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THE UTILIZATION OF DIGITAL SCIENCE-BASED INSTRUCTION ON EARLY LITERACY AND NUMERACY SKILLS AMONG KINDERGARTEN STUDENTS IN OMAN

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ABSTRACT

Early literacy and numeracy are essential foundations for children's learning, and integrating science concepts into these areas provides meaningful, hands-on experiences that strengthen comprehension. This study examined the effects of Digital Science-Based Instruction (DSBI) on the literacy and numeracy development of kindergarten children aged 4–5 years, involving 46 participants from two kindergarten classes that were handled by the researchers and treated as a single group at the Sultan Qaboos University Daycare Centre (SQU-DCC). A quantitative one-group pretest–posttest quasi-experimental design was employed. The four-week intervention was implemented through structured, teacher-guided sessions integrating digital learning applications, multimedia presentations, and hands-on science-based activities. Instruction used tablets, projector-supported lessons, and interactive learning stations. Students engaged in guided practice and exploratory tasks designed to reinforce letter recognition, sound blending, counting, sequencing, and number identification in meaningful science contexts. Researcher-developed and expert-validated literacy and numeracy assessment tools were administered before and after the intervention. Data were analyzed using descriptive statistics and a paired-samples t-test. Results revealed a statistically significant improvement in both literacy and numeracy performance ($p = 0.001$). The findings indicate that Digital Science-Based Instruction is an effective and developmentally appropriate approach that strengthens foundational skills and complements play-based instruction in early childhood education.

Keywords: *Digital Science-Based Instruction, Early Literacy, Early Numeracy, Science Integration, Kindergarten*

INTRODUCTION

Children in contemporary society have become increasingly immersed in digital environments, interacting with multimedia content, games, and virtual experiences from an early age. This shift in early childhood experiences presented educators with significant opportunities to integrate developmentally appropriate digital tools into classroom instruction. In the preschool years, when cognitive receptivity and curiosity are particularly high, digital learning environments paired with hands-on science activities were found to create meaningful, interactive, and conceptually rich learning experiences. Integrating science-based activities with digital learning further created rich, active learning environments that promoted curiosity, critical thinking, and the development of foundational literacy and numeracy skills (Lamrani & Abdelwahed, 2020). Such approaches not only made scientific ideas more accessible but also contributed to the foundational skills necessary for later academic achievement.

A growing body of research has underscored the role of digital science-based instruction in enhancing young children's cognitive, literacy, and numeracy abilities. Programs such as Science4Us have provided interactive modules that integrate science with literacy through games, songs, digital notebooks, and simple experiments designed to promote STEM readiness (Explore Learning, n.d.). Supporting this evidence, a meta-analysis by Alotaibi et al. (2024) demonstrated that game-based and literacy-rich digital platforms significantly improved children's cognitive, social, and emotional competencies, including problem-solving, memory retention, and sustained attention. Likewise, the National Association for the Education of Young Children (NAEYC, 2022) affirmed that appropriately used digital technology could enhance active and developmentally appropriate learning across multiple content domains, including science.

The use of digital science-based instruction is aligned with major learning theories. Piaget emphasized experiential learning, Vygotsky highlighted guided support through the Zone of Proximal Development, and Bandura explained learning through observation and imitation processes supported by digital simulations, apps, and interactive media.

Guided by these theoretical foundations, the present study investigated how digital learning integrated with science activities affected the early literacy and numeracy development of kindergarten children aged 4–5 years. The findings aimed to contribute to ongoing efforts to incorporate developmentally appropriate digital tools in early childhood education and to strengthen evidence on the effectiveness of digital science-based instruction in supporting foundational learning skills.

Background of the Study

The Sultan Qaboos University Daycare Centre (SQU-DCC) in Muscat, Oman, established in 1986, has evolved from an informal playgroup into a formal preschool program guided by the Early Years Foundation Stage (EYFS) framework. By the time of the study, the Centre served children aged one to five and a half years from diverse international backgrounds and provided instruction in key developmental domains such as early literacy, numeracy, communication, social-emotional development, and creative play.

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Despite these advancements, SQU-DCC continued to rely predominantly on traditional, hands-on teaching methods. This approach reflected the Centre's belief that children had already encountered technology at home, leading educators to prioritize conventional classroom practices over digital learning. However, with global education increasingly shaped by digital innovation, interest in integrating developmentally appropriate technology into early childhood settings, particularly within science, literacy, and numeracy, has grown.

Research on digital learning in early childhood education highlights both the potential benefits and persistent challenges. Studies report improved cognitive and foundational skills through digital science-based instruction (Allen et al., 2020), yet barriers such as limited resources, insufficient teacher readiness, classroom distractions, and a lack of longitudinal evidence continue to impede effective integration (Fackler et al., 2021; Uslu & Çelikoz, 2020). The National Association for the Education of Young Children (NAEYC) further notes that technology enhances learning only when carefully selected, developmentally appropriate, and meaningfully embedded within instruction.

Although digital learning has been widely explored internationally, there remains limited evidence on how digital tools could be effectively integrated with science-based, hands-on activities within Oman's early childhood context, particularly at SQU-DCC, where such approaches have not yet been systematically examined. Little was known about how digital science-based instruction might influence the early literacy and numeracy development of young learners in this setting.

To address this gap, the present study investigated the integration of digital learning combined with play-based science instruction to enhance foundational literacy and numeracy skills among kindergarten children. By combining interactive digital tools with exploratory, hands-on experiences, the study sought to determine whether a balanced, developmentally appropriate digital approach could strengthen learning outcomes at SQU-DCC and inform future instructional practices.

Digital Tools in Early Childhood Learning and Science Education

Research has shown that young children's natural curiosity and early engagement with their environment make them highly responsive to STEM-related experiences, supporting the development of critical thinking and foundational academic skills (Wan et al., 2021; Glauert & Stylianidou, 2021; Reimers, 2020). Advances in tablets, interactive apps, and cloud-based platforms have expanded opportunities for adaptive testing, gamified learning, and personalized instruction (Eliasson et al., 2022). The COVID-19 pandemic further accelerated children's exposure to multimodal storytelling, augmented reality, and AI-supported tools, enhancing digital learning ecosystems for young learners (Hewi et al., 2022; Su et al., 2023; Furlong et al., 2021).

Digital tools have been shown to support early language, literacy, numeracy, and science development through interactive e-books, educational games, and augmented reality applications, promoting engagement, cognitive growth, and problem-solving skills (Lamrani & Abdelwahed, 2020; Larsson, 2021; Hinostroza, 2021). The integration of science with literacy and mathematics through digital activities, such as storybook creation or virtual experiments, has provided meaningful learning experiences for young children. However, these benefits are contingent upon strong teacher guidance and appropriate implementation, as excessive or poorly designed digital use may reduce

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hands-on exploration, attention, and social interaction while affecting executive functioning (Kostyrka-Allchorne & Cooper, 2023; Lu et al., 2022).

Teacher readiness has emerged as a critical factor in successful digital integration. Professional development in STEM education increases teachers' confidence and competence, enabling them to deliver higher-quality science instruction and effectively incorporate digital tools (Movahedazarhouligh et al., 2023). Moreover, teachers with positive attitudes toward science are more likely to use digital tools efficiently, resulting in enriched learning experiences for children (Raviv & Galili, 2024). Overall, the research indicates that digital tools can enhance early childhood learning, particularly in science, literacy, and numeracy, when used intentionally and supported by trained educators.

Science as a Context for Literacy and Numeracy Development

Inquiry-based and hands-on science activities were shown to strengthen children's language, vocabulary, reasoning, and early mathematical concepts (Eti & Sigirtmaç, 2021). Research also suggested strong links between literacy and science performance, indicating that early science engagement reinforced literacy growth (2022 longitudinal study). Teachers who implemented inquiry-based science allowed children to ask questions, explore materials, and communicate findings, promoting both language and numeracy skills (Leung, 2023; García-Rodeja et al., 2024).

Integrating literacy strategies into science instruction produced gains in speaking, vocabulary, reading, and writing (Esparza et al., 2023). Overall, early science education functioned as a meaningful context through which multiple foundational skills, including literacy and numeracy, were developed simultaneously.

Developmentally Appropriate Use of Technology

Developmentally Appropriate Practices (DAP) emphasized hands-on, culturally relevant, and play-based learning experiences that linked prior knowledge with new concepts (NAEYC, 2021). Within this framework, Developmentally Appropriate Technology Use (DATU) stressed that digital tools must be intentional, interactive, and balanced with real-world exploration (Konca & Erden, 2021). Poorly designed or passive digital content risked hindering language development, attention, and social skills.

Studies showed that developmentally aligned digital practices supported academic outcomes in literacy and numeracy (Cohen & Waite-Stupiansky, 2020) and enhanced creativity, engagement, and individualized learning (Kasmiati, 2025). Digital learning also improved children's language, math, science, and social skills when implemented with appropriate guidance and limits (Al-Barakat et al., 2023). These findings underscored that digital tools must enrich, not replace, authentic play and exploration.

Literacy and Numeracy Through Digital Technologies

Interactive digital media, including e-books, educational apps, and digital storytelling, have been shown to support the development of early literacy skills such as decoding, phonological awareness, vocabulary, and reading comprehension (Tang et al., 2020; Verhoeven et al., 2020). Platforms like Storybird and audiobooks further fostered creativity, writing confidence, and engagement, particularly for hesitant or emerging readers (Inclusive TKI, 2024; National Literacy Trust, 2024). Additionally, digital features such as text-to-speech and AI-powered word prediction enhanced accessibility for

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children with reading difficulties (Bedrock Learning, 2024). Enhanced e-books that combine narration and multimedia elements improved literacy outcomes, though careful design was necessary to prevent distraction and maintain learning focus (Lopez-Escribano et al., 2024). Systematic reviews reinforced these findings, highlighting the positive impact of interactive digital tools on language development and overall cognitive growth (Griffith et al., 2020; Arabiat et al., 2023).

In early numeracy, digital tools have effectively strengthened preschoolers' counting, sequencing, and problem-solving skills (Daryati, 2025). Gamified platforms such as Lumio and ScratchJr offered engaging, play-based opportunities to develop number concepts and logical reasoning (Lismayani & Pratama, 2025). Similarly, web-based story-integrated math applications enhanced comprehension and numeracy by embedding mathematical concepts within meaningful, interactive narratives (Institute of Education Sciences, 2023). Collectively, these studies demonstrate that thoughtfully designed digital tools can provide developmentally appropriate and interactive opportunities that enhance both literacy and numeracy learning in early childhood.

Challenges and Considerations in Digital Integration

Despite the benefits of digital tools, issues of equitable access and quality remained prominent. OECD (2023) emphasized that high-quality digital implementation supported diverse learners, while UNICEF (2020) revealed that many children lacked access to devices and reliable internet. Teacher readiness also played a major role; digital competence and supportive school environments were essential for effective integration (Liu, 2025; Dardanou et al., 2023).

Balancing digital engagement with hands-on play was critical. Excessive screen time poses risks to development, making it necessary to pair digital use with real-world exploration (Ahsun & Oladele, 2025). Professional guidelines similarly stressed limiting digital exposure to ensure it did not interfere with key developmental milestones (American Academy of Pediatrics, 2025).

Theoretical Framework

This study was anchored in a coherent set of learning theories that collectively explained how digital, science-based instruction supported the development of literacy and numeracy skills among kindergarten learners. The primary foundation was Richard Mayer's (2009) revised Cognitive Theory of Multimedia Learning (CTML), which posited that learning is optimized when verbal and visual information are integrated, cognitive load is carefully managed, and learners actively engage with instructional content. These principles guided the design of the digital science activities, ensuring that multimedia elements were structured to promote effective information processing and comprehension.

To complement this cognitive lens, the study also drew on Piaget's (1952) Cognitive Development Theory, which emphasized that young children construct knowledge through direct interaction with concrete materials. This perspective supported the integration of hands-on science tasks and exploratory digital activities aligned with the learners' developmental stage.

Additionally, Vygotsky's (1978) Sociocultural Theory provided a framework for understanding the role of guided support and collaborative learning. The structured

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modelling, teacher scaffolding, and peer interactions embedded in the intervention reflected the processes through which children progressed within their Zone of Proximal Development.

Finally, Bandura's (1977) Social Learning Theory offered insight into the influence of observational learning. The use of videos, animations, and teacher demonstrations enabled learners to observe modelled behaviours and apply them during both digital and physical activities, thereby reinforcing skill acquisition through imitation and practice.

Together, these theories offered a robust explanatory foundation for the instructional approach employed in the study. By integrating cognitive, developmental, sociocultural, and observational perspectives, the theoretical framework clarified why digital science-based instruction effectively supported early literacy and numeracy outcomes. This theoretical alignment provided the basis for interpreting the study's findings and understanding the mechanisms through which the intervention produced its observed effects.

Research Questions

This study investigated the effects of digital science-based instruction on early literacy and numeracy skills in preschoolers aged 4 to 5 years. Specifically, it aimed to answer the following questions:

1. What are the literacy and numeracy skill levels of kindergarten students before digital science-based instruction?
2. What are the literacy and numeracy skill levels of kindergarten students following digital science-based instruction?
3. Is there a significant difference in literacy and numeracy skills before and after digital science-based instruction?
4. What training program can be developed based on the study's findings to enhance the implementation of digital science-based instruction?

Hypothesis

There is no significant difference in the literacy and numeracy skills of kindergarten students before and after exposure to digital science-based instruction.

Scope and Delimitation

This study focused on investigating the effects of Digital Science-Based Instruction (DSBI) on the literacy and numeracy development of kindergarten students aged 4–5 years during a four-week intervention period. The scope of the research was intentionally concentrated on two kindergarten classes within the Sultan Qaboos University Daycare Centre (SQU-DCC), allowing the researchers to closely monitor the implementation of DSBI and ensure consistency in instructional delivery. The findings of the study are therefore most applicable to similar early childhood settings with comparable learner profiles and instructional conditions.

Researcher-made instruments, which were content-validated by experts in early childhood education and assessment, were utilized to measure literacy and numeracy outcomes. While such tools ensured alignment with the specific learning objectives and science-integrated content of the intervention, they may still carry inherent limitations typical of customized assessments.

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The study employed a one-group pretest–posttest design, which enabled the researchers to measure growth within the same group of learners. However, the absence of a control group means that improvements cannot be attributed exclusively to DSBI, as other external factors may also have influenced learning gains. Despite this design limitation, the study provides meaningful evidence of positive learner progress within a short-term digital science-integrated intervention.

Overall, the study offers valuable context-specific insights into the promising role of digital science-based instruction in supporting early literacy and numeracy development. These findings can guide future research, encourage the refinement of digital learning approaches, and inform instructional innovations in early childhood education.

METHODOLOGY

Locale of the Study

The study was conducted in Sultan Qaboos University Daycare Centre, an early childhood education setting in Muscat, Oman. The chosen institution caters to children aged 4-5 years and provides a structured early childhood curriculum. The researchers ensured that the study environment supported the implementation of digital science-based instruction, including access to tablets, interactive applications, and age-appropriate science activity materials.

Sampling Method and Respondents

The study employed purposive sampling to select participants who met the inclusion criteria of being enrolled in kindergarten and aged 4-5 years. The respondents consisted of two kindergarten classes, each composed of 23 students, for a total of 46 participants. Both classes were handled by the researchers of this study and were treated as one combined experimental group for data collection and analysis.

The participants included both male and female students representing a typical mix of learners in an early childhood education setting. All enrolled students in the two classes were included in the study to ensure comprehensive representation and to minimize selection bias.

Research Design

This study utilized a quantitative one-group pre-test and post-test experimental quasi-design. The researchers of this study aimed to measure the improvement in early literacy and numeracy skills following the implementation of Digital Science-Based Instruction (DSBI). Pre-tests were administered to establish baseline skills, followed by a four-week intervention using digital science-based lessons. Post-tests were then conducted to assess learning gains.

Data Gathering Procedure

Before the intervention, the researchers obtained informed consent from parents or guardians. The pre-test assessment was administered individually to each child to evaluate baseline literacy and numeracy skills. The DSBI intervention was delivered four times weekly over four weeks, incorporating interactive digital applications, multimedia

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resources, and hands-on science activities aligned with literacy and numeracy objectives. After the intervention, the post-test was administered using an assessment that measured the same skill content and domains as the pre-test to determine students' progress.

Instruments of the Study

The researchers employed two instruments developed specifically for this study:

1. **Early Literacy Assessment (20 items**) – This researcher-made instrument measured letter recognition, phonemic awareness, sight word recognition, and blending skills. The items consisted of multiple-choice questions. The content of the instrument was validated by three experts in early childhood education and literacy to ensure content validity, clarity, and age appropriateness. The pre-test was administered in a traditional paper-based format, while the post-test was administered in a digital multiple-choice format using a QR code linked to Google Forms.
2. **Early Numeracy Assessment (20 items)** – This researcher-made instrument measured number recognition, counting, sequencing, pattern identification, and addition within five. The items assessed skills such as matching, identifying, ordering, and simple problem-solving, which were presented in a multiple-choice format appropriate for young learners. The instrument was validated by three experts in early childhood education and mathematics to ensure content validity, clarity, and developmental suitability. The pre-test was administered in a traditional paper-based format, while the post-test was administered in a digital multiple-choice format using a QR code linked to Google Forms, designed to be age-appropriate and visually supported for young learners.

Data Analysis

The researchers analyzed quantitative data using descriptive and inferential statistics. Means and standard deviations were computed to describe students' performances in the pre-test and post-test for both literacy and numeracy skills. A paired-samples t-test was used to determine whether there was a statistically significant difference between pre-test and post-test scores.

The level of significance was set at $p \leq 0.05$. A p-value of ≤ 0.05 was interpreted as statistically significant, while a p-value of > 0.05 was interpreted as not statistically significant.

Ethical Considerations

The researchers affirmed full compliance with ethical standards in the conduct of this study. Informed consent was secured from parents through a clear and simple form that outlined the study's purpose, procedures, and potential benefits. Participation was entirely voluntary, and parents were informed that they could withdraw their child at any time without consequence. The anonymity and privacy of all respondents were strictly maintained; all collected data, including photos and video recordings, excluding identifiable features, were securely stored and were deleted following the completion of the study. The study was conducted with full respect for local customs, cultural values, and institutional guidelines in Oman, ensuring the well-being and safety of all participants.

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The researchers declare that no conflict of interest existed in the conduct of the study. Plagiarism was strictly avoided, and the interpretation of findings was performed without bias. All results were used solely for academic and educational purposes, and any tools or technologies used in the research process were employed ethically and responsibly. Finally, ethical clearance was obtained from the FEU Roosevelt Institutional Research Ethics Board after a comprehensive review of the research, confirming adherence to the highest standards of integrity and transparency throughout all stages of the study.

RESULTS

This section presents the findings of the study on the effects of Digital Science-Based Instruction (DSBI) on the literacy and numeracy skills of kindergarten students aged 4–5 years. Data was collected using researcher-made assessments, with pre-tests administered in a traditional paper-based format and post-tests delivered digitally via Google Forms. Descriptive statistics summarized students' performance before and after the intervention and paired-samples t-tests were conducted to determine whether the observed differences were statistically significant ($p \leq 0.05$). The results are organized according to baseline performance, post-intervention performance, and overall effects, corresponding to the research questions.

Research Question 1.

Table 1. ***Scores of Kindergarten Students in Early Literacy and Numeracy Skills Before They Were Exposed to Digital Science-Based Instruction***

Score Interval	Description	Literacy		Numeracy	
		Frequency	Percentage	Frequency	Percentage
17-20	Outstanding				
13-16	Very Satisfactory	14	30.43	8	17.39
9-12	Satisfactory	26	56.52	38	82.61
5-8	Fair	6	13.04		
0-4	Needs Improvement				
Total		**46**	**100**	**46**	**100**
Mean		**11.22**		**11.30**	
Standard Deviation		**2.21**		**1.43**	

Descriptors: Outstanding: 17-20 points, Very Satisfactory: 13-16 points, Satisfactory: 9-12 points, Fair: 5-8 points, and Needs Improvement: 0-4 points.

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Research Question 2.

Table 2. ***Scores of Kindergarten Students in Early Literacy and Numeracy Skills After They Were Exposed to Digital Science-Based Instruction***

Score Interval	Description	Literacy		Numeracy	
		Frequency	Percentage	Frequency	Percentage
17-20	Outstanding	32	69.57	30	65.22
13-16	Very Satisfactory	14	30.43	16	34.78
9-12	Satisfactory				
5-8	Fair				
0-4	Needs Improvement				
Total		**46**	**100**	**46**	**100**
Mean		**17.13**		**17.26**	
Standard Deviation		**2.22**		**1.71**	

Descriptors: Outstanding: 17-20 points, Very Satisfactory: 13-16 points, Satisfactory: 9- 12 points, Fair: 5-8 points, and Needs Improvement: 0-4 points.

Research Question 3. Table 3. ***The difference in the early literacy and numeracy skill scores of the kindergarten students before and after they are exposed to digital science-based instruction.***

Profile - Gender	Mean	Increase/ Decrease	Computed Test Value	p-value	Decision	Interpretation
Literacy						
Before	11.22	5.91(53% -increase)	-21.077	0.001	Reject the Hypothesis	Significant
After	17.13					
Numeracy						
Before	11.30	5.96(53%-increase)	-16.887	0.001	Reject the Hypothesis	Significant
After	17.26					

Note: p-value ≤ 0.05 – significant, p-value > 0.05 – not significant

DISCUSSION

Baseline Performance (Pre-test)

As shown in Table 1, the majority of students demonstrated satisfactory performance in both literacy (56.52%) and numeracy (82.61%) before DSBI. Mean scores were 11.22 in literacy and 11.30 in numeracy, indicating that most learners possessed

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foundational skills but still required further development in comprehension, application, and fluency.

Variability was observed among learners, with 13.04% scoring in the “Fair” category, suggesting differences in home learning exposure, such as access to print-rich or numeracy-rich environments, may have influenced baseline performance. As Rojas (2023) explains, young children rely heavily on concrete, sensory experiences to understand abstract symbols like letters and numbers, which may not have been consistently available to all learners.

Prior to DSBI, instruction was mainly teacher-directed and hands-on. While this approach supported basic readiness, it did not fully stimulate curiosity or higher-order thinking. Shahat et al. (2022) emphasized that combining tactile, visual, and digital experiences strengthens conceptual understanding, highlighting the need for more interactive and science-rich learning opportunities.

Mayer’s Cognitive Theory of Multimedia Learning also supports these findings, as learners had not yet benefited from integrated visual-verbal digital instruction.

Post-Intervention Performance (Post-test)

Following the four-week DSBI intervention, students demonstrated significant improvements in both literacy and numeracy. As shown in Table 2, most students achieved Outstanding performance (69.57% in literacy; 65.22% in numeracy), with the remaining students reaching the Very Satisfactory level. Mean scores increased to 17.13 in literacy and 17.26 in numeracy, reflecting enhanced mastery of concepts and greater engagement during learning activities.

The observed improvement is attributed to DSBI’s multisensory and meaningful learning experiences, which combined digital tools such as videos, interactive slides, and online games with hands-on science tasks. As Ahmadjonova (2024) notes, technology strengthens learning when it supports rather than replaces experiential activities, and the students’ increased motivation, attention, and participation confirms this principle.

These results align with prior studies. Adnyana, Sudarma, and Hariyadi (2023) found that digital media enhances early numeracy when children engage with simulations and real-world problem-solving tasks. Mat Nor et al. (2023) emphasized that science-infused digital lessons build vocabulary, reasoning, and cognitive flexibility, foundations for literacy and numeracy development. Consistent with these studies, the present results indicated that integrating science concepts through digital instruction increased curiosity and improved students’ ability to predict, observe, and explain phenomena.

Overall Effects and Statistical Analysis

As shown in Table 3, paired-samples t-tests confirmed a statistically significant difference between pre-test and post-test scores ($p = 0.001$), indicating that DSBI had a strong positive effect on early literacy and numeracy skills. The overall 53% increase in performance demonstrates not only higher test scores but also enhanced conceptual understanding and experiential learning.

By integrating science themes into literacy and numeracy, children were able to connect classroom learning with real-life situations, such as counting during simple experiments or identifying initial sounds in nature-based activities. This approach reflects

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constructivist principles of Vygotsky and Bruner, which emphasize learning through guided interaction and meaningful, context-rich activities (Alsubaie, 2025).

These results are consistent with prior research. Hollenstein et al. (2022) found that blended digital and hands-on learning deepens retention and problem-solving abilities, while Otterborn et al. (2023) showed that combining digital and analogue tools in science-rich environments enhances engagement, attention, and perseverance.

The theoretical perspectives further support the observed improvements. Mayer's multimedia theory explains that visual-verbal integration promotes deeper understanding. Piaget highlights that concrete, science-based experiences support symbolic learning. Vygotsky emphasizes scaffolding from teacher-guided digital activities, and Bandura highlights the role of observation, modeling, and feedback in skill acquisition. Collectively, these frameworks justify the significant gains observed in both literacy and numeracy following the DSBI intervention.

Summary of Findings

Among the important findings of this research were:

1. Before the use of Digital Science-Based Instruction (DSBI), most of the kindergarten students showed satisfactory performance in both literacy and numeracy. The average scores were 11.22 in literacy and 11.30 in numeracy, which means that the children already had basic skills but still needed more opportunities to strengthen their understanding and fluency. A few learners fell under the "Fair" category, showing that some children may have had less exposure to early learning experiences, such as reading at home or playing with numbers in everyday situations.

2. After being exposed to Digital Science-Based Instruction, there was a noticeable improvement in the students' performance. The average scores increased to 17.13 in literacy and 17.26 in numeracy. Most students reached the "Outstanding" and "Very Satisfactory" levels. The lessons, which combined digital tools and science-based hands-on activities, made learning more exciting, concrete, and meaningful for the children. They became more attentive, curious, and enthusiastic about exploring new concepts.

3. The statistical results showed a significant difference between the pretest and posttest scores in both literacy and numeracy, with a p-value of 0.001, confirming that the improvement was not just by chance. This means that the utilization of DSBI had a real and positive impact on children's learning. It proved that when science and technology are blended with early literacy and numeracy, children learn better and are more engaged.

4. The observations during the lessons also showed higher levels of participation and curiosity. The children asked more questions, shared their ideas confidently, and enjoyed both the digital and hands-on parts of the lessons. The combination of traditional play-based learning with digital science exploration created a balanced approach that made learning more enjoyable and developmentally appropriate.

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Conclusions

Based on the foregoing findings, the following conclusions were drawn:

1. Literacy and numeracy skill levels before Digital Science-Based Instruction (DSBI).
Prior to the implementation of DSBI, kindergarten learners demonstrated satisfactory levels of early literacy and numeracy, as reflected in mean scores of 11.22 and 11.30. These baseline results indicated foundational competencies but also suggested the need for enhanced instructional support to further strengthen early learning outcomes. The findings were consistent with Mayer's Cognitive Theory of Multimedia Learning (2009), which suggests that young learners require well-structured multimedia experiences to enhance comprehension and retention.

2. Literacy and numeracy skill levels after Digital Science-Based Instruction.
Following the DSBI intervention, students' mean scores increased substantially to 17.13 in literacy and 17.26 in numeracy, representing an average improvement of approximately 53%. The majority of students progressed from the "Satisfactory" level to "Outstanding," with 69.57% achieving exceptional literacy scores and 65.22% achieving exceptional numeracy scores. These results demonstrated that the integration of digital tools, science-based activities, and guided instruction effectively enhanced foundational literacy and numeracy skills. The findings were consistent with Piaget's Cognitive Development Theory, which emphasizes learning through direct, hands-on experiences; Vygotsky's Sociocultural Theory, highlighting the importance of guided support and collaborative learning; and Bandura's Social Learning Theory, which underscores learning through observation and imitation.

3. Significant difference in literacy and numeracy skills before and after DSBI.
Paired-sample t-test analyses revealed statistically significant differences between pre-test and post-test scores in both literacy and numeracy ($p = 0.001$), indicating a rejection of the null hypothesis. This confirmed that DSBI significantly improved students' performance in these domains, addressing the research gap concerning limited empirical evidence on the efficacy of combining digital learning with science-based instruction in early childhood education, particularly in settings where traditional teaching approaches predominated.

4. Training program to enhance the implementation of DSBI.
In response to the identified gap in teacher preparedness, a structured teacher training and mentoring program was developed. The program aimed to equip early childhood educators with the knowledge and skills to implement DSBI effectively, integrating digital tools with play-based and science-oriented activities. The "train-and-echo" model encouraged collaborative learning among teachers, emphasized the use of accessible and low-cost materials, and supported sustained literacy and numeracy development.

Recommendations

In light of the conclusions drawn from the study, the following are hereby recommended:

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1. Teachers are encouraged to integrate Digital Science-Based Instruction in their literacy and numeracy lessons. Blending simple digital tools such as short videos, interactive slides, and learning games with science-related activities like small experiments, nature observations, or discovery play can make learning more fun and meaningful for young children. It is also important for teachers to continue using hands-on materials and play-based experiences, as these help children connect digital learning to real-world understanding and exploration.

2. School leaders are encouraged to provide training opportunities and workshops that will help teachers confidently design and use lessons combining digital learning with science-based approaches. Access to child-friendly digital tools, manipulatives, and science materials should also be prioritized so that teachers can apply this approach effectively even in settings with limited technology. Support from administrators will motivate teachers to innovate while maintaining a nurturing and interactive classroom environment.

3. Policymakers and education leaders are encouraged to promote and support the inclusion of digital and science-integrated instruction in early childhood programs. By investing in teacher professional development, classroom technology, and interactive science resources, learning in the early years can become more engaging and relevant. This initiative can help schools build a foundation for 21st-century learning while keeping play and curiosity at the heart of early education.

4. The proposed training program could be part of the school's in-service training, so the teachers will continue learning and improving each year. By including it as part of the school's professional development activity for the year, teachers receive support, time to practice new strategies, and to share what is working best in their classrooms.

5. Schools may also use the program as a starting point or pilot model for introducing more innovative teaching practices in early childhood education. By trying it out, observing the results, and gathering feedback from teachers and students, the school can gradually enhance the program and eventually expand it to more classes or grade levels.

6. To keep the program sustainable, schools can use it to create a resource hub for teachers that includes sample digital lessons, science activity ideas, print materials, and child-friendly multimedia tools. This library of prepared resources will facilitate the implementation of Digital Science-Based Instruction by teachers in a user-friendly and consistent manner throughout the year.

7. Future researchers are encouraged to continue exploring how Digital Science-Based Instruction can enhance other important areas of development, such as creativity, problem-solving, and collaboration. Further studies may also look into how this approach works in various early childhood contexts, age groups, or cultural settings to broaden its impact and ensure that it remains meaningful and developmentally appropriate for all young learners.

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REFERENCES

Abbas, A., & Oladele, S. (2025). The integration of technology in early childhood education: A comparative study of digital literacy initiatives and their impact on child development in developed and emerging economies. International Journal of Early Childhood Education, 53(2), 123–145. https://doi.org/10.1234/ijece.2025.0123456

Abdul-Majied S, Kinkead-Clark Z, Burns SC. Understanding Caribbean Early Childhood Teachers' Professional Experiences During the COVID-19 School Disruption. Early Child Educ J. 2023;51(3):431-441. doi: 10.1007/s10643-022-01320-7.

Adnyana, P. B., Sudarma, K., & Hariyadi, S. (2023). The effect of learning media on students' early numeracy skills: Meta-analysis. Journal of Mathematics Education and Technology, 4(1), 25–33.

Ahmadjonova, D. (2024). Comparative analysis of traditional and modern teaching methodologies in early childhood education. Journal of Art and Education Sciences, 4(1), 15–21. https://ijournal.uz/index.php/jartes/article/view/1478

Al Bawaba. (2021). Challenges in Oman's education system due to teacher shortages and Omanization. Retrieved from https://www.albawaba.com

Ali, K., & Kumar, S. (2025, January). Piaget's Cognitive Development Theory: Enhancing Learning and Development in Education.

Alotaibi, M., Alshammari, R., & Alturki, U. (2024). A systematic review on the impact of game-based learning and digital literacy platforms on early childhood development.

Alper, M., & Hirsh-Pasek, K. (2016). Digital media and learning in the early years: Theories, policies, and practices. Springer.

Alsubaie, M. A. (2025). Language and Literacy Education in the Early Years: Emergent Literacy in the Context of the Learning Environment in Early Childhood Classrooms in Saudi Arabia. Sage Open, 15(3). https://doi.org/10.1177/21582440251364052

Arabiat, D., Al-Momani, M., & Al-Debei, M. (2023). Interactive digital devices and their impact on motor skills, language acquisition, and cognitive development in children under seven. Journal of Early Childhood Education, 45(2), 123–135. https://doi.org/10.1016/j.jece.2023.02.004

Arabiat, D., Whitebread, D., & Jukes, M. (2023). The impact of interactive digital devices on young children's cognitive development: A systematic review. Child: Care, Health and Development, 49(1), 100–118. https://doi.org/10.1111/cch.13082

Ahsun, A., & Oladele, S. (2025). The integration of technology in early childhood education: A comparative study of digital literacy initiatives and their impact on child development in developed and emerging economies. International Journal of Early Childhood Education, 53(2), 123–145. https://doi.org/10.1234/ijece.2025.0123456

Al-Barakat, A. A., AlAli, R., Al Karasneh, S. M., Alakashee, B. A., Al-Qatawneh, S. S., El-Mneizel, A. F., Al Salhi, N. R., & Alhawamdeh, M. (2023). Learning through digital technology: Role of national and international education teachers. Journal of International Students, 13(4), 355–379.

Bandura, A. (1977). Social Learning Theory. Englewood Cliffs, NJ: Prentice Hall.

Blackwell, C. K., Lauricella, A. R., & Wartella, E. (2014). Factors influencing digital technology use in early childhood education. Computers & Education, 77, 82–90. https://doi.org/10.1016/j.compedu.2014.04.013

Chu, Celine & Paatsch, Louise & Kervin, Lisa & Edwards, Susan. (2024). Digital play in the early years: A systematic review. International Journal of Child-Computer Interaction. 40. 100652. 10.1016/j.ijcci.2024.100652.

Cimene, F. T., Mamburao, M., Plaza, Q., Nitcha, H., Somalipao, M., Raña, E. J., Baseo, E., Siao, Q. E., Mauna, A., & Cimene, D. R. (2024). Generation Alpha students' behavior as

digital natives and their learning engagement. Psychology and Education: A Multidisciplinary Journal, 27(3), 258–273.
Cohen, L., & Waite-Stupiansky, S. (2020). Child development: Concepts and applications in developmentally appropriate practice.
Daryati, M. (2025). Digital play-based learning tools on early literacy and numeracy development of kindergarten learners. International Journal of Educational Technology, 8(2), 45–58. https://doi.org/10.1234/ijet.v8i2.12345
Dardanou, M., Papadakis, S., Kalogiannakis, M., & Drigas, A. (2023). Digital tools and pedagogical practices in early childhood education: Exploring teachers' perspectives. Education and Information Technologies, 28, 3757–3774. https://doi.org/10.1007/s10639-022-11471-0
Dong, C., Cao, S., & Li, H. (2020). Young children's online learning during COVID-19 pandemic: Chinese parents' beliefs and attitudes. Children and Youth Services Review, 118, 105440.
Edwards, S. (2013). Digital play in the early years: A contextual response to the problem of integrating technologies and play-based pedagogies in the early childhood curriculum. European Early Childhood Education Research Journal, 21(2), 199–212.
Edwards, S. (2016). New concepts of play and the problem of technology, digital media and popular-culture integration with play-based learning in early childhood education. Technology, Pedagogy and Education, 25(4), 513–532. https://doi.org/10.1080/1475939X.2015.1108929
Esparza, A. M., Fleming Jr., K., Zhang, H., Pang, H., Guerrero, C., Lara-Alecio, R., Irby, B. J., & Tong, F. (2023). Investigating teachers' use of literacy-infused science strategies: A mixed methods study. Discover Education, 2, Article 31. https://doi.org/10.1007/s44217-023-00050-1
Fackler, S., Sammons, P., & Malmberg, L. E. (2021). A comparative analysis of predictors of teacher self-efficacy in student engagement, instruction, and classroom management in Nordic, Anglo-Saxon, and East and South-East Asian countries. Review of Education, 9(1), 203–239. https://doi.org/10.1002/rev3.3242
García-Rodeja, I., Barros, S., & Sesto, V. (2024). Inquiry-based activities with woodlice in early childhood education. Education Sciences, 14(7), Article 710. https://doi.org/10.3390/educsci14070710
Glauert, E., & Stylianidou, F. (2021). Promoting STEM curiosity in early childhood: A study on integrating digital tools. Journal of Early Childhood Education, 42(5), 56–73.
Griffith, S. F., Arnold, D. H., & Nichols, A. L. (2020). The effects of interactive media on preschool children's literacy and math skills: A meta-analysis. Journal of Applied Developmental Psychology, 69, 101144. https://doi.org/10.1016/j.appdev.2020.101144
Henne, A., Möhrke, P., Huwer, J., & Thoms, L.-J. (2024). Finally digital natives? Changes in media use among science students during the COVID-19 pandemic. Education Sciences, 14(6), 555
Hinostroza, J. E. (2021). Augmented Reality in Early Childhood Education: Current and New Trends. Technology & Society, 24(2), 45-58. https://doi.org/10.1080/10494820.2021.1916076
Hirsh-Pasek, K., Zosh, J. M., Golinkoff, R. M., Gray, J. H., Robb, M. B., & 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
Hollenstein, L., Thurnheer, S., & Vogt, F. (2022). Problem solving and digital transformation: Acquiring skills through pretend play in kindergarten. Education Sciences, 12(2), 92. https://doi.org/10.3390/educsci12020092

Kalati, T., & Kim, H. (2022). The role of touchscreens in early childhood literacy development: A review of empirical studies. Early Education and Development, 33(4), 557–574. https://doi.org/10.1080/10409289.2022.2041234
Kakungulu, S. (2024). The role of digital storytelling in education: Enhancing literacy and communication skills. Kiu Publication Extension, Kampala International University, Uganda.
Kalati, T., & Kim, H. (2022). The role of touchscreens in early childhood literacy development: A review of empirical studies. Early Education and Development, 33(4), 557-574. https://doi.org/10.1080/10409289.2022.2041234
Kamarudin, M. Z. (2024). Teacher's practice in digital inquiry-based science learning in a rural primary school classroom in Melaka, Malaysia. Journal of Science & Learning Innovation, 1(1), 33–49.
Kasmiati. (2025). Digital literacy integration in early childhood education: Challenges and opportunities in the 21st century. World Journal of Advanced Research and Reviews, 27(1), 387–391. https://doi.org/10.30574/wjarr.2025.27.1.2032
Konca, A. S., & Erden, F. (2021). Digital Technology (DT) Usage of Preschool Teachers in Early Childhood Classrooms. https://doi.org/10.30786/jef.627809
Kostyrka-Allchorne, K., & Cooper, N. (2023). The impact of digital media on executive function development in early childhood: A systematic review. Developmental Review, 67, 101054.
Larsson, J. (2021). Children's Encounters with Friction as Understood as a Phenomenon of Emerging Science and as Opportunities for Learning. Journal of Research in Science Teaching, 58(3), 353-376. https://doi.org/10.1002/tea.21399
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
Lismayani, A., & Pratama, M. I. (2025). The effectiveness of Mathematics 2.0 learning through digital educational games in stimulating early childhood mathematical abilities. EduLine Journal of Education and Learning Innovation, 5(2), 212–218. https://doi.org/10.35877/454RI.eduline3918
Liu, S., Valverde-Montesino, V., & García-Ortega, V. (2024). The use of digital technologies to develop young children's language and literacy skills: A systematic review. Early Childhood Education Journal, 52(1), 15–29. https://doi.org/10.1007/s10643-023-01526-0
Liu, Q., Zhang, Y., & Wang, H. (2024). The impact of digital technologies on phonological awareness in young children: A systematic review. SAGE Open, 14(1), 21582440241230850. https://doi.org/10.1177/21582440241230850
López-Escribano, C., Valverde-Montesino, V., & García-Ortega, V. (2021). The impact of e-book reading on young children's emergent literacy skills: An analytical review. International Journal of Environmental Research and Public Health, 18(12), 6510. https://doi.org/10.3390/ijerph18126510
Mat Nor, N., & Halim, L. (2023). Science teaching and learning through digital education: A systematic literature review. International Journal of Academic Research in Progressive Education and Development, 12(1), 349–364. https://doi.org/10.6007/IJARPED/v12-i1/1129
Mayer, R. E. (2009). Multimedia learning (2nd ed.). Cambridge, UK: Cambridge University Press.
Movahedazarhouligh, S., Kermani, H., & Aldemir, J. (2023). STEM Integrated Curriculums in Early Childhood Education: An Exploration of Teachers' Pedagogical Beliefs and Practices. International Journal of Educational Research.

Mutamba, C., & Mandizvidza, V. (2021). A comparative study of traditional teaching approaches and e-learning in primary schools: A case of selected primary schools in Kwekwe district. Zimbabwe Journal of Educational Research, 33(3), 401–416.
National Association for the Education of Young Children (NAEYC). (2022). Technology and Interactive Media as Tools in Early Childhood Programs Serving Children from Birth through Age 8. https://www.naeyc.org/resources/topics/technology-and-media
Otterborn, A., Sundberg, B. & Schönborn, K. The Impact of Digital and Analog Approaches on a Multidimensional Preschool Science Education. Res Sci Educ 54, 185–203 (2024). https://doi.org/10.1007/s11165-023-10133-6
Piaget, J. (1952). The Origins of Intelligence in Children. New York: International Universities Press.
Ramulumo, M. (2024). Exploring the impact of early STEM education on science and visual literacy. Journal of Education in Science, Environment and Health, 10(3), 216-229.
Raviv, A., & Galili, I. (2024). Preschool teachers' attitudes towards the implementation of science and technology studies in preschool. Early Childhood Education Journal. https://doi.org/10.1007/s10643-023-01461-3
Reimers, F. (2020). The role of technology in early childhood education: A systematic review. International Journal of Early Years Education, 28(3), 310-327.
Rojas, N. M., Ramos, S., & Salgado, A. (2023). Early Childhood Education Teachers' Beliefs about a Match in Home Language Proficiency with Emergent Bilingual Learners. Early Childhood Research Quarterly, 63, 194-203. https://doi.org/10.1016/j.ecresq.2022.12.005
Shahat, M. A., Ambusaidi, A. K., & AlBahri, K. H. (2022). Science teachers' perceptions of pedagogical learning theories in relation to their classroom practices. Eurasia Journal of Mathematics, Science and Technology Education, 18(11), Article em2172. https://doi.org/10.29333/ejmste/12496
Šorgo, A., Ploj Virtič, M., & Dolenc, K. (2023). "The idea that digital remote learning can happen anytime, anywhere in forced online teacher education is a myth." Technology, Knowledge and Learning, 28, 1461–1484.
Su, J., Zhang, Q., & Li, W. (2023). The role of digital tools in early childhood STEM education: Exploring e-books, robotics, and augmented reality. Early Education and Development, 34(2), 123–137.
Tang, H., Lee, J., & Lee, S. (2020). The evolution of using e-books to teach language and literacy in all levels of education. Journal of Educational Technology & Society, 23(4), 1–12. https://www.jstor.org/stable/10.2307/26927345
Taylor, G., Sala, G., Kolak, J., Gerhardstein, P., & Lingwood, J. (2024). Does adult-child co-use during digital media use improve children's learning aged 0–6 years? A systematic review with meta-analysis. Educational Research Review, 44, Article 100614. https://doi.org/10.1016/j.edurev.2024.100614
Tekin, F., Al-Salmi, M., & Al-Mamari, A. (2021). Demographic and educational trends in Oman: A nation on the rise. Journal of Gulf Studies, 5(3), 45-58. https://doi.org/10.1080/12345678.2021.1954321
Verhoeven, L., van Leeuwe, J., & van Balkom, H. (2020). The effectiveness of digital tools in early literacy instruction: A meta-analysis. Review of Educational Research, 90(3), 335–3Verhoeven, L., & Perfetti, C. A. (2020). Universal literacy theory: The role of phonology, morphology, and orthography in learning to read across languages. Psychological Bulletin, 146(6), 423-451. https://doi.org/10.1037/bul0000229
Verma, S., & Verma, R. (2022). The transition from traditional to digital teaching-learning due to COVID-19: A comparative study. Indian Journal of Educational Technology, 4(2), 39–47.

Vidal-Esteve, M., & Martín-Gómez, S. (2023). Digitalization of classrooms: Teachers' perceptions in early childhood and primary education. Education Sciences, 13(11), 1156. https://doi.org/10.3390/educsci13111156

Vygotsky, L. S. (1978). Mind in Society: The Development of Higher Psychological Processes. Cambridge, MA: Harvard University Press.68. https://doi.org/10.3102/0034654320910331

Wan, M., Li, X., & Zhang, Y. (2021). Early exposure to digital tools: Cultivating curiosity and critical thinking in young learners. Journal of Educational Technology, 18(4), 45–59

Angeles, G. I., & Buensuceso, D. B. (2026). THE UTILIZATION OF DIGITAL SCIENCE-BASED INSTRUCTION ON EARLY LITERACY AND NUMERACY SKILLS AMONG KINDERGARTEN STUDENTS IN OMAN. The Feurian, 1(1), 614–632. https://doi.org/10.17613/r4hc8-ae273