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The Integration of Technology-Based Learning in Early Science Learning: An Investigative Approach

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Abstract

The worldwide education system, particularly STEM education, has been significantly impacted by technological advancements in the 21st century. In general, science education in preschool incorporates technology as educators engage in activities within the classroom. However, previous research indicates that numerous educators still lack a clear understanding of the most effective methods for incorporating technological tools into classroom instruction. Even more surprisingly, several educators lack the ability to effectively utilise technology in their teaching due to their perception of it being challenging. Hence, this recent study aims to identify the best methods highlighted by contemporary early childhood education (ECE) educators to enhance children's knowledge in learning science by incorporating a Technology-Based Learning (TBL) environment in the classroom. The study employed a qualitatively investigative approach using three different research instruments to examine the perceptions of four Malaysian educators and to explore the experiences of 60 preschool children aged 5-6 years from three distinct preschools. The outcomes of the study were discovered through data triangulation using ATLAS.ti software. They demonstrate that educators are strongly confident that empowering children by using hardware and software in the classroom is the best practice to assist children in enhancing their critical thinking skills. Thus, it is advocated that educators increase the number of activities using digital tools in science classrooms, but this needs to be limited to learning purposes related to relevant topics. Further study is recommended to discover simple, yet exciting, PBL activities that can be carried out by educators in preschool settings.

Keywords: Physical Education, Psychological Resilience, Children Development.

Introduction

In recent years, many countries have recognised the significance of including science education into early childhood curriculum. As a result, the fascination in examining the teaching and learning of science during early childhood has risen, becoming a significant area of research in social science studies (Trundle & Saçkes, 2021). Essentially, early science learning in ECE refers to the acquisition of knowledge and skills related to sensory development and comprehension of a child’s environment. Early science education characteristically prioritises active learning, which entails both extended and brief periods of time dedicated to exploring scientific concepts. Children typically acquire a thorough comprehension of ideas by observing, exploring, touching, tasting, and manipulating objects (Lichene, 2019). Furthermore, by allowing children to learn science from an early age, they can enhance their abilities in using science processes and, hence, improve their comprehension of new topics (Abu Hasan, 2021). Similarly, Abdul Rahman et al. (2019) found that children can develop mastery in science skills when they are provided with many opportunities to engage in practical activities. This enables them to formulate hypotheses and conduct experiments collaboratively. Thus, by engaging children in hands-on activities, such as carrying out science projects at an earlier age, children can effectively gain new knowledge about their world (Setyowati et al., 2023).

While hands-on science learning and activities enhance children's comprehension of diverse captivating topics in science education, such as animals, plants, physical phenomena, anatomy, material properties, and fruit themes, previous research has demonstrated that incorporating technology has a significant and influential effect on stimulating children's enthusiasm for science education. Interestingly, Letchumanan and Karim (2024), found that the utilisation of technological tools, such as desktop computers and mobile phones, can captivate children's curiosity in science-related topics and enhance science comprehension in preschoolers. Concurrently, they propose that educators should more extensively incorporate technology when conducting science activities in the classroom so as to attain more dynamic goals in the science instruction and learning processes of preschool children. To foster children's development, educators can utilise digital technology in a manner that is suitable for their needs (Fakherji, 2018). This involves facilitating the interaction between educators, children, and technology, as well as carefully selecting appropriate software and devices. In doing so, educators can establish a digital environment that effectively stimulates children's curiosity, particularly when engaging in science projects alongside peers (Levin & Tsybulsky, 2017).

Problem Statements

Science education is widely recognised as an essential academic discipline for children in the 21st century. Nevertheless, multiple stakeholders, such as educators, children, and schools, encounter numerous challenges related to science education. When considering Malaysia’s education system, major obstacles to improving science education include ineffective orientation training for educators, a shortage of qualified educators, a lack of learning materials and resources, and incomplete science laboratories (Chirwa et al., 2022). This demonstrates that educators’ level of preparedness in establishing an engaging classroom atmosphere hinders the achievement of a definite objective in science education. According to a study conducted by Shakera and Saleh (2021), lesson planning complexities, inadequate knowledge, insufficient pedagogical training, substandard textbooks, and a lack of organisational support pose challenges when implementing changes in the Science curriculum. Comparably, a study conducted by Ealangov et al. (2024) found that educators face challenges when implementing relevant early science activities due to the advanced nature of the science curriculum, which necessitates that educators devote extra effort in relearning the curriculum. Furthermore, the government's goal of achieving a 60 percent enrolment rate in the science stream, compared to a 40 percent enrolment rate in the literature stream, has not been realised due to these challenges (Adnan, 2023).

While considering the issues of enhancing science education across different countries, previous research has revealed major obstacles that prevent science education from meeting national norms and objectives. A survey conducted by Rennie et al. (2001) has shown that Australian science educators hold a favourable view of science education; however, they also encounter specific difficulties, including:

i. Insufficient scientific curricular resources,
ii. Insufficient time allocated for the necessary preparation required for teaching science,
iii. Insufficient expertise of educators to instruct in the field of science,
iv. Insufficient or limited opportunities for professional development in science,
v. Overburden of the entire school curriculum,
vi. Insufficient time allocated for the instruction of science.

On one hand, according to a study conducted by Sundberg et al. (2018), Swedish educators encounter difficulties in offering early science activities to preschoolers. The study found that children's interest in these activities diminishes quickly, leading to a decline in the quality of science learning. The fundamental reason for this issue lies within the educators' inability to successfully deliver lessons, rather than in the children themselves. In addition, the challenges educators face when instilling aspirations in children also lead to the development of children's misconceptions about the issue. On the other hand, a previous significant study, conducted by Leung (2023), found that educators in Hong Kong face challenges when implementing science activities due to difficulties in comprehending the pedagogical technique and the curriculum itself, as supported by the data. Their initial struggle with executing STEM activities led to a shift from activity-centred instruction to self-directed learning.

The challenges encountered by educators in promoting science education have led to a significant and profound expansion of educational issues. Science education poses a significant challenge in fostering substantial progress and development in children. Thus, the Belonging, Being and Becoming: The Early Years Learning Framework document (Australian Government Department of Education, and Workplace Relations, 2009) suggests that early childhood educators should include scientific language, content, and processes in the early year's curriculum. This should be achieved through a combination of holistic play-based learning experiences and intentional teaching (Nolan, 2012). As shown in the current study, the implementation of Teaching-Based Learning (TBL) will address two research questions by offering meaningful activities:

i. What are the most efficient methods for improving children's understanding of early science concepts through the use of technology?
ii. How does an educator facilitate the development of children's comprehension of science through TBL in preschool?

Literature Review

Educational Technology in Science Education

The history of technology in education can be traced back to the early 20th century, when the role of technology in STEM teaching and learning was recognized globally (Synder, 2018). In addition, the American capitalist, Thomas Edison, once prophesied that the use of moving pictures in education would assist the community, but he also stressed that books should remain the cornerstone of instruction (Keeler, 2012). However, with the rise of information technology, the effectiveness of books, educators, and classrooms have been questioned by numerous earlier researchers (Kumari et al., 2021). Technology has changed education, replacing blackboards with smart boards, and pen and paper with writing software. In the United States, the study of technology and technical processes have become vital to the education industry, especially following World War II (Miller, 1998). Today, the incorporation of technology in education is considered an integration of disciplines and a development of technical literacy among students. This history has led to the inclusion of technology in the STEM movement, acknowledging its relevance in preparing students for the modern world (Hu et al., 2024).

The incorporation of technology in educational institutions has been extensively debated within the broader context of science education in numerous nations, including the United States of America (Kelley & Knowles, 2016), Australia (Harman, 1999), United Kingdom (Smith & White, 2024), Singapore (Boon, 1998), China (Ding, 2013), South Korea (Jung & Mah, 2024), Japan (Shizuo & Shousuke, 2017), Malaysia (Siddique et al., 2023), and India (Sarangi et al., 2023). Notably, Toro Hardy (2020), elucidates in a scholarly manner how China and the United States, two major world powers, are competitively advancing the utilisation of technology across all domains, including education. Past research has demonstrated the significance of incorporating technology in science education in a contemporary environment (Murati & Ceka, 2017). Furthermore, even developing nations have made preparations to include the use of technology in the realm of science education inside their communities (Isman et al., 2017). A research study conducted by Uçar (2015) has shown that preschoolers in Turkey are being introduced to computer application technology under the guidance of highly skilled educators. Moreover, technology becomes an essential tool when it is effectively incorporated into the curriculum to teach children scientific concepts. Considering the historical context of technology in science education, there is a clear correlation between the advancement of technology in the past century and its modernisation in the present century.

Best Practices for Integrating TBL in Science Education

Intended educational activities should have the capacity to stimulate children's analytical and imaginative thinking through active engagement (Hadzigeorgiou et al., 2012). Science curriculums need to emphasise teaching and learning practices that focus on acquiring and mastering skills and knowledge, developing a child's mind to its highest potential (Mulholland & Wallace, 2001). A closer look at today's socioeconomic situation shows that many occupations require workers to possess sophisticated abilities, such as learning, reasoning, thinking creatively, making verdicts, and solving problems. In order to accomplish these objectives, one of the most effective approaches is to offer children possibilities to enhance their proficiency in comprehending scientific concepts and developing scientific problem-solving abilities (National Research Council, 1996). Thus, incorporating TBL in science education can more effectively help children enhance their ability to apply high order thinking skills when solving problems related to their discoveries (Said et al., 2015).

Particularly within the context of early childhood education, children might be motivated to offer a more thorough emphasis of investigating science topics by being empowered to use technology in early science activities. A study carried out by Kermani and Aldemir (2015) explained that, when educators attempt to encourage the development of children's thinking skills by exploring the Google service or "Googling" to investigate problems related to a topic, children's knowledge in science-related areas increases. The results of this study have provided a clear explanation as to why the number of instructional software games has risen over time. Furthermore, by enabling the use of TBL for preschool educators, it becomes possible to convert science experiments from being perceived as "abstract" phenomena to a more tangible comprehension (Papantonis Stajcic & Nilsson, 2024). The study's participant emphasised that the utilisation of digital technologies in conjunction with tangible items enhances comprehension of the subject matter. During an educator-led activity, children not only investigated liquid water and ice directly, but also gained an understanding of the various stages of water through visual and auditory means, such as watching a film showcasing different types of aggregation.

Moreover, the provision of technological tools to children, such as educational software, might offer possibilities for iterative practice, thereby enhancing the learning that takes place during scientific inquiry. Digital applications and tools that are explicitly aligned with educational objectives (Vahey et al., 2018) have been thoughtfully developed based on principles from the learning sciences and appropriately developed practices. They intentionally foster "active, enthusiastic, valuable, and socially engaging learning" (Hirsh-Pasek et al., 2015) and can have a positive influence on the discoveries of young children in early learning environments.

Research Framewrok

The current study uses the concept of enhancing early science education utilizing TBL in a science learning setting. Participants followed four primary phases, which are outlined by Vygotsky's socio-cultural theory (Fadeev, 2019). These outlined phases are derived from the learning and facilitation method endorsed by the Malaysian Ministry of Education, which aligns with 21st century learning principles (see, Figure 1; Wedde, 2014). One crucial aspect of the TBL science learning process requires educators to have a deep understanding of planning and facilitation for learning, whereby the foundation of effective teaching is found in the meticulous planning of instruction. This is because integrating technology into planned instruction is both appealing to children and meets their needs (Jones, 2008). More significantly, Burtoon (2001) asserts that good classroom management is a skill in which children acquire knowledge through their own learning, rather than a skill educators directly teach them. He further elaborates that the focus is mostly on assessment within the school system, rather than on the educator or the act of teaching, where assessment of a subject or topic takes precedence over determining the content and methodology of teaching. In this regard, the learners' specific needs are at risk of being seen as less important.

Additionally, the significance and indispensability of a lesson plan are analogous to a blueprint for construction in this current study. Just as a construction engineer creates a blueprint before starting a repair project, an educator should likewise develop an educational plan, including the topic of education, teaching methods, media, and educational aids before teaching a lesson; this should then be followed during the teaching process (Farhang et al., 2023). In this case, the emphasis should rather be placed on fostering the wide-range of children's developmental experiences than on evaluating their cognitive comprehension. Hence, in order to effectively plan for learning and facilitation, educators should inquire about appropriate and implementable activities to introduce in the classroom. According to Taşdemir and Yıldız (2024), the most suitable activities are those that align with the age, developmental level, and interests of the students. Furthermore, it is essential to incorporate teaching aids that possess sensory characteristics. Within the framework of TBL the utilisation of technological instruments (Sonor et al. 2022), such as computers or laptops, can enhance children's eye-hand coordination, which necessitate focused attention throughout digital task completion.

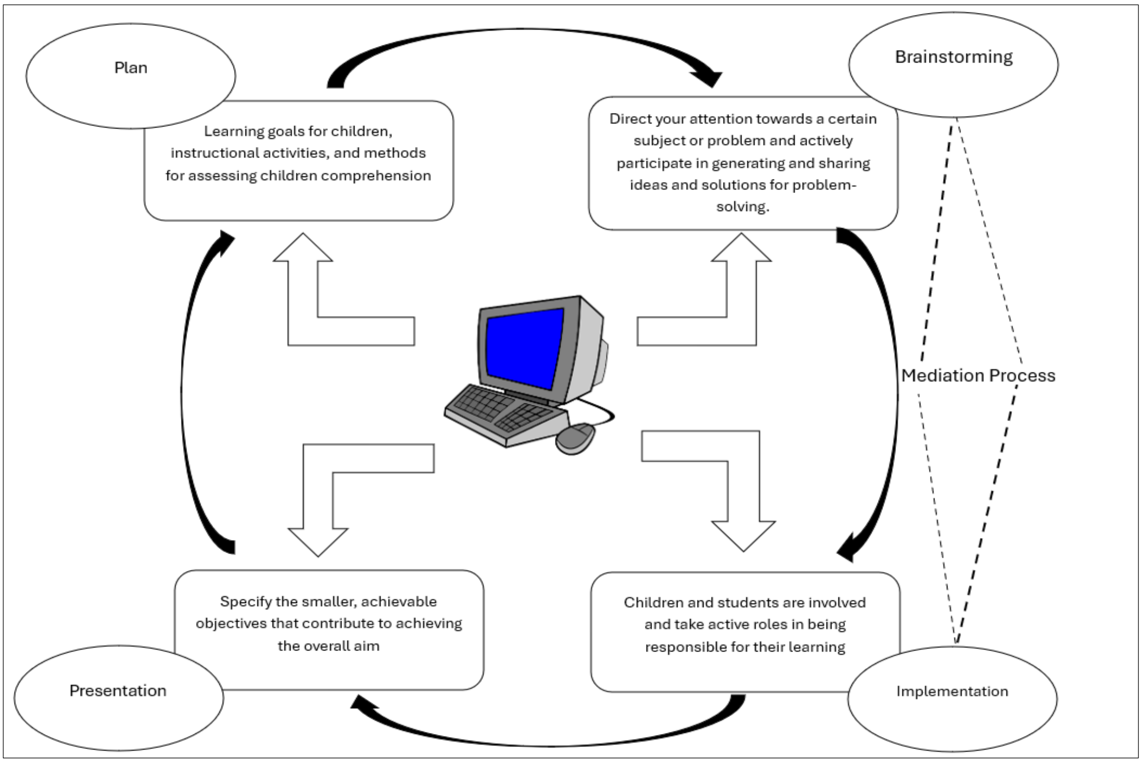


Figure 1 Technology-Based Learning in Early Science Education

Once the educator has developed an appropriate strategy to enhance children's scientific literacy by incorporating technological tools and resources, the subsequent phase is to facilitate collaborative brainstorming sessions for the children. In modern education, the brainstorming technique seeks to foster active participation from every child within a group by encouraging them to openly express and share their ideas and perspectives on certain issues or topics (Jarwan, 2005). This technique also has various advantages, such as the preservation of absolute anonymity for the ideas put forth, and the facilitation of simultaneous and parallel idea generation (Pham, 2022). In addition, Al Masri and Smadi (2023) elucidate that incorporating brainstorming activities into children's learning sessions enhances their creative thinking skills when engaging with new topics. Prior to implementing primary activities in preschool, teachers must possess a fundamental understanding of how to effectively introduce activities to children in order to ensure the success of brainstorming sessions. Ritter and Mostert (2018) propose that children should engage in a hybrid condition, where they participate in both individual and group idea-generation sessions. This approach allows for the unrestricted generation of individual ideas, as well as encouraging the generation of additional ideas by being exposed to those of group members. For instance, when teachers instruct children to investigate the concept of learning parts of the body using technological instruments (Rusli et al., 2022), the initial step is to commence the class with cycle time (Reich, 2007). Subsequently, the teacher can proceed to ask each individual child about their comprehension of a human’s body parts. Once the educator has gathered the understandings of each child, they might then pose a more general question, including all the children. The involvement of each child, both individually and in groups, will occur during this brainstorming session.

At the conclusion of the brainstorming activity, the educator and children will directly proceed to the subsequent phase, known as the implementation of the activity. When implementing learning activities in preschool, educators must consider creating a dynamic learning environment both inside and outside the classroom, as this will produce optimal conditions for children's learning (Sahib et al., 2021). The teacher should construct conducive learning environments that foster a positive atmosphere and promote educational engagement, thereby cultivating children's enthusiasm for learning. In this sense, Bonwell and Eison (1991) recommend that teachers use Activity-Based Teaching (ABT) in the classroom – an educational approach that emphasises the engagement of children in hands-on activities when carrying out classroom tasks. Within the framework of ABT, educators assume the role of educator-as-facilitator, assisting children to acquire knowledge and providing goals to achieve the learning objectives. These activities can include a range of actions and tasks that actively engage children in the learning process, rather than allowing them to be passive observers (Bonwell & Eison, 1991). The social theory of interaction intricately connects ABT to the mediation process in learning and facilitation. Fadeev (2019) specifically explains that Vygotsky's theory of mediation in digital learning environments aims to examine the function of inner speech within the framework of symbolic mediation in a multimodal setting. In the mediation process, one of the tools that becomes a mediator between the object (the science topic) and the subject (the child) is the people in the surrounding environment (the teacher; Vygotsky, 1978). Furthermore, a possible additional tool in the process of TBL science learning is the use of technological tools, specifically computers, in providing new information and knowledge to children when they are engaged with activities. To comprehend the process of child-teacher mediation, Gross (2016) describes a study participant’s occurrence of this event as follows:

"The crucial aspect of this mediation was that both the student and I were temporarily required to set aside our assigned roles and artificial hierarchy in order to openly discuss concerns and work together to find a solution.' This experience had a profound impact on all of us, as it not only saved a potential disappearance for my student but also enhanced my happiness and efficacy in the classroom."

Following the completion of the activity by the teacher and children, where they engage in computer activities together while analysing body parts, the final phase involves the teacher encouraging the children to demonstrate their confidence by making individual or group presentations. In tandem with the rapid expansion of our digital culture, the need for effective communication skills becomes paramount at a young age (Brodin & Renblad, 2019). Weimer (2013) argues that presentations as a communication strategy in school are a highly effective approach for teachers to assess children's comprehension of what they have learned. Moreover, by means of presentations, educators can assess the educational possibilities not only for the presenters, but also for the audiences. Peer evaluations can further enhance the degree of attention given to presentations and promote learning through active listening. Furthermore, Tsang et al (2017) elucidated that delivering regular presentations to an individual not only diminishes their apprehension in expressing their views, but also affords them the chance to enhance their communication skills when interacting with others directly. Therefore, it is crucial to incorporate presentations in science classes at an early age in order to enhance children's ability to effectively explain their views on a certain learning topic.

Methodology

Research Design

This study utilised a qualitative research methodology. The data were collected using the investigative case-based learning approach, as delineated by Das et al. (2021), which involved educators and students collaborating in the teaching process (Teach the Earth, 2004). As children expressed their weaknesses, striving to address them and convey findings that mirrored their own discoveries to others, both educators and fellow peers served as essential sources of support. The primary objective of this study was to offer children the chance to acquire scientific knowledge through the use of technology, particularly computers, while being supervised by their educators and accompanied by their classmates. The purpose of utilising technology was to inspire and cultivate the children's interest and excitement in mastering these topics. In addition, to provide evidence for the observed experiences, analytical documentation and interviews with supplementary research participants were also carried out. Therefore, the study's results were analysed using a triangulation data structure (Social Sciences Research Laboratories, 2018), meaning that the researcher used different methods to collect the required information and carefully assess the outcomes.

Participants

The participant selection for this study was divided into two categories: the selection of educators and the selection of children. The researcher utilised a purposive sample technique (Adeoye, 2023) to select for the study. Specifically, children between the ages of 5-6 years who attend preschool were chosen. A total of 60 children partook in this study, whereby they were separated into four groups. The children had been educated in private preschools in Malaysia, with three cohorts attending preschools in the state of Selangor and the other cohort in the state of Perak. Furthermore, the researcher utilised the snowball sampling method (Sefcik et al., 2023) to enlist preschool educators. The initial study participant was asked to suggest three other individuals who possess significant experience in teaching preschool children. The study had a total of four educators as participants.

Instruments

This study utilised three research instruments: (1) a checklist employed by the researchers to observe and evaluate the participants' learning and facilitation processes, (2) a lesson plan, serving as a learning document, utilised by each group of educators, and (3) a collection of interview procedures. The initial instrument utilised was a checklist known as the Children's Critical Thinking Skills Investigation Instrument within the TBL Environment. The researcher employed this measurement during each learning and facilitation session to assess the demeanour of both educators and children while engaging in activities, including those involving technological instruments. The components of this instrument are detailed in Table 1.

Table 1
Checklist Instrument

No.	Construct	Item
1.	Use technology to attempt new task	1
2.	Demonstrate hand-eye coordination and fine motor skills through Computer-Based Activity	1
3.	Explore visual media such as using laptop / computer / hand phone during learning	1
4.	Use technological tools in solving problems	1
5.	Show abilities using various methods of communication tools	1
6.	Express agreement and dissatisfaction on matters using technological tools politely	1

This instrument was verified by two Ph.D.-level professors and experts in early childhood education and educational psychology programmes in Malaysian public universities. After obtaining their consensus, the researchers assessed the reliability value of the research instrument using Cohen's Kappa Statistics. The agreement value (R=0.84) indicated that the instrument is reliable for use in this study. Moreover, this instrument is justified as reliable for use in each learning and facilitation session. Additionally, the second instrument used was an analysis document known as a lesson plan. Table 2 presents the three main constructs observed and analysed by the researchers.

Table 2
Document Analysis Instrument

No.	Construct	Item
1.	Learning Objective	1
2.	Learning and facilitation steps	3
3.	Reflection	1

Regarding the analysis document instrument, no validation and reliability methods were deployed, as its effectiveness depended solely on each educator's creativity and how they implementation it during their interactions with children. The third instrument, referred to as the Best Practice Exploration Instrument for the Use of Technology Materials in Preschool, highlights five significant constructs (see Table 3). Similarly, this instrument underwent validation by two Ph.D. professors and experts in early childhood education programmes at Malaysian public universities. Again, once the researchers obtained agreement, they assessed the reliability of the instrument using Cohen's Kappa Statistics. The agreement value (R=0.94) suggested that this instrument was suitable for use in this study. Moreover, the instrument was justified as a dependable tool to be utilised in every learning and facilitation session.

Table 3
Interview Instrument

No.	Type Of Question	Construct	Item
1	Introduction Question	Background of participant	5
2	Transition Question	Educator's experience with TBL environment.	1
3	Key Question	Best practices of using technological tools.	1
4	Closing Question	Suggestion for further action.	1

Data Collection

The certification procedure commenced in early March 2021 and concluded in early May 2021. The data gathering period was two months, beginning in early July and ending in early September 2021. The researchers used two approaches to gather data: physical data collection from three educators and three groups of children in the State of Selangor, and online data collection from a single educator and one group of children in the State of Perak. In 2021, researchers were unable to travel to other states due to a regulation implemented by the Malaysian government, prohibiting cross-border movement because of the COVID-19 pandemic. To guarantee a seamless execution of the data gathering process, researchers adhered to the ethical procedures suggested by the Research Management and Innovation Centre (RMIC) of Sultan Idris Education University. In order to include preschool children in this study, the researchers successfully obtained permission to employ human research subjects by submitting the required paperwork (UPSI/PPPI/UPP/BE01). Subsequently, upon obtaining approval to carry out the research, the researchers disseminated the parental consent form (Remien & Kanchan, 2022) to the children with the support of the educators.

Data Analysis

The researchers conducted a three-phase analysis of the data obtained using three study instruments. During the early stage, the researchers initially transcribed the data collected from interview sessions and video recordings. Once the transcriptions were accurately documented, the data were divided into significant analytical units. The researchers organised the data by partitioning it into various segments, which were assessed and recovered. Subsequently, once the valid data fragments were identified, they were encoded. In other words, each piece of data was allocated a distinct code and number to signify its contents. The researchers then proceeded with the coding process and determined the category system as the final step. The data was analysed using ATLAS.ti 8 software, which involved extracting text fragments, assigning them labels, and arranging them into distinct categories (Soratto et al., 2020).

Results

Q1: What are the most efficient methods for improving children's understanding of early science concepts through the use of technology?

The researchers conducted sequential interviews with four individuals in order to gain a comprehensive view of the most effectively employed strategies by preschool instructors when carrying out activities for children. The researchers derived two primary themes from the semi-structured interviews: (T1) Hardware Utilisation and (T2) Software Utilisation. Regarding theme T1, three participants assert that the use of hardware can augment children's critical thinking abilities while tackling issues relating to the topic. This is exemplified in the interview transcripts presented below:

*"By utilising the computer's hardware resources available in the classroom, such as the mouse, it can enhance children's cognitive skills by challenging them to navigate the mouse and locate correct answers in educational games provided by the teacher." – **Participant 1***

*“Through the laptops that we have at our preschool, the children will learn how to on and off it. Besides, they will be given, what do we call it? The opportunity to decide their own answer when they play the games based on the topics.” – **Participant 4***

*“There are computers for children to play games. We do give them to explore physically, to get involved in the conducted activity,” – **Participant 3***

It is evident from Participant 1’s argument that allowing children to explore digital devices will enable them to acquire profound information, valuable insights, and in-depth understanding by actively applying critical thinking skills when performing technological activities.

Two study participants for the theme T2 suggest that the software, such as interactive and learning videos, might offer children meaningful experiences to enhance their comprehension by engaging their auditory, visual, and observational senses. This can be demonstrated by the outcomes of the interviews provided below:

*“We give children the opportunity to install software or more easily, we call it, application on a tablet or phone. In this day and era, to ensure that children's cognitive development can be developed, they cannot be separated to learn with gadgets, even in this preschool.”– **Participant 2***

*“Now, it's 21st century learning. We see that children feel difficult and tried so hard to focus on the book. So, we decide to teach them with technological tools. Even here, we provide a few software related to early childhood education to ensure our students – the children, I mean – they can think out of the box when doing the blended activities.” – **Participant 1***

Ultimately, it is crucial to enhance children's critical thinking abilities by equipping them with technological devices such as laptops, computers, tablets, and phones in educational institutions. Children's cognitive development can be enhanced, not just when engaging in stimulating activities, but also when actively exploring the technology itself, such as learning how to operate a computer mouse. This is because children engage in observational learning during early developmental stages, where they observe and imitate the behaviours of others around them, actively seeking to maximise their own skill acquisition.

Q2: How does an educator facilitate the development of children's comprehension of science through TBL in preschool?

The researchers identified educators' strategies for enhancing children's knowledge in particular science topics during activities by analysing checklists used to access each participant's activity implementation and examining documents prepared by each of them. Each educator exhibited various instructional approaches while helping children resolve issues related to their individual academic disciplines as below:

Table 4
Findings from Checklist Instrument

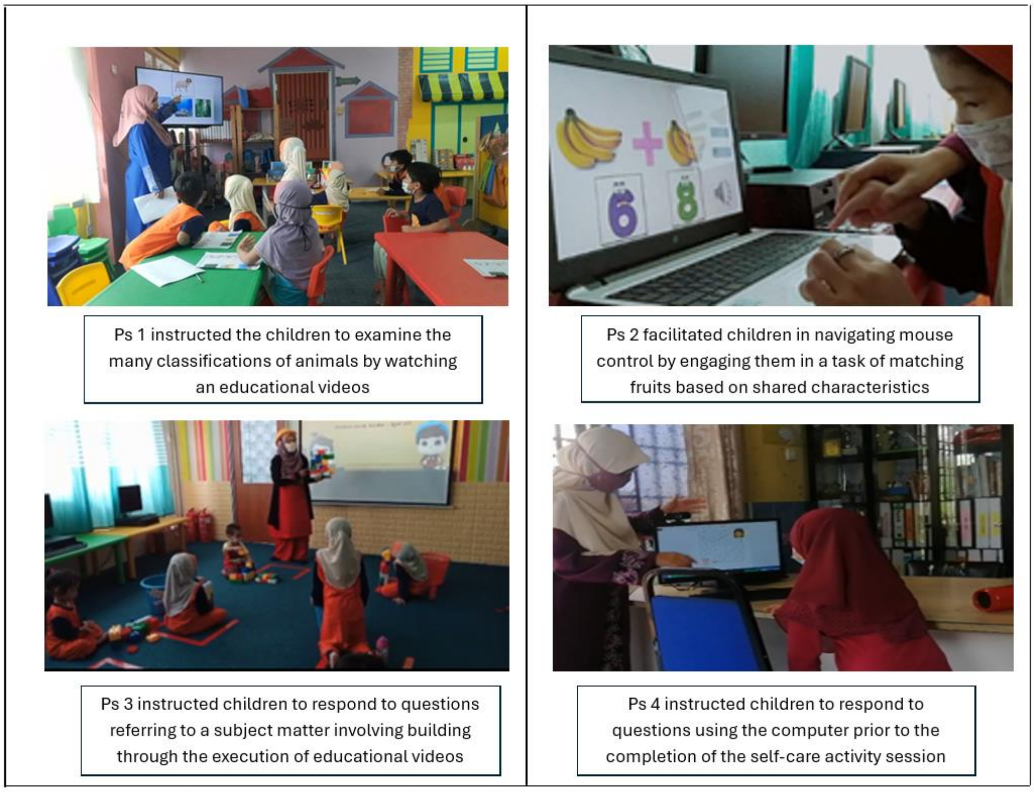
No.	Construct	Ps 1	Ps 2	Ps 3	Ps 4
1.	Use technology to attempt new task	No	Yes	No	Yes
2.	Demonstrate hand-eye coordination and fine motor skills through Computer-Based Activity	No	No	Yes	Yes
3.	Explore visual media such as using laptop / computer / hand phone during learning	No	No	Yes	Yes
4.	Use technological tools in solving problems	No	Yes	No	Yes
5.	Show abilities using various methods of communication tools	Yes	Yes	Yes	Yes
6.	Express agreement and dissatisfaction on matters using technological tools politely	Yes	No	No	No

As indicated, there are two strategies used most often by the participants for empowering the TBL environment at school. Firstly, for example, when teaching about the world of science, each study participant would ask children to use technology to attempt a new task. This meant that the educator would open a learning video related to the introduced topic, after which the students would explain their understanding and knowledge of the topic, depending on the educator's questions when finished watching the video's content. Evidence of this, as used in participant 2's classroom, is supported in Figure 2.

Time/Step	Learning Content	Learning and Facilitation Activity		Notes
		Teacher's Act	Children's Action	
Step 2 10 minutes (10.20 am – 10.30 am)	Watch the learning video about the respirational system of human.	1) Teacher instructs children to watch the video. 2) Teacher instructs children to focus on the content of the video. 3) Teacher enquires about the children's knowledge of the respiratory system.	1) Children begin viewing the video. 2) Children keep their attention on the video. 3) Children respond to the questions based on their comprehension of the respiratory system.	Observing the body part of human using laptop, LCD, and projector

Figure 2 Document Analysed from Participant 2

Secondly, another commonly used strategy to ensure adequate completion of an activity was encouraging children to show their abilities through utilising various methods of communication tools. Figure 3 demonstrates the educators' and children's experiences of this strategy.



Ps 1 instructed the children to examine the many classifications of animals by watching an educational videos

Ps 2 facilitated children in navigating mouse control by engaging them in a task of matching fruits based on shared characteristics

Ps 3 instructed children to respond to questions referring to a subject matter involving building through the execution of educational videos

Ps 4 instructed children to respond to questions using the computer prior to the completion of the self-care activity session

Figure 3 Children's skills when communicating with technology tools

Based on the observation implemented, researchers found out that the educators demonstrated minimal utilisation of the technique involving the gentle use of technological tools to teach children how to express agreement and dissatisfaction. Only participant 1 (Ps 1) encouraged the children to praise their classmates who successfully answered the question. The educator invited learners to raise their hand and offer their comments if they had exceptional ideas or solutions. Our study revealed that for TBL to be successful in preschool, educators and children need to engage in close and effective collaboration. Educators that have the skill to create a temporary classroom setting are capable of fostering a suitable learning environment. Nevertheless, children's cognitive developments cannot be improved if they are just exposed to traditional learning such as exposing to paper and pencil learning approach, without being afforded the opportunity to delve into issues more extensively using digital resources.

Overall, the educators demonstrated effective planning and presentation skills during the teaching and facilitation sessions. They carefully selected topics that were suitable for the children's cognitive development. Throughout the brainstorming phase, each participant deliberately employed technological aids, such as presenting instructional videos prior to engaging in the main activity. At the implementation phase of the activity, however, only participant 4 employed technology instruments in conducting the primary activity. She guided students' interactions with the computer to solve topical problems by using gaming activities. Participant 1 and participant 2 rather chose to implement physical activities by inserting simulation videos as a guideline for children to solve problems in the assigned task. Participant 3 implemented a combined activity, which integrated technological tools with physical activities. During the reflection phase, participant 4 asked the children to reflect by engaging in a final activity presented as a game. Finally, all the participants asked the children to summarise the activities based on their comprehension and understanding through the analysis constructed in the brainstorming activities and the primary activities.

Discussion

The discipline of education has consistently evolved and expanded in response to societal shifts and advancements in technology. The emergence and utilisation of digital technology has led to both significant and swift changes in the field of education, particularly during the 21st century. In this study, findings revealed that, in order to promote the development of children's knowledge in learning early science through the TBL environment in preschool, it is vital for educators to provides opportunities and spaces for children to investigate the hardware supplied by a technology tool. Ghazali et al (2023), study substantiates this notion, where urban preschool children showed a sense of confidence when engaging with computers and striving to solve problems through the possibilities and opportunities provided by their educators at school. This result is further supported by the findings of Lawrence (2022), where children's physical exploration through computers may assist children to enhance their holistic development and foster their cognitive development. However, she also emphasised that the use of technology should be confined to educational purposes only. This is because computers arguably have the potential to be used for other educational purposes, not just for formal learning – provided the computer activities are well-designed (Aydin, 2005). Moreover, Cadiz et al (2023), argued that using a suitable educational platform for gaming creates a more favourable learning environment because children are better able to enhance their skills with the various features offered by the programme with which they engage. This further corroborates the results of the aforementioned study, in which the participants expressed a high consensus of the benefits when introducing children to educational video games. Specifically, it was found that such exposure can enhance children's interest in and knowledge of science.

Other than the physical features provided by technological tools, the child-friendly, utilisable software specified by educators has the potential to increase children's capacity to learn, further encouraging them to think critically throughout the programme's engaging activities.

David and Weinstein (2024), discovered that, when a learner is encouraged by their educator to utilise and use educational software, it can enhance their competency in lessons. This can also indirectly empower them to make analytical decisions when performing software-provided activities. Furthermore, Tang (2023), explained that software features in digital games found on school devices could potentially help learners increase their comprehension through creative and critical tasks. These findings show that there are 'best strategies' to improve children's knowledge in science learning, such as the influence of educators who encourage children to attempt new activities that are made accessible by technological tools. Similarly, Wilson et al (2023), discovered that digital resources, such as educational videos and learning games, can enhance children's understanding of a subject by complementing the current curriculum. Hence, educators assert that promoting children's cognitive development can be enhanced when allowing them to showcase their abilities by engaging with electronic devices.

Essentially, providing an engaging and thorough learning experience through successful implementation of technology in preschool science classrooms involves consistent efforts from multiple stakeholders, particularly teachers and children. Undheim (2021) has provided a more comprehensive explanation of this, highlighting the disregard for the function of educators and children in the establishment of a classroom environment. The researchers provided a critical explanation of five indicators that promote digital education, including: 1) recognising that digital play is equivalent to real play; 2) addressing the disparity between digital learning at school, as well as technology exploration at home; 3) considering teachers' knowledge and beliefs regarding digital tools; 4) emphasising the importance of learning with and from technology; and 5) recognising the role of children as creators in the digital classroom. Typically, preschool children require guidance and support from nearby teachers in their learning process. These teachers should critically evaluate the potential and constraints of incorporating digital technology in the classroom, and consider the appropriate timing, methods, and reasons for using it with the children (Gibbons, 2010; Jernes & Engelsen, 2012; Selwyn, 2010; Stephen & Edwards, 2018).

Furthermore, it is worth noting that the study highlights the significant impact of the blended learning approach on enhancing children's early science learning. During the observation process, it was seen that children demonstrated a favourable disposition towards engaging in activities. They demonstrated no signs of inhibition in attempting to construct new tasks, even in the absence of prior experience with technology learning resources. This is evidenced by a study conducted by Tomar and Sharma (2022) which demonstrates that the incorporation of blended learning not only impacts children's cognitive development, but also enhances the quality of learning by fostering their socio-emotional development during activities. Positive emotions serve as a catalyst for the child's motivation to complete the given activity. The preparation of blended learning activities in science education not only offers engaging activities for children, but also demonstrates that these activities effectively motivate children to persist in completing tasks that they are less familiar with.

Implication and Limitation

According to extensive study, prior studies have discussed the positive effects of incorporating TBL activities in education in Malaysia (Zaira et al., 2016). It does not only boost children's cognitive development and foster their motivation to study scientific disciplines, but it also reinforces a country's education policy. Examining the Malaysian government's policy on enhancing 21st century education reveals a focus on the necessity for schools to use technology into various subjects in order to promote diversification of study. Kamaluddin and Husnin (2022), elucidated that the advancement of technological educational tools has a profound impact on the teaching and learning culture, leading to a paradigm shift in teachers' pedagogical approaches. The seventh shift in the Malaysian Education Development Plan or known as PPPM (2013-2025), emphasises on the technological requirements of Malaysian schools, beginning from preschool level. As a comparison, in a critical review conducted by Williams et al (2019), the Australian education system has emphasised the integration of technology-based activities in the national education curriculum of 2014. More precisely, the implementation of technology in schools has been targeted at all levels of education, including kindergarten (ACARA, 2013). Hence, the government should provide incentives and assistance to preschool educators to enhance the quality of science education. This is supported by a study conducted by Adewusi et al (2024), which found that the integration of TBL activities in preschool settings can enhance the quality of learning in the United Kingdom, due to government policies that promote such educational practices.

Furthermore, this current research emphasises the need of utilising digital empowerment as a means to augment, rather than supplant, conventional teaching approaches. A thoughtful and balanced approach is essential to maximize the benefits while mitigating the risks. As previously mentioned in the conceptual framework part, incorporating TBL into preschool science learning necessitates a mediation process (Christ et al., 2022), which involves publicly merging modern and traditional educational approaches. Graham (2013), defined this approach as blended learning, which is extensively used in education. Some scholars have referred to it as the "new traditional model" (Ross & Gauge, 2006) or the "new normal" in teaching and learning (Norberg et al., 2011). Interestingly, Nong et al (2023), elucidated that individuals who engage in blended learning activities demonstrate high levels of involvement, which in turn has a favourable influence on the development of academic self-confidence. More profoundly, a study conducted by Khairoh et al (2023), demonstrated that blending learning approaches can effectively promote positive behaviours in children, as long as they actively engage in the science activities facilitated by the teacher. Hence, the study's findings indicate that incorporating technology into science classes in preschool aims to diversify existing education methodologies rather than abolish them, moving towards a more current approach.

However, when it comes to considering the primary limitation of conducting this study, researchers encounter obstacles in conducting face-to-face data collections in all study locations. Due to the COVID-19 post-epidemic phase, researchers were only able to do physical research on three preschools in the Malaysian state of Selangor. However, due to state boundary restrictions, online data collection was limited to one preschool in the Malaysian state of Perak. Despite the hurdles, researchers have followed the university's research ethics guidelines when conducting online research, proving our dedication to successful data collection. Periodic discusses with study participants ensure proper data gathering.

Conclusion

The current condition of using technological tools in the classroom may be aptly described as a rapid proliferation. Both developed and developing nations are enthusiastically adopting technology into classrooms to enhance the learning and facilitating processes. By improving educators' proficiency in utilising technology tools in the classroom from an early stage, it is feasible to cultivate future professionals who align their thinking with the ideals of 21st-century education. Children that possess a positive mindset exhibit optimal growth and success in a competitive, inventive, and purposeful classroom environment. To ensure the ability to research various themes using technology, it is crucial to promote the early adoption of ICT. In traditional schools, children may need to depend on verbal explanations from the educator about foreign concepts, such as extraterrestrial beings, in order to understand lesson topics. Nevertheless, by employing accessible technological resources in the classroom, preschool educators can prompt children to articulate descriptions of such concepts. Hence, technology is essential in contemporary education, but it should be used in moderation to prevent detrimental effects on children's overall development.

References

Abdul Rahman, N., Yusop, N. A. M., Yassin, S. M., & Isa, Z. M. (2019). Science process skills in preschool children through project approach. *Sains Humanika, 1*(11), 43–61. https://doi.org/10.11113/sh.v11n1.1386

Abu Bakar, A. (2021). *Implementation of science process skills in the teaching and learning of Early Science in kindergarten* [Master’s thesis, Universiti Pendidikan Sultan Idris]. UPSI Digital Repository. https://ir.upsi.edu.my/detailsg.php?det=7190

Acara. (2013). Draft Australian Curriculum: Technologies Foundation to Year 10. Sydney: Australian Curriculum, Assessment and Reporting Authority. Retrieved on July 22nd, 2024, from http://consultation.australiancurriculum.edu.au/Static/docs/Technologies/Draft%20Australian%20Curriculum%20Technologies%20-%20February%202013.pd

Adeoye, M. A. (2023). Review of sampling techniques for education. *ASEAN Journal for Science Education, 2*(2), 87-94.

Adewusia, O. E., Mohd Al Hamadb, N., Adelekec, I. J., Chidiebere, Nwankwod, U. C., & Nwokocha, G. C. (2024). Technology integration in early childhood education: A review of practices in Nigeria and the UK. *Education & Learning in Developing Nations, 2*(1), 10-16. http://doi.org/10.26480/eldn.01.2024.10.16

Adnan, W. A. (2023, August 24). Student involvement in STEM is decreasing, it should be taken seriously. *The Voice of Sabah*. Retrieved on July 1st, 2024, from https://sabahmedia.com/2023/08/15/penglibatan-pelajar-dalam-stem-semakin-menurun-wajar-diambil-perhatian-serius/

Al Masrim A., & Smadi, M. (2023). the effect of using brainstorming on developing innovative thinking and achievement in teaching English language students. *Asian Social Science, 19*(6), 72-83. https://doi.org/10.5539/ass.v19n6p72

Australian Government Department of Education and Workplace Relations. (2009). *Belonging, being and becoming: The early years learning framework*. Canberra: ACEQA

Aydın, E. (2005). The use of computers in mathematics education: A paradigm shift from “Computer Assisted Instruction” towards “Student Programming”. *The Turkish Online Journal of Educational Technology, 4*(2), Article 4.

Bonwell, C. C., & Eison, J. A. (1991). *Active learning: Creating excitement in the classroom*. 1991 ASHE-ERIC Higher Education Reports. ERIC Clearinghouse on Higher Education, The George Washington University, One Dupont Circle, Suite 630, Washington, DC 20036-1183.

Boon, G. C. (1998). Science and Technology in Singapore: The Mindset of the Engineering Undergraduate. *Asia Pacific Journal of Education, 18*(1), 7–24. https://doi.org/10.1080/0218879980180102

Brodin, J., & Renblad, K. (2019). Improvement of preschool children's speech and language skills. *Early Child Development and Care, 190*(14), 2205–2213. https://doi.org/10.1080/03004430.2018.1564917

Burtoon, N. (2001). *Managing the curriculum*. LA: Sage.

Cadiz, G. S., Lacre, G. J. R., Delamente, R. L., & Diquito, T. J. A. (2023). Game-Based Learning approach in science education: A Meta-analysis. International Journal of Social Science And Human Research, 6(3), 1856-1865. https://doi.org/10.47191/ijsshr/v6-i3-61

Chirwa, G. W., Banda, E., & Mwakapenda, W. (2022). Challenges facing the implementation of the new secondary school curriculum in Malawi: A case study of Lilongwe District. *Afrika Focus 35*(2), 343–374. https://doi.org/10.1163/2031356X–35020005

Christ, A. A., Capon-Sieber, V., Grob, U., & Praetorius, A-K. (2022). Learning processes and their mediating role between teaching quality and student achievement: A systematic review. Studies in Educational Evaluation, 75, Article. 101209. https://doi.org/10.1016/j.stueduc.2022.101209.

Das., S, Das., A, Rai, P., & Kumar, N. (2021). Case-based learning: Modern teaching tool meant for present curriculum: A behavioral analysis from faculties' perspective. *Journal of Education and Health Promotion, 29*(10), Article 372. https://doi.org/10.4103/jehp.jehp_1265_20

David, L., & Weinstein, N. (2023). Using technology to make learning fun: Technology use is best made fun and challenging to optimize intrinsic motivation and engagement. *European Journal of Psychology of Education,* https://doi.org/10.1007/s10212-023-00734-0

Ding, B. (2013). Science Education in Mainland China. In Gunstone, R. (Eds) *Encyclopedia of Science Education*. Springer, Dordrecht. https://doi.org/10.1007/978–94–007–6165–0_530–1

Ealangov, S., Md Saleh, S. N. H., Derasip, M. Z., & Jamaludin, K. A. (2024). Changes in the science subject curriculum for year 1: Analysis of teachers 'readiness, challeges and strategies. *Akademika, 94*(1), 67–79. https://doi.org/10.17576/akad–2023–9401–06

Graham, C. R. (2013). Emerging practice and research in blended learning. In M. G. Moore (Ed.), *Handbook of distance education,* (3rd ed., pp. 333–350). New York: Routledge.

Jernes, M., & Engelsen, K. S. (2012). Quiet struggle for power: A study of children's interactions in a digital kindergarten context]. *Nordic Studies in Education*, *32*(3-4), 281–296.

Fakherji, W. (2019). Teachers' use of technology in science supports student knowledge. *journal of Teaching and Education, 8(*2), 161–174. https://doi.org/10.21608/jrciet.2019.31979

Fadeev, A. (2019). Vygotsky's theory of mediation in digital learning environment: Actuality and practice. *Punctum, 5*(1), 24-44. https://doi.org/10.18680/hss.2019.0004

Farhang, Q., Hashemi, S. S. A., & Ghorianfar, S. M. (2023). Lesson plan and its importance in teaching process. *International Journal of Current Science Research and Review, 6*(8), 5901-5913. https://doi.org/10.47191/ijcsrr/V6-i8-57, Impact Factor: 6.789

Ghazali, A., Mohamad Ashari, Z., Hardman, J., Omar, R., & Handayani, S. W. (2023). Best practices in STEM Education for preschool children: A case study in Malaysia. *Sains Humanika, 16(*1), 87–99. https://doi.org/10.11113/sh.v16n1.2102

Gibbons, A, N. (2010). Reflections concerning technology: A Case for the Philosophy of Technology in Early Childhood Teacher Education and Professional Development Programs. In S, Izumi-Taylor & Sally, B., (Eds), *Technology for Early Childhood Education and Socialization: Developmental Applications and Methodologies*, Hershey: IGI Global.

Gross, O. (2016). *Restore the respect how to mediate school conflicts and keep students learning.* London: Paul.H.Brookes Publishing Co.

Harman, G. (1999). Australian science and technology academics and university–industry research links. *Higher Education 38,* 83–103. https://doi.org/10.1023/A:1003711931665

Hadzigeorgiou, Y., Fokialis, P., & Kabouropoulou, M. (2012). Thinking about creativity in science education. *Creative Education, 3*(5), 603–611. http://dx.doi.org/10.4236/ce.2012.35089

Hirsh–Pasek, K., Zosh, J., Golinkoff, R., Gray, J., Robb, M., & Kaufman, J. (2015). Putting education in 'Educational' apps: Lessons from the science of learning. *Psychological Science in the Public Interest 16*(1), 3–34. https://doi.org/10.1177/1529100615569721

Hu, X., Fang, Y., & Liang, Y. (2024). Roles and effect of digital technology on young children's STEM education: A scoping review of empirical studies. *Education Sciences, 14*(4), Article. 357. https://doi.org/10.3390/educsci14040357

Isman, A., Yaratan, H., & Caner, H. (2007). How technology is integrated into science education in a developing country: North Cyprus case. *The Turkish Online Journal of Educational Technology, 6*(3), Article 5.

Jarwan, F. (2005). *Teaching thinking: Definition and applications*. Amman: Dar Al-fkir. Jordan

Jones, P., & Davis, R. (2008). Instructional design methods integrating instructional technology. In Association, I. (Ed*.), Instructional Design: Concepts, Methodologies, Tools and Applications,* (pp. 101-1130, IGI Global: Hershey, PA, USA. https://doi.org/10.4018/978-1-60960-503-2.ch110

Jung, H., & Mah, J. S. (2024). The Role of the Government in Science and Technology Education of Korea. *Science, Technology & Society 19*(2), 199–. https://doi.org/10.1177/0971721814529877

Kamaluddin, N. A., & Husnin, H. (2022). The use of information and communication technology (ICT) in education. *Jurnal Dunia Pendidikan, (Special Issue), 4*(2), 333-343.

Keeler, A. R. (2012). John Collier, Thomas Edison and the educational promotion of moving pictures John Collier. *College of Communication Faculty Research and Publications, 124*, 1–14.

Kelley, T. R., & Knowles, J. G. (2016). A conceptual framework for integrated STEM education. *International Journal of STEM Education, 3,* Article. 11. https://doi.org/10.1186/s40594–016–0046–z

Kermani, H., & Aldemir, J. (2015). Preparing children for success: integrating science, math, and technology in early childhood classroom. *Early Child Development and Care, 185*(9), 1504–1527. https://doi.org/10.1080/03004430.2015.1007371

Kumari, S., Gautam, H., Nityadarshini, N., Das, B. K., & Chaudhry, R. (2021). Online classes versus traditional classes? Comparison during COVID–19. *Journal of education and health promotion, 10,* Article. 457. https://doi.org/10.4103/jehp.jehp_317_21

Lawrence, A. (2022). *Effects of increased use of technology on elementary school students in the classroom* [Master's thesis, California State University of Monterey Bay]

Letchumanan, Y., & Karim, A. (2024). Increasing knowledge and interest in science education among preschool students by building and using augmented reality technology. *E–Jurnal Penyelidikan Dan Inovasi, 11*(1), 150–176. https://doi.org/10.53840/ejpi.v11i1.181

Leung, W. M. V. (2023). STEM Education in Early Years: Challenges and Opportunities in Changing Teachers' Pedagogical Strategies. *Education Sciences, 13*(5), Article. 490. https://doi.org/10.3390/educsci13050490

Levin, I., & Tsybulsky, D. (2017). *Digital tools and solutions for Inquiry–based STEM learning*. IGI Global

Lichene, C. (2019). Promoting science education in early childhood: A research in a nursery school. *European Early Childhood Education Research Journal, 27*(3), 397–408. https://doi.org/10.1080/1350293X.2019.1600809

Mulholland, J., & Wallace, J. (2001). Teacher induction and elementary science teaching: Enhancing self–efficacy. *Teaching and Teacher Education, 17*, 243–261. https://doi.org/10.1016/S0742–051X(00)00054–8

Murati, R., & Ceka, A. (2017). The use of technology in educational teaching. *Journal of Education and Practice, 8*(6), 197–199.

Miller, C. R. (1998). Learning from History: World War II and the Culture of High Technology. *Journal of Business and Technical Communication, 12*(3), 288–315. https://doi.org/10.1177/1050651998012003002

National Research Council. (1996). *National Science Education Standards.* Washington, DC: The National Academies Press. https://doi.org/10.17226/4962.

Nolan, A. (2012). Science in the national early years learning framework. In C. Campbell & W. Jobling (Eds.), *Science in early childhood*. Melbourne: Cambridge University Press

Nong, W., Ye, J-H., Chen, P., & Lee, Y-S. (2023) A study on the blended learning effects on students majoring in preschool education in the post-pandemic era: An example of a research-method course in a Chinese university. *Front. Psychol. 13*, Article. 962707. https://doi.org/10.3389/fpsyg.2022.962707

Norberg, A., Dziuban, C. D., & Moskal, P. D. (2011). A time-based blended learning model. *On the Horizon, 19*(3), 207–216. https://doi.org/10.1108/10748121111163913.

Stajcic, M., & Nilsson, P. (2024). Teachers' Considerations for a Digitalised Learning Context of Preschool Science. *Research in Science Education, 54,* 499–521 https://doi.org/10.1007/s11165–023–10150–5

Pham, T. H. T. (2022). Using brainstorming techniques in teaching Vietnamese history from 1858 To 1918. *Journal for Educators, Teachers, and Trainers, 13*(4), 107-113. https://doi.org/10.47750/jett.2022.13.04.016T

Reich, L. R. (1994). Circle time in preschool: An analysis of educational praxis. E*uropean Early Childhood Education Research Journal, 2*(1), 51–59. https://doi.org/10.1080/13502939485207531

Remien, K., & Kanchan, T. (2022). *Parental Consent*. StatPearls [Internet]

Rennie, L. J., Goodrum, D., & Hackling, M, (2001). Science teaching and learning in Australian schools: Results of a national study. *Research in Science Education, 31*, 455–498.

Ritter, S. M. & Mostert, N. M. (2018). How to facilitate a brainstorming session: The effect of idea generation techniques and of group brainstorm after individual brainstorm. *Creative Industries Journal, 11*(3), 263-277. https://doi.org/10.1080/17510694.2018.1523662

Ross, B., & Gage, K. (2006). Global perspectives on blended learning: Insight from WebCT and our customers in higher education. In C. J. Bonk, & C. R. Graham (Eds.), *Handbook of blended learning: Global perspectives, local designs*, (pp. 155–168). San Francisco: Pfeiffer.

Rusli, R., Nalanda, D. A., Tarmidi, A. D. V., Suryaningrum, K. M., & Yunanda, R. (2023). Augmented reality for studying hands on the human body for elementary school students. *Procedia Computer Science, 216,* 237-244. https://doi.org/10.1016/j.procs.2022.12.132.

Said, C. S., Umar, I. N., Muniandy, B., & Desa, S. (2019). Multimedia Technology Application in Biology Science Learning: Effects on Students with Different Levels of Spatial Ability. *Journal of ICT in Education, 2,* 12–25.

Sarangi, C., Mohanta, T., Pradhan, M., & Guru, N. (2023). An analytical study on integration of pedagogy and technology in secondary science classes of India during COVID–19. *Journal of E–Learning and Knowledge Society, 19*(3), 49–58. https://doi.org/10.20368/1971–8829/1135859

Sefcik, J. S., Hathaway, Z., & DiMaria-Ghalili, R. A. (2023). When snowball sampling leads to an avalanche of fraudulent participants in qualitative research. *International of Older People Nursing,18*(6), Article 12572. https://doi.org/10.1111/opn.12572

Setyowati, Sri., Rakhmawati, N. I. S., Fitri, F., Saroinsong, W. P., & Simatupang, N. D. (2023). P roject–based Learning in improving early childhood children's ability to know social and geographical environments. *Jurnal Obsesi: Jurnal Pendidikan Anak Usia Dini, 7*(3), 3461–3467.

Selwyn, N. (2010). Looking beyond learning: Notes towards the critical study of educational technology. *Journal of Computer Assisted Learning, 26*(1), 65–73. https://doi.org/10.1111/j.1365-2729.2009.00338.x

Sonar, A. D., Sawant, N., Salunkhe, J., & Baraskar, S. S. (2022). Design, development, and validation of hand-eye coordination equipment. *IETE Journal of Research, 69*(11), 8373–8381. https://doi.org/10.1080/03772063.2022.2055659

Sundberg, B., Areljung, S., Due, K., Ekström, K., Ottander, C., & Tellgren, B. (2018). Opportunities for and obstacles to science in preschools: views from a community perspective. *International Journal of Science Education, 40*(17), 2061–2077. https://doi.org/10.1080/09500693.2018.1518615

Shaker, E. G., & Saleh, H. A. (2021). Teachers' perceptions of science curriculum reform in UAE: A study in an American private school in Dubai. *Millennium Journal of Humanities and Social Sciences, 2*(1),117–137. https://doi.org/10.47340/mjhss.v2i1.32

Shizuo, M., & Shousuke, T. (2017). Science and technology for a sustainable future. *Jurnal Bahasa dan Budaya Jepun, 7,* 50–66.

Siddiqui1, A., Khowaja, K., Ghulamani, S., & Shah, A. (2023). Integrating technology with science in STEM education for K–12 students. *Journal of Information Systems and Digital Technologies, 5*(2), 142–154.

Smith, E., & White, P. (2024). Science for All? School Science Education Policy and STEM Skills Shortages. *British Journal of Educational Studies,* 1–28. https://doi.org/10.1080/00071005.2024.2322964

Social Sciences Research Laboratories SSRL (2018, June 6*). Using Triangulation to Improve Credibility and Validity* [Video]. YouTube. Retrieved on July 11th, 2024. From https://www.youtube.com/watch?v=apcn0r3fL1o

Soratto, J., Pires, D. E. P., & Friese, S. (2020). Thematic content analysis using ATLAS.ti software: Potentialities for researchs in health. *Revista Brasileira De Enfermagem, 73*(3), Article 20190250. https://doi.org/10.1590/0034-7167-2019-0250

Stephen, Christine, and Susan Edwards. (2018). *young children playing and learning in a digital age: A cultural and critical perspective*. London: Routledge.

Synder, M. (2018). A century of perspectives that influenced the consideration of technology as a critical component of STEM education in the United States. *The Journal of Technology Studies, 44*(2), 42–57. https://www.jstor.org/stable/26730730

Tang, Y. (2023). The effect of mobile Internet educational software applications on elementary school students' learning ability. *Journal of Education, Humanities and Social Sciences, 8,* 1925-1931. https://doi.org/10.54097/ehss.v8i.4615

Taşdemir, C. Y., & Yıldız, T. G. (2024). Science learning needs of preschool children and science activities carried out by teachers. *Journal of Turkish Science Education 2*(1), 82-101. https://doi.org/10.36681/tused.2024.005

Teach the Earth. (2004). Using investigative cases. Retrieved on July 11th, 2024, from https://serc.carleton.edu/teachearth/teaching_methods/icbl/index.html

Tomar, K., & Sharma, P. (2022). Blended learning approach for early childhood education. *International Journal of Creative Research Thoughts, 10*(5), 113-121.

Hardy, A. (2020). *The technological contest between China and the United States*. GLO Discussion Paper, No. 521, Global Labor Organization (GLO), Essen

Trundle, K. C., & Saçkes, M. (2021). Teaching and learning science during the early years. *Journal of Childhood, Education & Society, 2*(3), 217–219. https://doi.org/10.37291/2717638X.202123159

Tsang, A. (2020). Enhancing learners' awareness of oral presentation (delivery) skills in the context of self-regulated learning. *Active Learning in Higher Education, 21*(1), 39-50. https://doi.org/10.1177/1469787417731214

Uçar, S. (2015). The use of technology in teaching science to young children. In Cabe Trundle, K., Saçkes, M. (Eds), *Research in Early Childhood Science Education*. Springer, Dordrecht. https://doi.org/10.1007/978–94–017–9505–0_8

Undheim, M. (2021). Children and teachers engaging together with digital technology in early childhood education and care institutions: A literature review. *European Early Childhood Education Research Journal*, *30*(3), 472–489. https://doi.org/10.1080/1350293X.2021.1971730

Vahey, P., Reider, D., Orr, J., Lewis Presser, A., & Dominguez, X. (2018). The evidence–based curriculum design framework: Leveraging diverse perspectives in the design process. *International journal of designs for learning, 9*(1), 135–48. https://doi.org/10.14434/ijdl.v9i1.23080

Vygotsky, L. S. (1978). *Mind in society: The development of higher psychological processes*. Cambridge, MA: Harvard University Press.

Wedde, I. S. (2014). *Arabic language learning model, driving factors and barriers to use.* Yogyakarta, Indonesia: Penerbit Deepublish.

Weimer, M. (2013). Student presentations: Do they benefit those who listen? Retrieved on July 3rd, 2024, from https://www.facultyfocus.com/articles/teaching-and-learning/student-presentations-do-they-benefit-those-who-listen/

Williams, P. J., Ellis, D., Pagram, J., Macgregor, D., Seeman, K., & Fujita, S. (2019). A critical perspective on technology education in Australia. *Journal of the Japan Society of Technology Education, 61*(2), 169-186.

Wilson, S., Murcia, K., Cross, E., & Lowe, G. (2023). Digital technologies and the early childhood sector: Are we fostering digital capabilities and agency in young children? *The Australian Educational Researcher,* 1-19. https://doi.org/10.1007/s13384-023-00647-3