PBL activities, learners not only surpass the content provided by actively participating in projects but also involve themselves in learning activities beyond the confines of the classroom. Moreover, PBL activities provide numerous benefits to preschoolers, such as the chance to engage in cooperative learning with both their peers and teachers. This, in turn, fosters their active participation as investigators in group projects (Krnjaja et al., 2022; Lev et al., 2022).

Furthermore, the utilisation of the PBL approach enhances the applicability and appeal of LFP in the realm of science education (Ishak & Bakar, 2021). This is due to the fact that PBL activities have been discovered to be an effective learning paradigm for enhancing preschoolers' performance in science and developing their problem-solving skills, as demonstrated by Chrisyakov et al. (2023). Agreeably, as evidenced by Sumarni et al. (2022), PBL also has the capacity to augment preschoolers' comprehension when they engage with teacher-designed tasks. In addition, comprehensive PBL learning allows preschoolers to enhance their knowledge and proficiency in the subjects taught in class and helps sustain their interest in these areas (Zhang & Ma, 2023; Zhang, 2022). Upon closer analysis of the correlation between the PBL approach and cognitive development and the enhancement of preschoolers' interest in learning activities, numerous research provides further insights into the benefits of including project assignments that encourage exploration and discovery by preschoolers. Additionally, previous qualitative research examining the significance of implementing the PBL approach in the classroom has demonstrated that this method effectively engages preschoolers, fostering a more joyful and motivated learning experience. Consequently, this approach enhances preschoolers' motivation for the topics taught and cultivates a more knowledgeable disposition (Fridberg & Redfors, 2021; Othman et al., 2021; Shukor et al., 2022).

Hence, implementing the PBL approach as the primary method in LFP can facilitate the comprehensive development of preschoolers by fostering their learning in collaboration with the teacher and their surroundings (Awang et al., 2022). Within the structure of this study, there are multiple strategies teachers can employ to enhance preschoolers' eagerness to engage with introduced activities or subjects. In the research they conducted, Quro'and Choiriyah (2021) have demonstrated that project-based activities and experiments can be effectively conducted through three fundamental processes: assessing preschoolers' capabilities, directly facilitating their project work, and responding to the phenomena observed by preschoolers during their explorations. In addition, in ensuring that preschoolers can produce a final product through their creativity, teachers are also unable to limit the results that need to be obtained based on their own views. However, Yazıcı Arici et al. (2022) indicated that it needs to be based on an imaginary companion because this can help them to develop through creativity. In addition, teachers who implement the PBL approach can foster active learning, enhance creativity during activities, and inspire continuous innovation in directive materials (Mutiasari et al., 2023). Hence, teachers must enhance their understanding of effective planning and teaching approaches by engaging in pertinent training sessions. This would enable them to provide high-quality, impactful, and meaningful education to preschoolers (Stojanović et al., 2023).

21st-century learning prioritises collaborative learning among teacher-preschoolers, as well as preschooler-peer learning. This approach fosters student teamwork, leading to enhanced knowledge, interest, social development, and overall personal growth. It also helps eliminate negative attitudes about cooperating with others (Basari, 2023). In collaborative learning, teachers could enhance preschoolers' comprehension of LFP in the classroom by stimulating activities that stimulate their curiosity in the subjects being taught. Among many of the roles of the teacher, as outlined in Vygotsky's sociocultural theory (1978), this study highlights the role of the facilitator. Remarkably, this hypothesis elucidates how preschoolers' engagement with their environment can foster and augment their capacity for cognitive processing of novel information. The study undertaken by Harun et al. (2022) focused on a preschooler's learning and examined four key components identified by Vygotsky: ZPD, interpersonal com-

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munication, cooperative learning, and social pedagogy. Expanding on the initial component, Ruswanda (2020) asserted that the ZPD is the intermediary stage between a preschooler's prospective abilities and their current level of performance. The preschooler's stage of development is demonstrated through their capacity to do assignments autonomously.

Meanwhile, the level of prospective development is evident in the student's proficiency in accomplishing activities or resolving difficulties with assistance. Upon entering the ZPD, the preschooler possesses the capability to perform tasks alone. However, it would be more advantageous for them to get guidance from a knowledgeable individual or a teacher in order to fully realise their potential and achieve their current stage of development (Stéphanie et al., 2023). This suggests that preschoolers who struggle to comprehend a new subject will acquire information if the teacher assists in facilitating their grasp of the tasks they are engaging with.

Continuing with the discussion of the component of interpersonal communication, it can be understood that this refers to the verbal and nonverbal transfer of ideas, feelings, and information between at least two people. Direct eye contact, listening, and the use of body language to convey meaning are all hallmarks of face-to-face communication. Furthermore, preschoolers with special needs benefit from teachers who are skilled communicators, according to research by Mutiah and Utami (2020). Moreover, the teacher's role is to make things easier for preschoolers to understand by simplifying their explanations or making better use of existing resources and tangible objects (Liang et al., 2021). In addition, when discussing the third element, namely cooperative learning, it is incumbent upon the teacher to foster a more dynamic classroom environment by engaging all students. Cooperative learning is associated with improved academic achievement in school (Namaziandost et al., 2020) and fosters an engaged, enjoyable, and secure atmosphere for profound learning (Keramati & Gillies, 2022). Last but not least, the social pedagogy component should be considered to enhance teacher-preschooler relationships in PBL activities. Social pedagogy examines information, education, and training as valuable tools that improve human nature in the quest for greatness. However, the destiny of a preschooler might vary significantly based on whether they possess the capacity to create or lack this capacity. Therefore, the objective of social pedagogy is to establish an exemplary curriculum by effectively aligning suitable methodologies with the desired outcomes. Pantazis and Styla (2020) discovered that teachers who transition into the role of social pedagogues effectively support preschoolers facing difficulties in the classroom and cultivate a more vibrant learning atmosphere.

Hence, it is crucial for teachers to motivate preschoolers to engage in a subject pertaining to early science within the classroom through the implementation of PBL. This is because, as Sharma (2023) asserted, the introduction of this approach in educational institutions has proven to be beneficial for preschoolers in fostering their independent learning and facilitating real-world application of knowledge. Using comprehensive and high-quality learning modules is one of the greatest ways for teachers to pique preschoolers' interest in science-related activities (Wandi et al., 2023). To enable effective implementation of PBL activities by teachers for preschoolers, this study attempts to identify the three primary focal points of research:

RQ1: What are the challenges encountered by teachers that necessitate the use of the E-sky Module based on PBL?
RQ2: How is the E-sky Module based on PBL developed?
RQ3: How effective are the PBL-based activities developed in the E-sky Module?

Research Methodology

General Background

The researchers employed multiple types of research methods in this present study. The multiple methods have gained recognition as a firmly established field of empirical social research and methods. Integrated research designs encompass the integration of various qualitative or quantitative methods for the purpose of gathering and analysing data within a single study (Knappertsbusch et al., 2021). In order to provide access to diverse data sources, this study utilises a Design and Development Research (DDR) approach, with the researchers focusing on developing a learning module using both qualitative and quantitative learning methods to obtain expert feedback (Reeves, 2006). The implementation of DDR approach can be developed using many methods and tools, depending on the specific goals and research challenges being addressed at each step (Gandhi et al., 2021). The study consists of three crucial phases: the needs analysis phase, the module development phase, and the module evaluation phase. This study was conducted over approximately one year, starting from the first implementation phase, which involved obtaining authorisation from the school and concluding with drafting a study report. The

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researchers conducted this study on a government preschool owned by the National University of Malaysia (UKM), primarily collecting qualitative data and using quantitative data as supplementary information. The data acquired from the data collecting procedure was examined using content analysis in three phases: needs analysis (phase one), module development (phase two), and module evaluation (phase three). Conversely, descriptive-analytic approaches were employed in phases one and two in order to explore teachers' perceptions of thematic challenges in teaching early science concepts. The three-phase exploration commenced in late November 2016 and concluded successfully in late October 2017 to be certain all work is completed thoroughly.

Participant Selection

Each phase of this study involves the selection of three distinct participants. As a result, during each stage, participants were selected according to the predetermined research questions, consisting of distinct populations. Initially, preschool teachers were selected for phase one, which is needs analysis. During phase two, module development, three experts specialising in ECE were selected to validate the constructed items. Furthermore, for the third phase, module evaluation, the study participants consisted of preschool teachers who were previously participating in phase one and preschoolers. Consequently, the research samples were selected using purposive selection procedures. Purposive sampling involves deliberately selecting informants who possess the capacity to provide insight into a certain theme, principle, or phenomenon (Robinson, 2014). Table 1 displays the varying numbers of study participants with diverse origins using this approach.

Table 1
The Study Participants' Background was Collected During the Three Phases of Data Collection

Phase	Background of Participants
Phase 1: Needs Analysis	Two preschool teachers who have 10 years of experience teaching in preschool.
Phase 2: Module Development	Two preschool teachers as mentioned in Phase 1.
	Three highly qualified experts in early childhood education, with doctoral degrees and a minimum of 10 years of research experience in the field.
Phase 3: Module Evaluation	Two preschool teachers as mentioned in Phase 1.
	19 preschoolers who are 5-6 years old who learn physically in preschool

Instruments

In order to effectively gather data for phases one, two, and three, the researchers have utilised a total of 5 independent research instruments. In phase one, the needs analysis, the researchers utilised a single instrument to gather qualitative data, specifically a semi-structured interview protocol. This instrument was derived from the research conducted by Ismail and Yunus (2004) and Yazid et al. (2017). The adapted questions are similar to the following constructs in Table 2.

Table 2
Interview Protocol Instrument for Phase 1: Needs Analysis

Question	Construct
1	Knowledge
2	Level of teaching skills
3	Teaching confidence
4	Frequency of attending knowledge courses
5	Teaching load

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Question	Construct
6	Setting up of teaching
7	Tools and teaching aides
8	Applications of technology

In addition, the Science Teaching Questionnaire for Teacher Feedback was utilised as the second instrument in phase one. The responses to the quantitative data were limited to two teachers who exclusively taught and facilitated the preschool age group. The constructed items may be denoted by the following designations in the following Table 3.

Table 3
Science Teaching Questionnaire for Teacher Feedback in Phase 1: Needs Analysis

Question	Construct	Item	Question No
1	Confidence	1	1
2	Time Allocation	2	3
3	Class Control	2	4, 8
4	Teaching methods	1	5
5	Knowledge	1	6
6	Skills	1	7
7	Interest	3	9, 14, 15
8	Preschooler response	4	10, 16, 17, 18
9	Experience	1	11
10	Question and Answer	1	12
11	Method Integration	1	13
12	Extra Activity	1	19
13	Space of Classroom	1	2

Furthermore, during the second phase of this study, the researchers utilised the Theme Difficulty Form to aid in the development of the learning module. This form consisted of ten items provided to two research participants, specifically preschool teachers. The purpose of this exploration was to identify and prioritise the topics that should be included in the comprehensive learning module. In addition, during this phase, the researchers evaluated the level of qualitative expert consensus on the items constructed in the E-sky Module leveraging the Expert Review Form. While this form does not contain any specific questions, it does encourage experts to provide open commentary and evaluation on what needs to be improved in the activities that are formed. Besides, during phase three, which is module evaluation, the researchers employed a semi-structured interview protocol as illustrated in Table 4.0 specifically designed for preschool teachers. The questions for this interview protocol were developed by the researchers and subsequently validated by experts in the field of ECE. In addition, the researchers have employed field notes of activities as shown in Table 5 as empirical data to assess the comprehension of the preschoolers utilising the introduced learning module.

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Table 4
Interview Protocol Instrument for Phase 3: Module Evaluation Phase (Effectiveness)

Population	Question	Construct
Preschool Teacher	1	Preschoolers' Comprehension and Understanding
	2	Interesting Activities for Preschoolers
	3	Burden to Apply in Class
	4	Module Improvements
	5	Useful in the LFP

Table 5
Field Notes for Phase 3: Module Evaluation Phase (Preschoolers' Understanding and Motivation)

Population	Question	Construct
Preschoolers	1	Volcanic Processes
	2	Rainbow Process
	3	Sink and Float Process

Data Collection

In the initial phase, the researchers allocated a period of two weeks to conduct interviews with two participants. Each participant was interviewed once, each session lasting a maximum of 60 minutes per week. Meanwhile, during the second phase, the researcher allotted a duration of 4 weeks for specialists to assess the applicability of the E-sky Module on preschoolers. In addition, in the final phase, the evaluation process of this module occurs after the study participants have finished the LFP for 60 minutes each week over a period of 3 consecutive weeks. Furthermore, the researchers diligently adhered to the university and school's norms and research ethics before, during, and after data collection. It is the responsibility of every researcher to guarantee that ethical concerns and study protocols are conducted and documented in a transparent manner during the data collection process. Ethics, as defined by Bos (2020), pertains to the exploration of principles governing morally acceptable and suitable conduct for researchers. Prior to collecting data, the researchers obtained authorisation from the UKM to conduct this present study on preschoolers and teachers, ensuring ethical practices. Subsequently, this application received approval at the university level. The researchers subsequently delivered this letter to the principal of TUNAS-UKM Preschool. The researchers then met with the preschool principal to deliberate about incorporating study participants from this preschool. Upon establishing a consensus over the objective of the study, the researchers provided the principal with a letter of consent, authorising her to participate actively in the data collection procedure. This authorisation has been personally authorised and provided by the Chairman of TUNAS-UKM preschool, who obtained a letter of consent from the preschool management granting permission for the preschoolers, referred to as "students," to participate in the study. The approval of this consent letter is granted in accordance with ethical reference UKMFND/1/1.

Data Analysis

This study employed technology configurations to analyse both qualitative and quantitative data. Two software applications are utilised to effectively analyse the data collected in the first and second phases, with one application employed in the third phase. However, the comprehensive study reveals that only two software programmes are utilised. The initial software employed was ATLAS.ti version 8. This software has been widely acknowledged in previous studies as an essential tool for researchers to perform systematic, structured, productive, and efficient data analysis. It is imperative to guarantee the thorough analysis and documentation of the data gathered during the interviews conducted in phases one and three. Researchers have utilised thematic analysis to enhance the clarity of their findings when reporting them. Note that coding is a crucial approach for organising qualitative data in order to assist data analysis. Based on the advantages provided by the software, the data is divided into citations or data segments to facilitate its reduction into a set of codes for subsequent analysis. Once the relevant code is

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categorised into a certain group, a theme will be generated based on the code group. This software is utilised for the evaluation of interview contents throughout both the analysis and evaluation stages. Furthermore, throughout the module development phase, this software was also utilised to create themes that would gauge the perceptions of ECE experts regarding their verbal and written feedback on the effectiveness of the E-Sky Module based on PBL in preschool settings.

In addition, the second software, the Statistical Package for the Social Sciences (SPSS), is used to generate and analyse the quantitative data. This software is a sophisticated statistical analysis software programme developed exclusively for social science research, particularly in the field of quantitative research. A descriptive analysis was conducted to examine the levels of teacher knowledge and expertise in early science teaching in the first phase and explore the difficulty of teaching themes in early science topics in the second phase. This software was utilised to analyse 19 questions from the Science Teaching Questionnaire for Teacher Feedback and 10 questions from the Theme Difficulty Form. The numerical calculation of the teacher's levels is solely determined by the mean value.

Research Results

The research results show the findings of the needs analysis phase, focusing on the perceptions of teachers regarding the challenges, experiences, and knowledge related to teaching science education in preschool.

Figure 1
Themes were Successfully Documented in Needs Analysis Phase

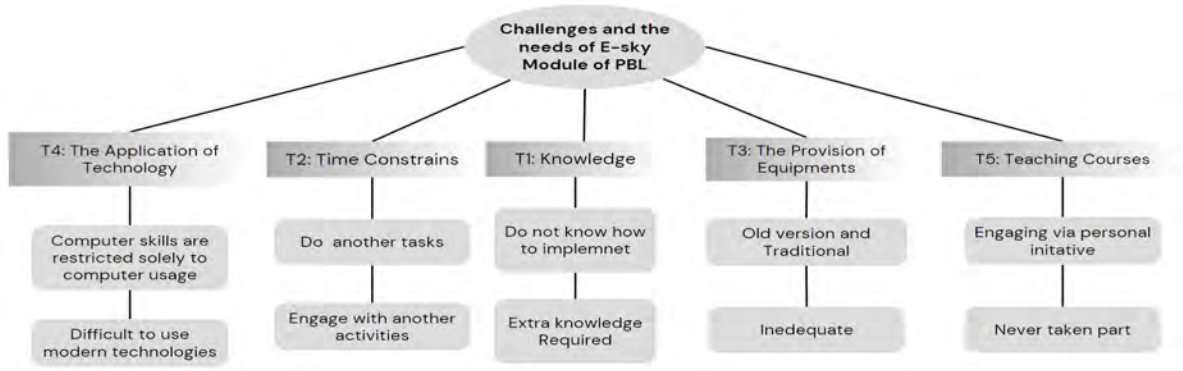

Table 6
Descriptions of the Interviews in Needs Analysis Phase

Theme	Participant	Description
T1: Knowledge	1	Lack of knowledge in conducting early science activities. Guessing that sufficient knowledge is necessary for teachers to teach preschoolers about early science.
	2	Require extra knowledge to do science activities of superior quality.
T2: Time Constraints	1	Engage in additional responsibilities alongside the facilitation of early science activities.
	2	Giving effort in creating educational materials for early science is being neglected due to the urgency of other tasks.
T3: The Provision of Equipment	1	The current inventory of equipment and resources in preschools is inadequate for conducting early science activities of superior quality.
	2	The current equipment and facilities are inadequate and ineffective for modern-day learning.

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Theme	Participant	Description
T4: Applications of technology	1	Unable to effectively utilise contemporary applications such as smartboard.
	2	Restricted to utilising the computer only in LFP
T5: Teaching Courses	1	Exclusively enrol in paid courses to enhance teaching proficiency.
	2	Never taken part in any courses aimed at consolidating knowledge and teaching.

Possessing a profound understanding of early science is crucial for a teacher to properly and comprehensively implement the LFP. Within the scope of this exploration, the participants elucidated that they continue to possess a deficiency in their understanding of fundamental scientific skills and principles. Participant 1 (P1) stated that despite having over a decade of teaching experience in preschool, she still requires enough knowledge and abilities in science topics, particularly in the field of early science. Conversely, time limitations pose a challenge for teachers in their endeavour to develop high-quality activities within the classroom. This can be demonstrated by examining the perspectives of Participant 2 (P2), who maintains that the available time for preparing teaching aids is severely constrained due to her responsibilities in managing a transit centre or being assigned as a carer for an extended duration in a preschool setting. Furthermore, she mentioned that a significant amount of time was dedicated solely to overseeing the extension activities during the afternoon session, leaving no opportunity to enhance knowledge or prepare for LFP activities the next day. In addition, the lack of teaching aids also hinders the optimal execution of early science activities. This can be demonstrated by considering the perspectives of P1 and P2, who assert that the current availability of teaching aids in schools remains inadequate.

In addition, P1 and P2 articulated that they lack the requisite proficiency to effectively utilise technological resources in their teaching practices. Consequently, they are limited to utilising only rudimentary technology resources, mostly computers provided in the classroom. Consequently, they possess insufficient confidence to incorporate technology into their teaching practices. This condition triggers a challenge in developing a timely 21st-century learning method. Lastly, another significant barrier to conducting early science activities at school is the lack of explicit lessons due to restricted opportunities for teacher preparation, such as participation in teaching courses. Indeed, P1 alone engaged in seminar independently, without any assistance from the school. It is even more astonishing that P2 never partook in any pedagogical training.

Transitioning to the conditions that justify the development of this educational module, a series of Questionnaires on Early Science Teaching Knowledge and Experience was provided to the aforementioned two participants. The research data was analysed quantitatively, focusing on the levels of the study participants. The analysis involved a descriptive scrutiny of the mean values using SPSS.

Table 7
Levels of Experience and Knowledge of Teachers in Implementing Science Activities

Item	*n*	*Min*	*Max*	*M*	*SD*
1	2	3.00	3.00	3.00	0
2	2	5.00	5.00	3.00	0
3	2	3.00	3.00	3.00	0
4	2	3.00	3.00	3.00	0
5	2	3.00	3.00	5.00	0
6	2	4.00	5.00	5.00	0.71
7	2	4.00	5.00	4.50	0.71
8	2	2.00	2.00	2.00	0
9	2	5.00	5.00	5.00	0
10	2	3.00	3.00	3.00	0

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Item	*n*	*Min*	*Max*	*M*	*SD*
11	2	3.00	4.00	3.50	0.71
12	2	3.00	4.00	3.50	0.71
13	2	4.00	4.00	4.00	0
14	2	4.00	4.00	4.00	0
15	2	2.00	2.00	2.00	0
16	2	5.00	5.00	5.00	0
17	2	3.00	3.00	3.00	0
18	2	3.00	3.00	3.00	0
19	2	4.00	4.00	4.00	0

According to the results of this survey, the highest mean (m) value is 5.0, with four items having the same value. Both participants faced challenges in teaching early science due to their limited scientific knowledge. Furthermore, they also asserted that teaching early science necessitates a profound level of expertise. Moreover, they asserted that a limited number of students engaged in scientific pursuits face a dearth of resources, equipment, and scientific apparatus. In addition, they concur emphatically that preschoolers encounter challenges comprehending the science concepts that have been taught. Conversely, the lowest mean value effectively documented was a solitary item with a value of m = 2.0. They asserted that the challenge of managing the class is not a determinant that renders teaching early science difficult but is attributable to other issues.

In order to address the second research question, two sequential measures have been implemented to construct the E-Sky Module using PBL. Initially, the researchers conducted a comprehensive analysis of the data gathered from the Theme Difficulty Form. The researcher has conducted a quantitative analysis of the data by estimating the difficulty level for the ten themes that were designed. During this step, the calculation solely concentrates on the mean (m) value.

Table 8
Level of Theme Difficulty Based on Preschool Teachers' Perceptions

Item	n	Min	Max	M	SD
Self	2	1.00	1.00	1.00	0
Health and safety	2	2.00	2.00	2.00	0
Plants, Fruits, and Vegetables	2	4.00	4.00	4.00	0
Sports and games	2	7.00	7.00	7.00	0
Nature	2	10.00	10.00	10.00	0
Celebrations	2	5.00	5.00	5.00	0
Animals and Insects	2	6.00	6.00	6.00	0
Vacancy	2	8.00	8.00	8.00	0
Transportation	2	3.00	3.00	3.00	0
Drama in Science	2	9.00	9.00	9.00	0

According to the presented table, it is indicated that the Nature theme has the highest level of difficulty for teachers to execute in LFP, with a value of m = 10.0. Using the acquired replies, the researchers have devised 16 activities centred around this nature theme. During the process of constructing the activities for this learning module, the researchers focused exclusively on the activities pertaining to preschoolers' acquisition of knowledge and motivation about nature, which are based on the PBL approach. Table 9 below lists all 16 activities as provided in Table 8.

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Table 9
16 Activities based on Nature Theme that were Successfully Designed

Activity	Content Standard	Learning Standard
Activity 1	SA 3.0 Investigating Life SA 3.1 Identify living things and non-living things	SA 3.1.1 Distinguish between living things and non-living things SA 3.1.2 Identify the characteristics of living things and non-living things
Activity 2	SA 2.0 Science Process Skills SA 2.1 Make observations using the five senses	SA 2.1.2 Observes the environment using a combination of two senses
Activity 3	SA 2.0 Science Process Skills SA 2.1 Make observations using the five senses	SA 2.1.3 Observes the environment using a combination of three or more senses
Activity 4	SA 2.3 Make measurements	SA 2.3.2 Measure the length or height of an object using a non-standard unit
Activity 5	SA 2.2 Classifying objects	SA 2.2.3 Group objects according to identified characteristics
Activity 6	SA 4.0 Investigating the Material Realm SA 4.1 Exploring the properties of materials	SA 4.1.1 Investigate objects that can sink and rise
Activity 7	SA 4.1 Exploring the properties of materials	SA 4.1.2 Describe the process of changing water conditions from water-to-water vapour and vice versa. from water to ice.
Activity 8	SA 2.3 Make measurements	SA 2.3.4 Weighing objects using non-standard units
Activity 9	SA 2.3 Make measurements	SA 2.3.5 Measuring liquids using non-standard units
Activity 10	SA 2.4 Making Inferences SA 2.5 Divination	SA 2.4.2 Make reasonable assumptions based on observations SA 2.5.1 Make predictions about situations based on past experiences
Activity 11	SA 2.4 Making Inferences SA 2.5 Divination	SA 2.4.2 Make reasonable assumptions based on observations SA 2.5.2 Make a prediction of what will happen based on the activities carried out
Activity 12	SA 5.1 Explore the physical world in everyday life	Exploring earth's gravity
Activity 13	SA 5.1 Explore the physical world in everyday life	Observe and record the formation of rainbows
Activity 14	SA 5.1 Explore the physical world in everyday life	Observing volcanic eruptions
Activity 15	SA 5.1 Explore the physical world in everyday life	Exploring, observing, and narrating day and night events
Activity 16	SA 1.1 Demonstrate a scientific attitude and moral values	SA 1.1.2 Demonstrate a curious, systematic, cooperative, and responsible attitude

Once these activities have been effectively developed, the researchers will disseminate the Expert Comment Form on the developed activities. In order to assess the consensus among experts regarding these activities, the researchers conducted a qualitative analysis of the data. The researchers utilised the thematic analyser feature offered by the ATLAS.ti programme to compile the themes of agreement. From the data that was effectively gathered and documented, three primary themes emerged: T1: Effectiveness, T2: Suitability, and T3: Improvement.

Figure 2
Experts Consensus on the Development of the E-sky Module based on PBL

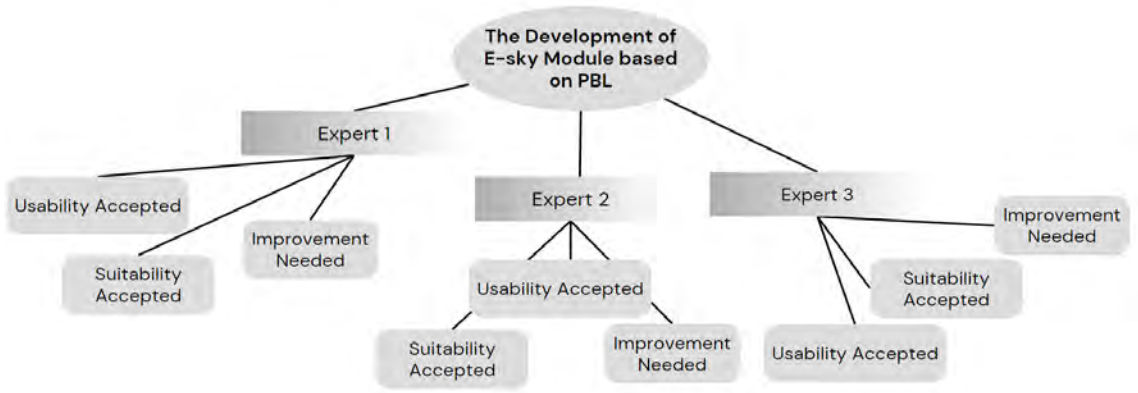

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Table 4
Descriptions Derived from Expert Consensus

Theme	Expert	Description
T1: Effectiveness	1	The activities are designed according to the developmental stage of preschoolers.
	2	All activities can be applied and performed to preschoolers aged 5-6 years.
	3	The planned activities have the capacity to enhance preschoolers' holistic development, particularly their cognitive growth, while also fostering an increased enthusiasm for learning.
T2: Suitability	1	All activities adhere to the guidelines set forth in the NPSCD 2017, and there is a strong emphasis on effective communication between the teacher and the preschooler.
	2	It aligns with the learning criteria outlined in the National Education Curriculum and appears to prioritise project-based learning activities.
	3	The activities developed in this module are interesting because the early childhood elements outlined by NPSCD 2017 have been used.
T3: Improvement	1	It is necessary to review the objectives of each designed activity.
	2	The time allocated must be in line with each activity that has been formed.
	3	The written content of each activity should be analysed and organised in a more methodical manner to enhance readability.

According to the conducted analysis, the three experts reached a consensus on the formation of sixteen activities. However, they provide recommendations that the product must undergo refinement and enhancement prior to its utilisation by preschoolers in the evaluation phase. Once the necessary adjustments have been made based on the expert's feedback, the evaluation procedure is conducted using empirical methods. During this phase, teachers were interviewed to gather information about their firsthand experience with the effectiveness of the E-sky Module based on PBL. Simultaneously, interviews were conducted with the preschoolers to assess their comprehension of the concepts covered in this module. Additionally, a series of impromptu interviews were conducted with the preschoolers to ascertain their comprehension of the three conducted activities.

Regarding the third question, the teachers have undertaken three activities on the topic of nature, following the principles of PBL outlined in the E-sky Module. The teachers and all children were actively engaged in all of these activities. Preschoolers' understanding of the stimulated activities can be evaluated by analysing the themes explored through the application of thematic analysis, as demonstrated in Figure 5. Five themes have been accurately documented based on the initial activity, which involves volcanic eruptions. For instance, during the implementation of this project, preschoolers demonstrate a favourable collaborative disposition while engaging in tasks alongside their peers. Additionally, they endeavour to articulate their thoughts discerningly and inventively while collaborating with educators on various initiatives. Furthermore, students have the capability to respond to the teacher's inquiries pertaining to volcanoes prior to, during, and subsequent to engaging in this task. Moreover, these individuals exhibit values seldom demonstrated in the classroom, such as attentively listening to the teacher's directions for extended periods.

In addition, all six themes were appropriately documented during the second activity, which involved monitoring objects that sank and floated. As evidence, while constructing a paper submarine, preschoolers engage in critical and creative thinking to design an aesthetically pleasing and durable vessel that remains buoyant for an extended period while submerged in water. The lecturers currently guide the students in constructing their own ships, employing the trial-and-error method. While launching the ship and stones into the water, certain preschoolers felt guilty as they were concerned about the possibility of the ship sinking. However, with the teacher's support and motivation, they successfully executed the assignments and demonstrated commendable values of responsibility.

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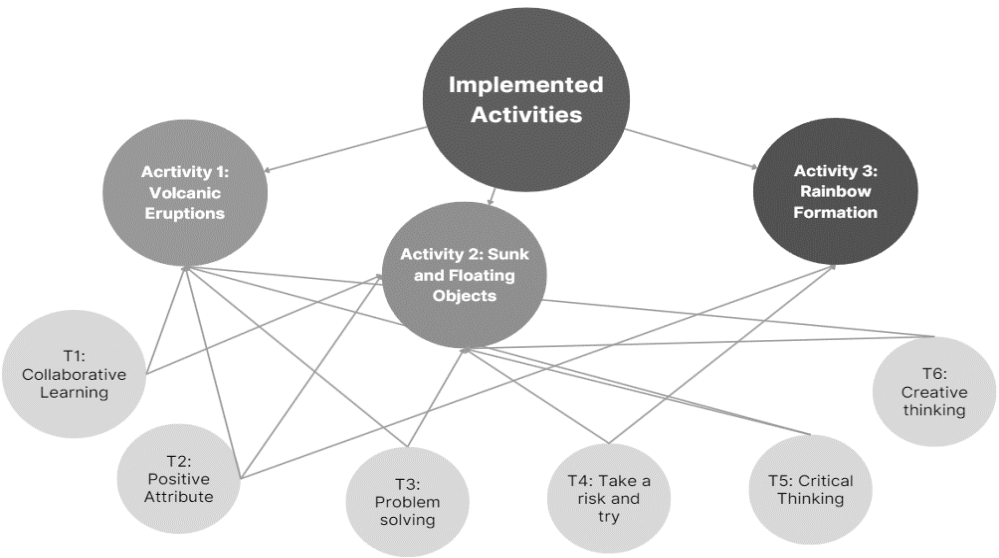
For the third activity, specifically the formation of a rainbow, only two themes were effectively documented. Preschoolers demonstrate the virtue of attentively following directions while engaging in the activity. Upon commencing the soap bubble-making activity, the preschoolers attentively followed the guidelines provided in the module. Additionally, the second theme that was successfully conveyed was the need to embrace chances. Initially lacking confidence in their creation, they sought assistance from their teacher to inflate the balloon. Eventually, their countenance turned joyful as they successfully crafted balloon foams adorned with a vibrant array of rainbow colours.

Figure 3
Experiences Gained by Children When Implementing PBL Activities



In addition, to evaluate the effectiveness of the module employed, both teachers were interviewed after completing the three activities. Within the scope of this study, the researchers noticed a favourable impact subsequent to the use of this learning module in LFP pertaining to the topic of nature in early science, as illustrated in Figure 6. According to P1's interview findings, the teacher engages in reflection or brainstorming sessions with the preschoolers after each activity to discuss the topics they have learned. She discovered that preschoolers possess the ability to recall past activities promptly and distinctly. Additionally, P2 elucidates that preschoolers exhibit heightened interest in the activities conducted subsequent to the implementation of this module, owing to its engaging and pragmatic nature. Additionally, both participants also believe that this module is pertinent to be incorporated into preschool education due to its user-friendly nature, which facilitates the implementation of uncomplicated and captivating classroom activities for teachers. Ultimately, they also discussed their favourable encounter when offering this module to preschoolers, resulting in an augmented passion for learning among them.

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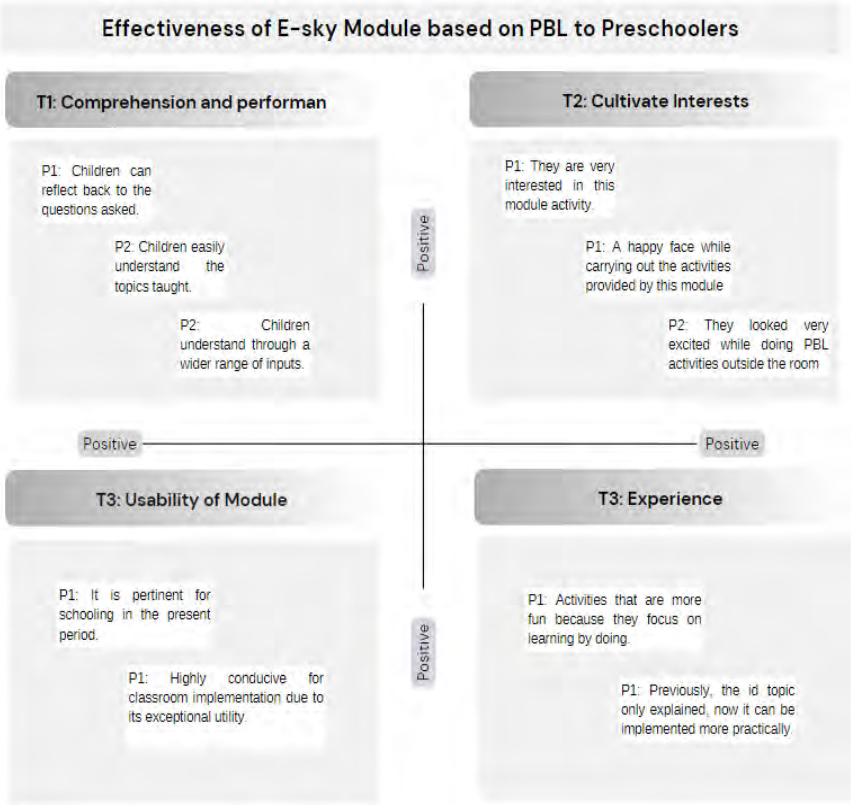
Figure 4
The Effectiveness of the E-sky Module based on PBL based on Teacher Experience



Discussion

The primary objective of this research was to evaluate the effectiveness of the E-Sky Module, which is based on PBL, in enhancing children's understanding and motivation for early science topics, particularly those related to the environment and nature. Additionally, the study involves the development of an early science learning module. The creation of this module follows a three-step process utilising the DDR approach. Regarding the developmental characteristics of the activities associated with the nature theme, three experts thoroughly reviewed and validated each developed structure. Note that the outcome is affirmative, as they all concur with the activities. However, there is room for development in certain parts. In the initial stage, known as the needs analysis, the present findings have revealed that one of the major obstacles in conducting high-quality science activities is the insufficient knowledge and comprehension of teachers about science topics, as well as the difficulties they have in adapting to preschoolers' growth and implementing effective pedagogical strategies in the classroom. The reason for this situation is that the teachers are ill-equipped and lack self-assurance due to their requirement for more extensive knowledge in order to execute higher-quality activities for preschoolers (Andin & Zainol, 2023). Furthermore, science teachers have a second obstacle stemming from the inadequate provision of high-quality resources and equipment in educational settings. The teachers believe that the activities conducted are hindered due to insufficient provision of equipment by the school. This scenario will impede preschoolers' ability to autonomously explore, experiment, learn, and comprehend concepts (Anto et al., 2023).

Further, the teachers also highlighted that their limited proficiency in utilising technology hindered their ability to facilitate early science activities effectively. In contemporary education, incorporating technology is crucial due to the inadequacy and inefficiency of traditional approaches in facilitating preschoolers' learning. However, it is imperative that this integration takes place through online, blended, or hybrid learning techniques (Nemalynne et al., 2023). In addition, the absence of adequate professional training exacerbates the difficulties faced by teach-

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ers in organising early science activities. This assertion is corroborated by the research conducted by Ismail et al. (2020), which indicates that teachers observe a challenge in implementing science-related activities due to the absence of a comprehensive support programme. Moreover, insufficient time allocation is a significant obstacle for teachers to effectively conduct early science lessons with heightened focus and proficiency. Teachers perceive additional responsibilities, such as childcare, as a contributing factor to their sense of urgency in completing more focused tasks. This aligns with the findings of Jamaluddin et al. (2023), who discovered that teachers experience time limitations in preparing science activities due to their involvement in supplementary school activities.

Considering the aforementioned challenges, there is a current demand for early science learning modules. A total of 16 activities were conducted, which were determined by the challenges identified. The topic selection is based on the participants' perception, as assessed using the Theme Difficulty Form. Subsequently, 16 activities were created, and based on the feedback gathered from the Feedback Form, which was evaluated and validated by experts in the area, this module has been fully constructed with enhancements made to its content. Form, which was evaluated and validated by experts in the area, this E-sky based on the PBL Module has been fully constructed with enhancements made to its content. The study conducted by Cyntia et al. (2023) emphasised the significance of validating the content of a learning module to ensure its compatibility with the current demand. In addition, Razak et al. (2023) have also indicated that expert validation of the content and items in the constructed learning module may accurately forecast favourable outcomes when using it in practical settings.

Following the successful completion of the second phase, the subsequent step involves evaluating the effectiveness of this module. After conducting three exercises, the teachers observed that the preschoolers demonstrated increased knowledge and improved performance in their learned themes. This aligns with the research conducted by Hsin and Wu (2022). The PBL learning module facilitates preschoolers' cognitive development by offering captivating activities. Furthermore, according to the guidelines suggested by this educational module, it can effectively captivate preschoolers' curiosity to explore extraordinary phenomena further. This can be demonstrated when preschoolers engage in collaborative project activities with their peers and educators. Furthermore, the conducted interviews have also demonstrated that preschoolers have a greater inclination towards engaging in more hands-on activities, as they find them more engaging. This assertion is substantiated by the results of the research conducted by Sugiarto et al. (2023), which demonstrated that individuals in the experimental group who utilised the Science Learning Module based on PBL exhibited a higher level of enthusiasm in acquiring proficiency in the subjects taught compared to preschoolers in the control group, who followed the conventional instructional approach. Hence, the PBL approach is highly effective for ECE teachers to enhance individuals' comprehension and enthusiasm for science education (Reyes & Orongon, 2023). Teachers need to periodically foster greater self-assurance and conviction to effectively implement high-quality early science activities. This will enable preschoolers to internalise diverse values and enhance their interpersonal skills within the educational setting.

Conclusion, Implications and Recommendations

The effectiveness of the E-sky Module based on PBL has been demonstrated in enhancing children's understanding and motivation in early science subjects. Not only do they acquire practical knowledge in the classroom, but they also engage in experiential learning activities beyond the classroom. Furthermore, this study has theoretically demonstrated that integrating Vygotsky's Sociocultural Theory and the PBL Implementation Process Model can enhance teachers' endeavours to facilitate and enhance the quality of activities during project implementation. This, in turn, enables preschoolers to acquire knowledge systematically through the sequential implementation of projects. Additionally, this study stands out as one of the few that employs quantitative approaches to assess expert recommendations in terms of research and validation of module contents. While the data is derived from empirical sources rather than statistical data, it is thoroughly examined to determine the necessary actions for enhancing the quality of this module. Moreover, this study primarily addresses the impacts and outcomes of incorporating this module in LFP. Recent findings indicate that preschoolers' learning outcomes using this learning module may not be successful if teachers continue to rely on traditional pedagogical approaches, such as solely explaining concepts to preschoolers. Instead, it is crucial for teachers to facilitate practical, hands-on activities in collaboration with the students, following a series of meticulously organised stages in the learning process. In order to effectively implement 21st-century learning for preschoolers in the present age, the current study offers three recommendations:

1. The Ministry of Education should offer specialised training to preschool educators on science education and effective pedagogy, enabling them to implement contemporary educational practices for preschoolers in the present era.

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2. In order to facilitate the development of learning modules suitable for teachers and practitioners in ECE, future studies should focus on increasing the number of studies that involve the design of PBL-based module instruments.
3. The school should increase the allocation of financial aid in order to enhance the quality of science facilitation by providing better teaching aids and modernising the science equipment.

Recent research has definitively demonstrated that engaging preschoolers in project-based activities can effectively enhance their enthusiasm and comprehension of science subjects within the school setting. Teachers have a crucial role in integrating a wide range of techniques and methods and pursuing tactics through PBL, making them the most essential support system.

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Declaration of Interest

The authors declare no competing interest.

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