



## Pedagogy Over Technology: Animal-Themed Digital Games to Support Early Mathematics Learning

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### Abstract

This study aims to develop and evaluate "Smartimals," an animal-themed digital game designed to support early mathematics learning in resource-limited contexts. Employing a Research and Development (R&D) approach adapted from the 4-D model, the study was conducted with 15 children aged 5–6 years in a rural area of East Aceh, Indonesia. The development prioritized accessible technology to ensure practicality for teachers in infrastructure-constrained settings. Data were collected through expert validation questionnaires and direct observation of learning outcomes. The results indicate that the developed media is highly feasible and effective, achieving expert validation scores of 95.3% for media design, 80% for content, and 96% for language, alongside a field trial effectiveness rate of 89.9%. Beyond technical feasibility, the findings suggest that the integration of familiar animal themes functions as a cognitive anchor, effectively reducing extraneous cognitive load and bridging abstract mathematical concepts, such as arithmetic and pattern recognition, with concrete experiences. This study reinforces the premise of "pedagogy over technology," demonstrating that simple, contextually relevant digital tools can significantly enhance early numeracy and student engagement, offering an inclusive solution for early childhood education in remote areas.

**Keywords:** *Cognitive Load, Contextual Pedagogy, Digital Game-Based Learning, Early Childhood Mathematics, Low-Tech ICT, Digital*

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## A. INTRODUCTION

Alongside the rapid advancement of digital technology, early childhood education (ECE) is encountering new opportunities to enhance learning quality, particularly in the development of early numeracy skills. A growing body of research has consistently emphasized that mastery of basic mathematical concepts in early childhood plays a critical role in shaping children's academic readiness for subsequent educational stages (Neumann et al., 2013; Retno Utami & Nur Inayah, 2022; OECD, 2018). Nevertheless, Indonesian students' numeracy achievement remains relatively low compared to that of other countries, indicating an urgent need for more effective learning approaches that align with the learning characteristics of young children from the earliest stages of development (OECD, 2018; Prasetyo, 2015).

In this context, the use of Information and Communication Technology (ICT)-based learning media is widely regarded as a promising strategy to support mathematics learning in early childhood education. ICT-based media enables mathematical concepts to be presented in visual, interactive, and contextualized forms, thereby assisting children in understanding abstract concepts through more concrete and meaningful learning experiences (Nasution et al., 2022; Anjarsari et al., 2020). Accordingly, the integration of ICT in early childhood mathematics learning functions not merely as a technological tool, but as a pedagogical approach that is congruent with children's cognitive developmental needs.

As a concrete application of ICT in early childhood mathematics learning, a thematic approach constitutes a relevant strategy for connecting mathematical concepts with children's real-life experiences. One particularly effective theme is animals, as animals are familiar objects in children's daily lives and can be easily recognized from an early age, especially in rural settings. The use of animal-related themes enables children to construct mathematical understanding more meaningfully through counting activities, classification, and pattern recognition linked to animal characteristics (Astrid Adisty et al., 2021; Rahayu et al., 2022). Thus, animal themes have the potential to serve as a context rooted in local wisdom, bridging abstract mathematical concepts with children's concrete lived experiences.

In this context, digital technology represents a more specific and practical manifestation of ICT in classroom implementation. Despite the widely acknowledged potential of digital-based learning media and thematic approaches, practical challenges remain evident in their implementation within early childhood mathematics instruction. In many ECE institutions, particularly in remote areas, teachers continue to face limitations in technological facilities and access to developmentally appropriate digital media (Suryana & Hijriani, 2021; Alfi et al., 2022). As a result, mathematics instruction is often delivered through conventional methods without interactive media support, limiting children's active engagement in the learning process.

Concurrently, recent digital-based studies demonstrate a growing trend in the development of interactive digital media with significant potential to enhance mathematical concept understanding across various educational levels. At the secondary and higher education levels, digital-based has been implemented through diverse platforms and technologies, including Augmented Reality (Saputra, D. H. & Dwiningsih, K., 2025; Nasution et al., 2022), application-based interactive multimedia and mobile learning (Ansori

et al., 2024; Hardika et al., 2024), as well as e-learning and digital instructional videos (Irianti & Alam Wicaksono, 2021; Yudela et al., 2020). These studies consistently report that digital media contribute to increased learning motivation, conceptual understanding, and learner engagement in mathematics instruction.

At the elementary school level, digital utilization has also shown positive trends, particularly through the development of Android-based interactive multimedia and narrative animation for mathematics and science learning (Rahayu et al., 2022; Solichah et al., 2024; Anjarsari et al., 2020). Such media have been proven effective in enhancing students' cognitive abilities, especially in terms of visualization, spatial reasoning, and comprehension of abstract concepts. However, the majority of existing studies continue to focus on elementary to secondary school students, employing media and technologies of relatively high complexity.

Meanwhile, research on digital -based media development within early childhood education contexts has begun to gain attention, although its scope remains limited. Several research and development (R&D) studies in Indonesia have produced digital media for children aged 5–6 years, including thematic learning videos (Suryana & Hijriani, 2021) and Augmented Reality–based media (Nasution et al., 2022). Furthermore, Syarfina et al. (2023) have begun exploring the use of interactive PowerPoint as a more practical learning media solution for ECE settings.

Nevertheless, studies that specifically develop digital -based mathematics learning media for early childhood using educational games with animal themes drawn from children's immediate environments remain scarce, particularly those designed using simple, practical, and easily accessible digital platforms suitable for areas with limited infrastructure. Most existing digital media rely on Android- or web-based applications that require specific devices and stable connectivity. Distinct from prior studies, the present research positions itself as an effort to develop digital -based mathematics learning media for early childhood through interactive educational games with animal themes, developed using PowerPoint, thereby offering a more contextualized, easily implementable, and relevant solution for ECE institutions, especially in remote regions.

Based on this identified gap, the present study aims to develop digital -based learning media that focus on early childhood numeracy through interactive educational games themed around animals commonly found in rural environments, utilizing PowerPoint as the primary platform. The developed media are designed to support children's gradual and enjoyable understanding of basic mathematical concepts, while simultaneously providing a practical and accessible digital learning alternative for early childhood educators. Accordingly, the objective of this study is to develop and evaluate the feasibility of digital -based learning media in the form of interactive, animal-themed educational games to support mathematics learning in early childhood education.

## **B. METHOD**

The methodology of this study was systematically designed to ensure that the process of developing, implementing, and evaluating digital -based mathematics learning media in the form of interactive educational games themed around animals for early childhood

education was conducted in a valid and reliable manner. This section outlines the research design, participants and research setting, research instruments, data collection procedures, and data analysis techniques.

### **1. Research Design**

This study adopted a Research and Development (R&D) approach by adapting the 4-D model (Define, Design, Develop, and Disseminate) proposed by Thiagarajan, Semmel, and Semmel (1974). The model was selected for its systematic structure and strong relevance to the development of learning media intended to produce valid, feasible, and effective products for early childhood education contexts. In this study, the development process was limited to the Develop stage, while the Disseminate stage was conducted on a limited basis.

### **2. Participants and Research Setting**

The study was conducted at Nurul Aisyah Early Childhood School, East Aceh Regency. The research participants comprised: (1) three expert validators, including a learning media specialist, an early childhood mathematics content expert, and a language expert; and (2) fifteen children aged 5–6 years who participated in a limited trial of the learning media. Participants were selected using purposive sampling, with consideration given to age appropriateness, children’s learning readiness, and the availability of facilities supporting digital -based learning.

### **3. Research Instruments**

The research instruments consisted of an expert validation questionnaire and a child development observation sheet. An expert validation questionnaire was employed to evaluate the feasibility of the digital learning media in terms of content, media design, and language. The questionnaire was constructed using a 4-point Likert scale and administered to the expert validators to obtain evaluative ratings as well as constructive feedback for product refinement.

An observation sheet was used to examine the development of children’s early mathematical abilities following the use of the media. The observed indicators of children’s early mathematical competence were limited to the aspects presented in Table 1.

Table 1. Indicators of the Child Mathematics Ability Observation Sheet

<b>Aspects</b>
Counting
Classification
Pattern Sequencing

### **4. Instrument Validity and Reliability**

Instrument validity was established through expert judgment involving three expert validators. The experts evaluated content relevance, indicator clarity, and the comprehensibility of the instruments within the context of early childhood education.

Feedback from the validators served as the basis for revising the instruments prior to their use in the field trial. Statistical reliability testing was not conducted, as the study represented an initial development phase with a limited trial.

## 5. Research Procedures

The research procedure followed the stages of the 4-D model, as outlined below:

### a. Define

A needs analysis was conducted based on the Early Childhood Education (ECE) Curriculum and the Regulation of the Ministry of Education and Culture (Permendikbud) No. 137 of 2014, with a focus on numeracy development outcomes for children aged 5–6 years and the existing conditions of digital utilization in ECE settings.

### b. Design

The researcher designed a prototype of the Smartimals media using interactive Microsoft PowerPoint, integrating visual elements, animations, audio, and simple quizzes tailored to children’s early numeracy abilities.

### c. Develop

This stage involved expert validation and a limited trial. The media were revised based on validators’ feedback prior to implementation with children to examine feasibility and preliminary effectiveness.

### d. Disseminate (limited)

The media were introduced on a limited basis to ECE teachers as an alternative digital -based learning resource.

## 6. Data Analysis Techniques

The obtained scores were converted into percentages using the following formula:

$$\text{Percentage} = \frac{\text{Obtained Score}}{\text{Maximum Score}} \times 100\%$$

The percentage scores were classified into categories as presented in Table 2.

Table 2. Media Feasibility Categories

Percentage Range	Category
76–100%	Highly feasible
51–75%	Feasible
26–50%	Less feasible
0–25%	Not feasible

Child observation data were analyzed using the ECE developmental scale, namely Not Yet Developed (1), Beginning to Develop (2), Developing as Expected (3), and

Very Well Developed (4). Mean scores were used to identify trends in the development of children’s early mathematical abilities after using the Smartimals media.

### 7. Score Interpretation

The Smartimals media were considered feasible for use if the expert validation results reached at least the “feasible” category ( $\geq 51\%$ ). Media effectiveness was indicated when the majority of children achieved the Developing as Expected (DE) or Very Well Developed (VWD) categories across the observed mathematical ability indicators.

## C. RESULT AND DISCUSSION

### 1. Result

The results of this study are presented according to the media development procedure using the 4-D model (Define, Design, Develop, Disseminate). The initial content design of the media was developed based on the Child Development Achievement Standards for children aged 5–6 years, with a particular focus on the cognitive domain of mathematics. The theme Animals was selected because it is familiar to children’s daily experiences and facilitates the integration of mathematical concepts such as counting, classification, and patterning. The media were developed using interactive Microsoft PowerPoint, enhanced with animations and audio, to create an engaging digital learning resource.



Figure 1. Main Page Interface of “Smartimals”

After the media design was completed, validation was conducted with three experts. Data analysis indicated that the average scores from both the expert validation and the limited trial fell within the “feasible” category, with a “very good” rating, according to the media feasibility criteria and product revisions, as presented in Table 3.

Table 3. Expert Validation Results

spect	Average Score	Percentage	Category
Media	4.7	95.3%	Very Good
Content	4.0	80%	Very Good
Language	4.8	96%	Very Good



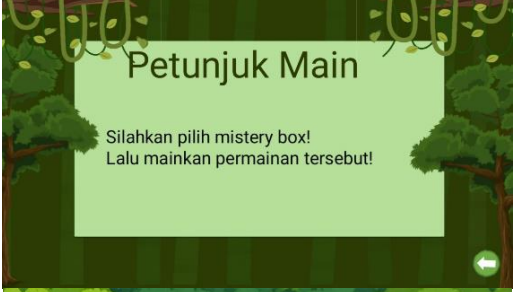

Based on the validation results, the experts provided several constructive suggestions to enhance the quality of the media. The researcher subsequently revised the media by adjusting the colors and background to make the interface more engaging for children, adding a greater variety of animal types, and reorganizing the game categories in accordance with the cognitive development indicators for early childhood. The results of these revisions are as follows:



Figure 2. Game Screen After Revisions

Next, the game was carefully prepared for use by young children to test its effectiveness. Smartimals features a mystery box interface designed to stimulate children’s curiosity. Each child can select a mystery box containing game rules and interactive challenges, such as counting the number of animal legs, continuing picture patterns, or matching cards in a memory game. The detailed gameplay instructions are presented in Table 1.

Table 3. How to Play “Smartimals”

Procedure	Screen Display
<p>The letter “<b>i</b>” in the bottom-left corner provides editor information. To start the game, click <b>Start</b>.</p>	
<p>Click <b>Instructions</b> to learn how to play the game.</p>	
<p>Use the Left Arrow to go back from the instructions screen</p>	
<p>After returning, click <b>Quiz</b> to begin.</p>	

Select a **Mystery Box** of your choice

Follow the game rules and click **Next** to proceed.

Answer the first question correctly.

If the answer is incorrect (e.g., counting the cow's legs incorrectly), a **Wrong** message will appear.

If the answer is correct, a **Correct** message will appear; then click **Next** to continue. Continue through the questions until the activity is completed, then click **Next** to return to the Mystery Box selection

After completing one Mystery Box, select another Mystery Box that has not yet been played.



Follow the game rules and click **Next** to proceed.

You will see several face-down cards. Click two cards alternately to reveal them.

If the images match, the cards remain face-up. If the images do not match, the cards will be turned face-down again. Continue until all pairs are correctly matched. Click **Next** to proceed to the next level. Repeat the process for subsequent questions until the activity is completed. After finishing all tasks, click **Finish** to automatically end the game

Click the **Home** button to return to the main screen



The results of the media trial were obtained from observing children’s activities while using Smartimals during classroom learning sessions, as summarized below:

Table 4. Effectiveness of Learning Using Smartimals.

Respondent s	Aspect	Total Score	Maximum Score	Percentage (%)	Category
15	Counting	39	45	90.9	Effective
	Classification	40	45	90.9	Effective
	Patterning	35	40	88.0	Effective
	<b>Overall Average</b>	<b>114</b>	<b>130</b>	<b>89.93</b>	<b>Effective</b>

The trial results indicate that the use of the Smartimals media consistently supported the development of early mathematical abilities in young children across the

assessed aspects. During the learning process, children demonstrated active engagement in counting, classification, and pattern recognition activities through direct interaction with the animal-themed digital game.

The counting and classification aspects showed relatively balanced achievements, suggesting that children were not only able to recognize quantities symbolically but also to understand relationships among objects through grouping animals based on specific characteristics. Meanwhile, the ability to recognize simple patterns also developed well, although it required a more complex cognitive adaptation process. This finding indicates that pattern recognition, as a more abstract concept, can begin to be understood when presented through visual and concrete contexts that are closely aligned with children's everyday experiences. Therefore, overall, these results suggest that the Smartimals media is effective as a learning tool for supporting early mathematics instruction in ECE settings.

## **2. Discussion**

**Effectiveness of Digital Learning Media in Early Numeracy** This study successfully achieved its primary objective by developing an digital -based, animal-themed learning medium that was empirically demonstrated to be both feasible and effective in enhancing the numeracy skills of children aged 5–6 years. These findings corroborate the growing body of recent literature indicating that digital game-based learning can have a significant positive impact on early childhood cognition when designed with explicit pedagogical goals (Papadakis et al., 2022). The high effectiveness scores observed in this study support the argument that instructional design quality plays a more decisive role than technological complexity itself (Mayer, 2020; Hirsh-Pasek et al., 2020). This is consistent with the meta-analysis by Outhwaite et al. (2022), which demonstrated that high-quality mathematics applications yield substantially better learning outcomes than conventional instructional methods.

**The Role of Gamification, Feedback, and Active Engagement** The effectiveness of the developed media can be explained through the principles of active, engaging, and meaningful learning. Visually appealing design elements combined with automatic feedback in the form of “Correct” or “Incorrect” responses function as critical gamification components. Zheng et al. (2022) emphasize that instant feedback in game-based learning significantly enhances learners' self-efficacy and intrinsic motivation to persist without fear of failure. Such interactive activities enable children to actively participate and make decisions—an essential element of early childhood learning identified by Zosh et al. (2022), whereby children transition from passive recipients to active constructors of knowledge.

**Reducing Cognitive Load Through Familiar Contexts** A key finding of this study is the role of the animal theme as a “cognitive anchor” that facilitates conceptual understanding. Integrating familiar animal contexts allows children to construct mathematical understanding in a meaningful manner, thereby reducing extraneous cognitive load. When mathematical concepts are presented through well-known representations, children's working memory resources can be devoted primarily to

mathematical reasoning rather than to processing unfamiliar objects. This finding aligns with Papadakis and Kalogiannakis (2021), who reported that realistic and familiar visual representations effectively bridge abstract concepts into concrete understanding. Accordingly, the digital media developed in this study do not replace real-world experiences but rather extend them through adaptive visualization (Kucirkova, 2020). These results also reaffirm Ausubel's Theory of Meaningful Learning, which posits that new information is assimilated more efficiently when connected to relevant existing cognitive structures—in this case, children's prior knowledge of animals.

**Impact of Social and Collaborative Interaction** The classroom implementation of the media using a projector introduced an important collaborative dimension. The findings indicate that social interactions during media use—such as peer discussions and mutual assistance—contributed meaningfully to concept mastery. This is supported by Karina et al. (2024), who demonstrated that social interaction in learning environments deepens conceptual understanding through the exchange of ideas. Furthermore, Sinaga et al. (2025) provided empirical evidence that collaborative learning models are significantly associated with improved learning outcomes compared to individual learning approaches. Beyond immediate comprehension, social interaction within a supportive learning environment has also been shown to be a key factor in enhancing long-term knowledge retention (Wagino et al., 2023).

**Implications for the Digital Divide and Rural Contexts** This study contributes novelty by demonstrating that relatively simple digital -based media can still produce substantial learning impacts, even in contexts with limited infrastructure such as rural areas. These findings challenge the assumption that digital effectiveness depends on high-end devices and instead reinforce the arguments of Burnett et al. (2020) and Mertala (2021) that alignment between instructional design and children's socio-cultural contexts is far more critical. From a Situated Learning perspective (Lave & Wenger, 1991), the use of locally familiar animal themes renders technology more grounded and accessible, reducing the psychological barriers often experienced by children in rural settings who may perceive technology as unfamiliar or intimidating.

**Practical Implications and Directions for Future Research** Practically, this study suggests that early childhood educators can integrate digital technology into learning without reliance on costly infrastructure. However, the findings also support the Guided Digital Play approach, in which teachers maintain a central role in facilitating children's interactions with digital media (Edwards et al., 2017). Future research is recommended to examine the longitudinal use of this media to assess long-term retention of mathematical concepts. In addition, subsequent studies should explore Blended Play models that integrate digital games with real-world physical activities to promote holistic development, as well as investigate teachers' readiness to independently develop digital content grounded in local wisdom. tendencies but weaker convergent structuring can be immediately targeted for scaffolded support in organizing ideas, while the reverse profile may suggest a need to encourage imaginative exploration.

## **D. CONCLUSION**

This study concludes that an animal-themed digital educational game is both effective and feasible as a strategic medium for enhancing early numeracy skills in young children. The findings emphasize that the integration of familiar contextual content, such as local animals, plays a vital role in reducing cognitive load and increasing learner engagement through adaptive gamification mechanisms. From a theoretical perspective, this study provides empirical evidence that the effectiveness of technology in early childhood education is not determined solely by the sophistication of hardware infrastructure, but rather by the appropriateness of pedagogical design in bridging abstract mathematical concepts with children's concrete experiences.

The practical implications of this study offer an inclusive solution for regions with limited technological resources, demonstrating that culturally responsive and simple digital media can generate meaningful learning impacts. Teachers are therefore encouraged to adopt a guided digital play approach, in which such media do not replace the instructor's role but function as collaborative tools to facilitate social interaction and conceptual discussion in the classroom. Future research is expected to broaden the scope by examining long-term effects on knowledge retention and exploring blended play models that holistically integrate digital interaction with physical activities.

## E. REFERENCES

- Alfi, C., Fatih, M., & Islamiyah, K. I. (2022). Pengembangan Media Power Point Interaktif Berbasis Animasi pada Pembelajaran IPA. *Jurnal Pendidikan : Riset Dan Konseptual*, 6(2), 351. [https://journal.unublitar.ac.id/pendidikan/index.php/Riset\\_Konseptual/article/view/487](https://journal.unublitar.ac.id/pendidikan/index.php/Riset_Konseptual/article/view/487)
- Alfi, T., Nabilah, N., & Dura, J. (2022). Pengaruh pemanfaatan teknologi informasi dan komunikasi terhadap kinerja guru dengan kompetensi guru sebagai variabel intervening (studi pada SMP Islam Syifaul Qulub Gresik). *e-Journal Inspirasi Manajemen Pendidikan*, 12(1), 7351–7360
- Anjarsari, E., Farisdianto, D. D., & Asadullah, A. W. (2020). Pengembangan Media Audiovisual Powtoon pada Pembelajaran Matematika untuk Siswa Sekolah Dasar (Development of Audiovisual Based Powtoon Media in Mathematics Learning for Elementary School Students). *JMPM: Jurnal Matematika Dan Pendidikan Matematika*, 5(2), 40–50. <https://doi.org/10.26594/jmpm.v5i2.2084>
- Anjarsari, E., Farisdianto, D. D., & Asadullah, A. W. (2020). Pengembangan media audiovisual Powtoon pada pembelajaran matematika untuk siswa sekolah dasar. *Jurnal Matematika dan Pendidikan Matematika (JMPM)*, 5(2), 40–50. <https://doi.org/10.26594/jmpm.v5i2.2084>
- Ansori, M. Z., Faiza, D., Thamrin, & Efrizon. (2024). Development of Digital Circuits Learning Media Using Articulate Storyline with the 4D Model. *Journal of Hypermedia & Technology-Enhanced Learning*, 2(3), 338–351. <https://doi.org/10.58536/j-hytel.v2i3.145>
- Astrid Adisty, A., Kurnia, R., & Chairilisyah, D. (2021). Pengembangan Media Scrabble Pola untuk Kemampuan Mengenal Pola ABCD-ABCD Anak Usia 5-6 Tahun. PAUD Lectura: *Jurnal Pendidikan Anak Usia Dini*, 5(01), 11–22.

<https://doi.org/10.31849/paud-lectura.v5i02.7008>

- Burnett, C., & Merchant, G. (2020). Literacy-as-event: Accounting for relationality in literacy research. *Discourse: Studies in the Cultural Politics of Education*, 41(1), 45–56. <https://doi.org/10.1080/01596306.2018.1460318>
- Edwards, L. C., Bryant, A. S., Keegan, R. J., Morgan, K., Cooper, S.-M., & Jones, A. M. (2017). Definitions, foundations and associations of physical literacy: A systematic review. *Sports Medicine*, 47(3), 113–126. <https://doi.org/10.1007/s40279-016-0560-7>
- Hardika, J., Ridwan, R., Bentri, A., Hakim, R., Rayendra, R., & Yeni J, F. (2024). Development of Interactive Learning Media Mobile Learning In Science for Class VIII Junior High School. *Jurnal Penelitian Pendidikan IPA*, 10(11), 9751–9758. <https://doi.org/10.29303/jppipa.v10i11.8630>
- Hirsh-Pasek, K., Hadani, H. S., Blinkoff, E., & Golinkoff, R. M. (2020). A new path to education reform: Playful learning promotes 21st-century skills in schools and beyond (Policy Big Ideas Report). The Brookings Institution. [https://www.brookings.edu/wp-content/uploads/2020/10/Big-Ideas\\_Hirsh-Pasek\\_PlayfulLearning.pdf](https://www.brookings.edu/wp-content/uploads/2020/10/Big-Ideas_Hirsh-Pasek_PlayfulLearning.pdf)
- Irianti, nathasa pramudita, & Alam Wicaksono, A. (2021). Pengembangan Media E-Learning Berbasis Web Untuk Mata Pelajaran Matematika. *JMN: Jurnal MathEducation Nusantara*, 4(1), 1–9. <https://doi.org/10.54314/jmn.v4i1.117>
- Karina, B. D., & Kastuhandani, F. C. (2024). Pre-Service English Teachers' Lived Experience in Using AI in Teaching Preparation. *Edunesia: Jurnal Ilmiah Pendidikan*, 5(1), 550–568. <https://doi.org/10.51276/edu.v5i1.767>
- Kucirkova, N., & Littleton, K. (2020). The distance between the “self” and the “other” in children’s digital books. *Frontiers in Psychology*, 11, 589281. <https://doi.org/10.3389/fpsyg.2020.589281>
- Mayer, R. E. (2020). *Multimedia learning* (3rd ed.). Cambridge University Press. <https://doi.org/10.1017/9781316941355>
- Mertala, P. (2021). The pedagogy of multiliteracies as a code breaker: A suggestion for a transversal approach to computing education in basic education. *British Journal of Educational Technology*, 52(6), 2227–2241. <https://doi.org/10.1111/bjet.13125>
- Nasution, N., Darmayunata, Y., & Wahyuni, S. (2022). Pengembangan Media Pembelajaran Anak Usia Dini berbasis Augmented Reality. *Jurnal Obsesi: Jurnal Pendidikan Anak Usia Dini*, 6(6), 6462–6468. <https://doi.org/10.31004/obsesi.v6i6.3408>
- Neumann, M. M., Hood, M., Ford, R. M., & Neumann, D. L. (2013). Letter and numeral identification: Their relationship with early literacy and numeracy skills. *European Early Childhood Education Research Journal*, 21(4), 489–501. <https://doi.org/10.1080/1350293X.2013.845438>
- OECD. (2018). *Students’ numeracy skills and practices (Adult Skills in Focus No. 8)*. OECD Publishing. <https://doi.org/10.1787/b6cce23eb-en>
- Outhwaite, D. E., Banham, J., & Cummings, A. (2022). A case study of the benefits of the Science Learning Partnerships in early years and primary education in England.

- Education Sciences*, 12(2), 107. <https://doi.org/10.3390/educsci12020107>
- Papadakis, S. (2022). Can Preschoolers Learn Computational Thinking and Coding Skills with ScratchJr? A Systematic Literature Review. *International Journal of Educational Reform*. <https://doi.org/10.1177%2F10567879221076077>
- Rahayu, D. F., Ardi, Helendra, & Yogica, R. (2022). Pengembangan Multimedia Interaktif Berbasis Android tentang Materi Animalia untuk Peserta Didik SMA/MA (Development of Android Based Learning Interactive Multimedia on Animalia Materials for Senior High School). *BIODIK: Jurnal Ilmiah Pendidikan Biologi*, 09, 126–134. <https://doi.org/10.22437/biodik.v9i2.21141>
- Retno Utami, N., & Nur Inayah, N. (2022). Pengembangan Media Jungle Board untuk Meningkatkan Keterampilan Scientific Inquiry Pada Anak Usia 5-6 Tahun. *Jurnal Pelita PAUD*, 7(1), 98–109. <https://doi.org/10.33222/pelitapaud.v7i1.2442>
- Saputra, D. H., & Dwiningsih, K. (2025). Integration of 3D animation flipbook to enhance spatial visualization in molecular geometry learning. *Indonesian Journal of Education Development (IJED)*, 6(3), 798-815. <https://doi.org/10.59672/ijed.v6i3.5401>
- Sinaga, A., Ritonga, S., & Lubis, M. S. (2025). Policy analysis of the occupational safety and health management system of SMK3 at the North Sumatra Provincial Employment Supervision UPTD. *PERSPEKTIF*, 14(1), 104–111. <https://doi.org/10.31289/perspektif.v14i1.13265>
- Solichah, R. Mulyati, S. Rahmasita, S. (2024). The Role Of Microteaching In Improving The Teaching Ability Of Prospective Educators, *Jurnal Dikdas Bantara*, 7(1), 11–24. <https://doi.org/10.32585/dikdasbantara.v7i1.5066>
- Suryana, D., & Hijriani, A. (2021). Pengembangan media video pembelajaran tematik anak usia dini 5–6 tahun berbasis kearifan lokal. *Jurnal Obsesi : Jurnal Pendidikan Anak Usia Dini*, 6(2), 1077–1094. <https://doi.org/10.31004/obsesi.v6i2.1413>
- Syarfina, S., Masruroh, S., Masyitah, N., Sahpitri, Y., & Pratiwi, A. D. (2023). Digital game in young children’s numeracy skill: An innovation through learning media development. *Child Education Journal*, 5(3), 155–164. <https://doi.org/10.33086/cej.v5i3.5458>
- Wagino, W., Maksum, H., Purwanto, W., Krismadinata, K., Suhendar, & Koto, R. D. (2023). Exploring the full potential of collaborative learning and e-learning environments in universities: A systematic review. *TEM Journal*, 12(3), 1772–1785. <https://doi.org/10.18421/TEM123-60>
- Yudela, S., Putra, A., & Laswadi, L. (2020). Pengembangan Media Pembelajaran Matematika Berbasis YouTube Pada Materi Perbandingan Trigonometri. *Imajiner: Jurnal Matematika Dan Pendidikan Matematika*, 2(6), 526–539. <https://doi.org/10.26877/imajiner.v2i6.7089>
- Zheng, R., & Badarch, T. (2022). Research on applications of artificial intelligence in education. *American Journal of Computer Science and Technology*, 5(2), 72–79. <https://doi.org/10.11648/j.ajcst.20220502.17>
- Zosh, J. M., Hassinger-Das, B., & Laurie, M. (2022). Learning through play and the development of holistic skills across childhood. The LEGO Foundation. [https://cms.learningthroughplay.com/media/kell5mft/hs\\_white\\_paper\\_008-digital-](https://cms.learningthroughplay.com/media/kell5mft/hs_white_paper_008-digital-)

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