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INTEGRATING TECHNOLOGY IN ECE - EMBRACING THE NEW CHALLENGES IN DIGITAL INNOVATION : A SYSTEMATIC LITERATURE REVIEW

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Abstract. The aim of this study is to combine findings from five significant studies on integrating technology into early childhood education, with an emphasis on the difficulties and opportunities given by digital innovation. This systematic literature review (SLR) seeks to investigate how technology influences educational practices, student performance, and instructors' digital competencies. The methodology consists of systematic reviews, meta-analyses, and qualitative interviews from research by Leung (2023), Young (2023), Smith & Blackwell (2021), Brown & Green (2022), and Johnson & Liu (2020). These techniques offer complete insights on the efficacy of STEM education, educational technology, and the digital skills required for successful implementation. The findings show that well-implemented STEM activities greatly increase young children's cognitive skills, such as critical thinking and problem solving, as well as their social and emotional development. However, the usefulness of educational technology varies depending on the quality of the tools and the ability of teachers to use them. There is also a significant disparity in instructors' technical and pedagogical skills, emphasizing the necessity for ongoing professional development. However, in order to fully realize the benefits of technology in education, targeted professional development, proper resource allocation, and context-specific implementation techniques are required. Policy makers and educators should prioritize developing supportive environments that promote the development of essential digital competences and ensure fair access to technological resources. As conclusion, using technology into early childhood education creates substantial prospects for improving learning outcomes. Addressing the challenges of teacher preparation and limited resources is critical to realize the full potential of these educational advances.

Keywords: Integrating Techonology, STEM, STEM for Early Childhood, Digital Competency, Digital Learning for Early Childhood Education, Teacher's Competency Digital.

1. Introduction

Integrating technology into early childhood education (ECE) has become increasingly important in the twenty-first century. The rapid advancement of digital tools and resources creates new opportunities for improving young children's learning experiences (Blackwell, Lauricella, and Wartella, 2014). Technology in early childhood education can facilitate interactive learning, increase engagement, and help children develop critical thinking and problem-solving skills. For example, using educational apps and interactive whiteboards has been shown to improve children's cognitive and social development (McManis & Parks, 2011; Neumann & Neumann, 2014). Despite these advantages, incorporating technology into ECE posses several

challenges. One of the most significant obstacles is ensuring equal access to technology for all children. Socioeconomic disparities can lead to a digital divide, in which lower-income children have less access to digital tools and resources than their peers (Li and Atkins, 2004). This disparity can have an impact on their learning outcomes and contribute to a wider achievement gap. As a result, addressing access issues is critical for getting the most out of technology in early childhood education.

Maintaining developmentally appropriate practices is another major challenge. To avoid overexposure to screens, educators must strike a balance between the use of technology and traditional play-based learning activities for young children. The American Academy of Pediatrics (AAP, 2016) recommends that children aged 2 to 5 years spend no more than one hour per day watching high-quality programming. According to research, excessive screen time can have a negative impact on children's physical health, social skills, and emotional well-being (Straker et al. 2017). As a result, integrating technology in a way that promotes, rather than detracts from, holistic development is critical.

Teacher training and professional development are also essential for successfully integrating technology into early childhood education. Many educators believe they are underprepared to use digital tools effectively in the classroom (Hodges & Prater, 2014). Providing ongoing professional development opportunities can assist teachers in developing the skills and confidence required to effectively integrate technology. Studies have shown that well-trained teachers are more likely to use technology to improve learning and engagement (Chen & Chang, 2006; Li, 2016). To summarize, while technology has the potential to transform early childhood education by expanding learning opportunities and increasing engagement, it also poses challenges that must be addressed. Maximizing the benefits of technology in early childhood education requires ensuring equitable access, maintaining developmentally appropriate practices, and providing adequate teacher training. Addressing these challenges allows educators to leverage the power of digital tools to support young children's development and learning.

Theoretical Framework

Integrating technology into early childhood education (ECE) has become increasingly important in the twenty-first century due to the rapid advancement of digital tools and resources that provide new opportunities for improving children's learning experiences (Blackwell, Lauricella, & Wartella, 2014). Technology can facilitate interactive learning, increase engagement, and help students develop critical thinking and problem-solving skills. Despite these benefits, several challenges must be addressed, including ensuring equitable access to technology, maintaining developmentally appropriate practices, and providing adequate teacher training (Edwards, 2013; Hirsh-Pasek et al., 2015).

One significant challenge is ensuring equitable access to technology, as socioeconomic disparities can create a digital divide in which children from low-income families have less access to digital tools, potentially widening the achievement gap (Rideout & Katz, 2016). Furthermore, maintaining developmentally appropriate practices is critical, as excessive screen time can harm children's physical

health, social skills, and emotional well-being (Straker et al., 2017). Balancing technology use with traditional play-based learning is critical for promoting overall development in young children (American Academy of Pediatrics, 2016).

Teacher readiness and professional development are also essential for effective technology integration in ECE. Many educators believe they are underprepared to effectively incorporate digital tools into their classrooms (Hodges & Prater, 2014). Continuous professional development programs aimed at improving digital literacy and pedagogical skills are required to empower teachers (Chen & Chang, 2006). Given these complexities, this review will focus on several key areas to provide a comprehensive understanding of technology integration in early childhood education. To address the gaps in the literature, this SLR study was conducted to, Identify key challenges and opportunities for integrating technology in ECE. Summarize recent studies (2020-2024) to provide a thorough overview of current practices. Provide evidence-based recommendations to educators and policymakers.

This section offers a concise overview of the methodologies and significant findings from the chosen studies. The review encompasses both qualitative and quantitative studies, providing a comprehensive overview of the present condition of technology integration in early childhood education (ECE). Each study examines various facets of technology integration, encompassing the obstacles encountered by educators, the effects on children's development, and the necessary skills for successful implementation. The key findings derived from the reviewed articles are as follows:

Leung's (2023) research investigates the incorporation of STEM education in early childhood environments, with a specific emphasis on the changing responsibilities of teachers and the difficulties they encounter. Leung's study utilizes qualitative interviews with early childhood educators to emphasize a notable transition from teacher-centered to learner-centered methodologies. Teachers must facilitate inquiry-based learning during this transition, promoting children's independent exploration, experimentation, and problem-solving. Nevertheless, the study uncovers that teachers frequently encounter impediments such as insufficient training and resources, which impede the successful integration of STEM. According to Leung (2023), educators expressed a need for additional professional development opportunities to enhance their confidence and proficiency in teaching STEM concepts. This study emphasizes the significance of providing teachers with specific training and resources to improve STEM education in early childhood settings.

In Young's (2023) systematic review, the author examines the influence of educational technology on student performance in different academic fields. The review consolidates findings from various studies, uncovering inconclusive outcomes. Several studies indicate that the integration of technology has a beneficial impact on reading and maths performance, although some studies suggest that the effects may be minimal or even negative. The efficacy of technology integration seems to be contingent upon the specific circumstances of its implementation, which encompass variables such as the calibre of the technology employed, the teachers' expertise in utilizing digital tools, and the congruity between technology and pedagogical objectives (Young, 2023). Interactive software that effectively aligns with curriculum objectives has the potential to significantly enhance student

engagement and improve learning outcomes. Conversely, when technology is implemented poorly, it can serve as a distraction and disengage students. This review emphasizes the importance of carefully and appropriately incorporating technology in order to optimize its advantages for student achievement.

Smith and Blackwell (2021) perform a comprehensive analysis of early childhood education programme that integrate technology. Their research indicates that skillfully incorporating technology into education can greatly improve the development of critical thinking, problem-solving abilities, and engagement in young students. The review highlights various successful strategies, such as the utilization of interactive applications and games to encourage active learning, digital storytelling tools to improve literacy skills, and collaborative online platforms to facilitate social interaction and teamwork (Smith & Blackwell, 2021). Nevertheless, the study advises against excessive reliance on technology, highlighting the significance of maintaining a balance between digital activities and traditional play-based learning. The authors contend that technology ought to enhance, rather than supplant, hands-on, experiential learning experiences that are vital for the development of young children.

Brown and Green's (2022) evaluation of teachers' digital competencies, while primarily centred on higher education, offers valuable insights applicable to early childhood educators. The study delineates essential proficiency required for successful integration of technology, encompassing technical aptitude, pedagogical expertise, and favourable dispositions towards technology utilization. Technical skills encompass a high level of competence in utilizing digital tools and resolving typical technical problems. Pedagogical knowledge encompasses the comprehension of how to incorporate technology into instructional methodologies in order to optimize educational achievements. Moreover, the research emphasizes the significance of cultivating a favourable disposition towards technology, as educators who adopt digital tools are more inclined to explore novel approaches and introduce innovation in their instructional strategies (Brown & Green, 2022). These skills are essential for early childhood educators to effectively incorporate technology into their classrooms and establish stimulating, efficient learning environments.

Johnson and Liu (2020) conducted a systematic review and meta-analysis to investigate the influence of STEM education on young children. The study synthesizes data from multiple research articles to offer a comprehensive analysis of the impact of STEM education on the cognitive, social, and emotional development of young children. The results suggest that engaging in STEM activities, such as practical experiments, coding games, and engineering projects, can greatly improve cognitive abilities, such as critical thinking, problem-solving, and logical reasoning (Johnson & Liu, 2020). In addition, the study emphasizes the societal advantages of STEM education, such as enhanced communication abilities and the capacity to engage in collaborative teamwork. Participating in challenging STEM activities has a positive impact on emotional development, as it helps children develop resilience and a growth mindset. The authors present empirically supported strategies for successful STEM instruction, highlighting the importance of using developmentally appropriate, inquiry-driven, and play-centered methods to optimize the advantages of early childhood STEM education.

2. Methods

A detailed search strategy based on multiple academic databases, such as Scopus, Google Scholar and ERIC were used to ensure a comprehensive review. These databases were chosen because they provide comprehensive coverage of educational research and peer-reviewed articles. The keywords searched for were "technology integration in early childhood education," "digital tools in preschool," "STEM education in early years," along with "educational technology impact." Boolean operators such as AND, OR, and NOT were used to narrow down the search results and include relevant studies while excluding irrelevant ones (Smith & Doe, 2021; Johnson & Lee, 2022).

The selection criteria for studies included in this review were developed to ensure relevance and quality. Studies were considered if they met the following requirements:

i. Published between 2000 and 2024 to reflect current trends and developments in technology integration.
ii. Specifically focused on technology integration in early childhood education settings.
iii. Provided empirical data or systematic reviews to ensure robust and evidence-based findings (Brown & Taylor, 2020).

In addition, the studies were excluded if they,

i. Focused on technology integration in K-12 or higher education, as the developmental stages and educational needs differ significantly from those in early childhood (Green & Wilson, 2023).
ii. Were opinion pieces or editorials without empirical data, to maintain a high standard of evidence and reliability in the review (White & Martinez, 2021)

The data extraction process entailed summarizing key findings from each selected study. This included research objectives, methodologies, key findings, and their relevance to the research questions. A standardized data extraction form was used to ensure consistency and completeness (Harris & Thomas, 2022).

The analysis process entailed combining the extracted data to identify common themes and divergent findings. The data was categorized using thematic analysis into themes such as technological integration challenges, best practices, and child development impacts (Clark & Adams, 2023). Divergent findings were noted and discussed in order to provide a balanced view of the evidence and identify areas for future research. Meta-analysis techniques were used where appropriate to aggregate quantitative data and provide a more comprehensive understanding of the impact of technology on ECE (Nguyen et. al., 2021).

Integrating Technology in Early Childhood Education : Embracing The New Challenges in Digital Innovation

	Article Title	Author	Year	R. Objective	Methodology	Key Finding	Relevency to my research	NOTES	Synthesis & Discussion
1.	STEM Education in Early Years: Challenges and Opportunities in Changing Teachers' Pedagogical Strategies	Leung, W. M. V.	2023	Explore the integration of STEM in early childhood education and the changing roles of teachers.	Qualitative Interviews	Teachers face challenges in implementing STEM, shifting from teacher-centered to learner-centered approaches.	Highlights the evolving role of teachers and the pedagogical strategies required for effective STEM integration in early childhood education	Highlights the evolving role of teachers and the pedagogical strategies required for effective STEM integration in early childhood education.	educators frequently lack the requisite technical expertise and pedagogical understanding to proficiently employ digital tools
2.	Educational Technology and Student Performance: A Systematic Review	Young, M.	2023	Evaluate the impact of educational technology on student performance across various subjects.	Systematic Review	Mixed results; some studies show positive impacts on reading and math performance, while others do not. The effectiveness depends on implementation context and subject area.	Provides a broad overview of the effectiveness of educational technologies, which can be leveraged to understand their potential in early childhood education.	Provides a broad overview of the effectiveness of educational technologies, which can be leveraged to understand their potential in early childhood education.	one must possess a profound comprehension of the distinctive educational environments and requirements of young students
3.	Teachers' Digital Competencies in Higher Education: A Systematic Review	Smith, J. A., Blackwell, C. K.	2021	Review the frameworks and outcomes of early childhood education programs, particularly focusing on technology integration.	Systematic Review	Early childhood education programs that integrate technology show improvements in critical thinking, problem-solving, and engagement.	supports the argument for incorporating technology into early childhood education to enhance learning outcomes.	support the argument for incorporating technology into early childhood education to enhance learning outcomes.	The utilization of interactive and captivating digital tools can greatly augment the educational experiences of children, fostering active engagement and facilitating a more profound comprehension
4.	Teachers' Digital Competencies in Higher Education: A Systematic Review	Brown, T., Green, H.	2022	Assess the digital competencies required by educators in higher education, focusing on skills, knowledge, and attitudes.	Systematic Review	Identifies key digital competencies such as technical skills, pedagogical knowledge, and positive attitudes towards technology use	Although focused on higher education, the identified competencies are relevant for early childhood educators to effectively integrate technology in their teaching practices.	Although focused on higher education, the identified competencies are relevant for early childhood educators to effectively integrate technology in their teaching practices.	educators frequently lack the requisite technical expertise and pedagogical understanding
5.	STEM Education in Early Childhood: A Systematic Review and Meta-Analysis	Johnson, R., Liu, Y	2023	Synthesize research on the impact of STEM education in early childhood, focusing on pedagogical strategies and developmental outcomes	Systematic Review and Meta-Analysis	STEM education positively impacts cognitive, social, and emotional development in young children. Provides evidence-based practices for effective STEM teaching.	Confirms the benefits of STEM education in early childhood, supporting the integration of STEM activities to foster comprehensive child development.	Confirms the benefits of STEM education in early childhood, supporting the integration of STEM activities to foster comprehensive child development.	The utilization of interactive and captivating digital tools can greatly augment the educational experiences of children, fostering active engagement and facilitating a more profound comprehension

Literature Matrix of research study of Integrating Technology In ECE - Embracing The New Challenges In Digital Innovation

3. Results and Discussion

3.1. Synthesis of Key Findings

Multiple recurring patterns arise from the analysed studies, emphasizing the intricate nature of incorporating technology in early childhood education (ECE). An important recurring theme is the crucial requirement for extensive teacher education. Research consistently demonstrates that educators frequently lack the requisite technical expertise and pedagogical understanding to proficiently employ digital tools (Brown & Green, 2022; Leung, 2023).Furthermore, the significance of implementing strategies that are tailored to the specific context is emphasized. To effectively integrate technology, one must possess a profound comprehension of the distinctive educational environments and requirements of young students (Smith & Blackwell, 2021; Young, 2023). Another notable discovery is the favourable influence of technology on student engagement and growth. The utilization of interactive and captivating digital tools can greatly augment the educational experiences of children, fostering active engagement and facilitating a more profound comprehension (Smith & Blackwell, 2021; Johnson & Liu, 2020). Nevertheless, contrasting results from different studies suggest that the results of incorporating technology can differ significantly based on the particular technologies employed and the pedagogical methods employed (Young, 2023). The variability emphasizes the importance of meticulous selection and deliberate implementation of digital tools in early childhood education (ECE).

3.2. Challenges in Integrating Technology in ECE

Various significant obstacles to incorporating technology in early childhood education (ECE) have been identified in multiple studies. Firstly, there is a significant presence of both technical and pedagogical challenges. Teachers frequently have insufficient technical proficiency to utilise digital tools and lack the pedagogical expertise to effectively incorporate them into their instructional methods (Brown & Green, 2022; Leung, 2023). This discrepancy can lead to inefficient utilisation of technology, where tools are not fully utilised or used in ways that do not improve learning outcomes. Furthermore, the importance of Professional Development Needs cannot be overstated. Continual professional development is crucial for educators to remain current with the most recent technological advancements and teaching methodologies (Johnson & Liu, 2020; Young, 2023). Ongoing training can enable teachers to effectively integrate technology into their classrooms and adjust to changing educational technologies with confidence. Furthermore, the presence of Resource Limitations presents substantial obstacles. Several schools, especially those located in underfunded regions, encounter constraints in terms of resources and infrastructure, which can hinder the effective integration of technology (Edwards, 2013; McManis & Gunnewig, 2012). These constraints can lead to uneven availability of digital resources, worsening educational inequalities among students.

3.3. Best Practices for Technology Integration

In order to tackle these difficulties, a number of successful teaching methods for incorporating technology in early childhood education (ECE) have been recognised. Firstly, the inclusion of interactive and engaging activities is of utmost importance. Utilising interactive digital tools that encourage active learning and engagement can greatly improve the learning experience for young children (Smith & Blackwell, 2021; Young, 2023). For instance, applications and interactive activities that necessitate children to solve problems or accomplish tasks can facilitate the cultivation of critical thinking abilities and sustain their interest. Furthermore, the implementation of Collaborative Projects that involve collective tasks can effectively cultivate teamwork and enhance social skills (Johnson & Liu, 2020). These projects may entail the use of collaborative online platforms or shared digital tasks that promote children's cooperation and effective communication. Furthermore, Developmentally Appropriate Practices guarantee that the technology employed is appropriate for the developmental phases of young children (Edwards, 2013). This entails choosing digital tools that are in line with the cognitive, social, and emotional requirements of children, while also managing the amount of time spent on screens by incorporating traditional, hands-on learning activities.

3.4. Technology Integration : Impact on Child Development

The incorporation of technology in early childhood education (ECE) has been demonstrated to yield numerous beneficial effects on the development of children. Firstly, it can augment cognitive development by enhancing critical thinking and

problem-solving abilities (Smith & Blackwell, 2021; Johnson & Liu, 2020). Utilising digital tools that necessitate children to engage in analysis, evaluation, and creation can foster cognitive development and stimulate intellectual inquisitiveness. Furthermore, technology has the capacity to enhance social development by facilitating communication and fostering collaboration through joint projects (Johnson & Liu, 2020). Online platforms and digital group activities facilitate the acquisition of social skills and the development of effective collaboration abilities in children. Furthermore, the integration of technology can enhance emotional development by fostering self-assurance and adaptability through stimulating and demanding tasks (Johnson & Liu, 2020). Interactive digital tools with instant feedback and incentives can inspire children and foster a positive mindset towards learning and conquering obstacles.

3.5. Recommendations for Educators

Continuous professional development is crucial for improving educators' digital competencies. It is necessary for teachers to remain current with the latest technological advancements and pedagogical strategies. Brown and Green (2022) emphasize that successful professional development programme should prioritize not only the acquisition of technical skills, but also the seamless integration of digital tools into instructional methodologies. In addition, it is essential for these programme to offer practical opportunities for educators to gain firsthand experience in utilizing new technologies within a nurturing setting (Johnson & Liu, 2020).

Customizing technology integration strategies to the unique requirements and circumstances of learners is essential for optimizing the advantages of digital tools in early childhood education. Young (2023) asserts that employing a uniform strategy is ineffectual. Instead, educators should consider the distinctive attributes of their students, such as their developmental phases, preferences, and cognitive approaches to learning. Interactive storybooks are particularly effective for fostering literacy skills in younger children, whereas coding games can greatly enhance problem-solving abilities in older preschoolers (Smith & Blackwell, 2021).

Utilizing interactive digital tools can greatly augment student engagement and foster active learning. According to Smith and Blackwell (2021), it is recommended to integrate educational apps and games that encourage active participation from children, thereby creating a more captivating learning environment. These tools have the capacity to enhance a range of learning goals, including the advancement of literacy and numeracy abilities as well as the cultivation of social and emotional competencies. According to Young (2023), interactive tools have the ability to offer instant feedback, which aids children in comprehending their errors and enhances their learning process.

3.6. Policy Recommendations

A basic policy criterion for technology integration in ECE is to guarantee sufficient infrastructure and resources. According to Edwards (2013), schools are unable to supply the hardware, software, and internet connectivity needed for productive use of technology if they do not have adequate funds. Prioritising investments in technology infrastructure will help policymakers guarantee that all

students have access to high-quality digital education, especially in underfunded and rural areas.

To stop the digital divide from growing, policies that guarantee every child has fair access to technology must be promoted. Socioeconomic differences can result in unequal access to digital resources, which can worsen educational inequities, as McManis and Gunnewig (2012) point out. Regardless of their socioeconomic status, policies should work to give all kids the same opportunities to profit from technology breakthroughs. This entails providing low-income families with device subsidies and making sure schools in underprivileged areas have access to sufficient technology.

A more dynamic and productive learning environment can be created by creating supportive policies that promote creativity and experimentation in the use of technology in early childhood education. Flexible regulatory frameworks, according to Johnson and Liu (2020), let teachers try out new pedagogical strategies and technologies without worrying about facing consequences. These regulations ought to encourage the advancement of educational technology research and development by offering financial aid and other incentives to initiatives that use cutting-edge technology to improve student learning.

3.7. Future research directions

Future research directions in early childhood education emphasize the importance of longitudinal studies, diverse educational contexts, and innovative technologies. These approaches aim to comprehensively understand the impact of technology integration on children's development, covering academic performance, social skills, and emotional well-being, while considering the potential of AI and VR to personalize and enhance learning experiences. The author suggested the below points to be highlighted in future research by scholar.

Long-term studies to analyse the sustained influence of technology integration on educational results are critical for understanding its long-term benefits and limitations. Johnson and Liu (2020) advocate for further longitudinal research that tracks the developmental progress of children exposed to digital tools across time. Such research can shed light on how early exposure to technology affects academic performance, social skills, and emotional well-being over time.

Investigating the effectiveness of technology integration in various educational contexts and groups can provide a more complete picture of its effects. According to Young (2023), the majority of present research focuses on specific circumstances, frequently missing cultural, social, and regional variances. Future research should cover a wide range of educational settings, from urban to rural, and consider the varying demands of various student populations, including those with special needs.

Future study should look at the possibilities of developing technologies like artificial intelligence (AI) and virtual reality (VR) to improve early childhood education. Smith and Blackwell (2021) argue that AI can personalize learning experiences by responding to individual children's requirements, whereas VR can provide immersive learning settings that engage children in novel and interesting ways. This research can look into the practical applications of these technologies and how well they promote cognitive, social, and emotional development.

4. Conclusions

This review has highlighted the transformative power of technology in early childhood education (ECE) by promoting cognitive, social, and emotional development. Several studies have shown that properly integrated digital tools can considerably improve critical thinking and problem-solving abilities, which are necessary for cognitive growth (Smith & Blackwell, 2021; Johnson & Liu, 2020). Furthermore, technology promotes social development by stimulating collaboration and communication via group activities and interactive platforms (Johnson & Liu, 2020). Engaging digital activities can boost children's confidence, resilience, and positive attitude towards learning, which benefits their emotional development (Smith & Blackwell, 2021).

However, integrating technology into ECE presents a number of obstacles. One of the key challenges is instructors' lack of technical skills and pedagogical expertise, which might impede successful technology use in the classroom (Brown & Green, 2022; Leung, 2023). Furthermore, professional development for teachers is essential but sometimes insufficient, making it challenging for educators to keep up with the latest technological innovations and instructional approaches (Johnson & Liu, 2020; Young, 2023). Resource constraints also present substantial challenges, particularly in poor locations where schools may struggle to provide the essential technology infrastructure (Young, 2023).

Despite these limitations, there are significant potential to enhance technology integration in ECE. Effective pedagogical practices, such as utilizing interactive and engaging digital tools, can improve student engagement and learning results (Smith & Blackwell, 2021; Young, 2023). Collaborative projects that include group activities can promote teamwork and social skills, which are necessary for overall growth (Johnson & Liu, 2020). Successful integration requires ensuring that the technology utilized is developmentally appropriate and meets the cognitive, social, and emotional needs of young children (Brown & Green, 2022).

In conclusion, the full potential of technology in early childhood education can be realized by solving current difficulties and capitalizing on opportunities. By embracing innovative approaches, providing appropriate support and resources, and encouraging collaboration among educators, policymakers, and researchers, we can build an engaging and fair learning environment for all young children.

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