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EFFECTIVENESS OF AUGMENTED REALITY ASSISTED DIORAMA MEDIA ON EARLY CHILDHOOD SCIENCE LITERACY

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Abstract

The development of scientific literacy is a crucial competency key in early childhood education in the 21st century. This study aims to measure the level and magnitude of effectiveness of the use of augmented reality-assisted diorama media in developing scientific literacy, especially on the theme of "natural phenomena/flood disasters" in children aged 5-6 years. This study was conducted with a quantitative approach using a quasi-experimental method with a non-equivalent control group design. The sample of this study consisted of 2 classes, namely 17 children in the experimental class and 17 children in the control class with a total of 34 children. Effectiveness was measured using an independent sample t-test, an N-Gain score test, and an effect size test. The results of the study showed a significant difference in the scientific literacy abilities of the experimental class and the control class, as evidenced by a 2-tailed t-test sig. of 0.000 <0.05; an N-Gain value of the experimental class of 0.78 which is categorized as having a high level of effectiveness; and a Cohen's'd value of 3.04 which is categorized as having a very large effect strength. The findings of this study demonstrate that augmented reality-assisted dioramas are highly effective in developing scientific literacy in early childhood. This research offers a contribution to the development of scientific literacy learning, specifically on the theme of "natural phenomena/flood disasters" in early childhood, and meets the needs of 21st-century education.

Keywords: Diorama Media, Augmented Reality, Science Literacy, Early Childhood Education.

INTRODUCTION

In the 21st century, early childhood education has become the first step in formal education following the UN's Sustainable Development Goals (Murray, 2023), which stipulate that every country is required to provide at least one year of preschool education to children before entering elementary school (Karlsson Lohmander, 2022). Early childhood education provides the initial foundation that supports a child's holistic development. One crucial developmental aspect needed by preschool children, which is a key educational competency in the 21st century, is cognitive development, particularly its relationship to scientific literacy in developing critical and scientific thinking (Eliza, D., et al., 2025). Scientific literacy encompasses the ability to understand scientific concepts, apply this understanding in everyday life, and think critically and systematically to solve problems (Januar et al., 2025). Learning scientific literacy in preschool children relates to children's ability to recognize their surroundings, observe natural phenomena, ask questions, and draw conclusions from their experiences.

Hurd (2000) stated that scientific literacy aims to develop life skills and improve the quality of life, which is related to the formation of an attitude of environmental care. By increasing mastery of scientific literacy, it can increase sensitivity and environmental care in children (Khowiyah, Z., & Eliza, D,. 2023). (Edison,S.P.D., Eliza, D., et al., 2025) also stated that scientific literacy is a fundamental competency for understanding natural phenomena. The importance of learning scientific literacy about caring for the environment and the surrounding nature is related to SDGs point 4 on quality education, SDGs point 12 on responsible consumption and production, and SDGs point 13 on handling climate change (Council, 2025). In early childhood education, scientific literacy learning has a significant influence in stimulating children's cognitive development for the rational use of scientific knowledge so that children are more open to new ideas and reason critically about understanding the surrounding environment scientifically (Harahap et al., 2024). (Sativa, B.R., & Eliza, D., 2023) also explained that scientific literacy influences the development of scientific thinking skills in children so that children are able to think based on logical facts.

However, statistical data on children's scientific literacy skills in Indonesia remains relatively low. Based on the results of the PISA scores in 2022, children's scientific literacy rankings increased from 2018, but experienced a decline in the assessment score, from 396 to 383 points (OCDE, 2023). This scientific literacy problem was also found in field learning practices in kindergartens. Based on observations conducted at Padang V State Kindergarten, the majority of children were not accustomed to maintaining environmental cleanliness, such as throwing trash outside the trash can. This behavior indicates low scientific literacy in children, due to a lack of understanding of the concept of scientific cleanliness, so children are unable to apply their scientific understanding of environmental cleanliness in everyday life and think critically to solve problems related to the surrounding environment. This research is important to review the development of scientific literacy in helping children understand scientific concepts and understand the cause-and-effect relationships of their actions, as well as fostering a sustainable attitude of environmental concern. (Eliza, D., et al., 2026) emphasize that the development of scientific literacy must begin early so that children gain a strong foundation for mastering scientific thinking skills in the future.

Based on observations, children's science literacy learning still faces challenges in the delivery of materials, including teacher-centered learning and the lack of use of technology-based educational media in conveying information to children. This condition prevents children from optimally understanding abstract science literacy concepts, as preschoolers aged 5-6 are in the pre-operational and iconic stages, acquiring knowledge through concrete objects (Bruner, 1966; Piaget & Inhelder, 2010). This finding is supported by Karimah & Mas'ula (2024), who stated that science literacy learning requires the support of innovative learning media to facilitate teachers' delivery of materials to children. Research (Eliza, D., Permana, I.A., & Dhanil, M., 2025) also confirms that the absence of technology-based media will hinder the comprehensive development of science literacy skills in early childhood. Technology is needed in learning media to provide engaging learning experiences for children, as learning experiences in the early years of life have a significant impact on children's future learning interests (Eliza, D., et al., 2024).

To address these challenges, this study proposes an interactive educational medium, using augmented reality-assisted dioramas as a digital-based learning tool to develop scientific literacy in children aged 5-6 years. This media selection takes into account children's learning needs, specifically the need for concrete teaching materials in accordance with Piaget's cognitive development theory and Bruner's learning theory (Bruner, 1966; Piaget & Inhelder, 2010). Research (Maletta, 2023) indicates that dioramas can stimulate visual presence and interest in children's learning activities. However, static dioramas are unable to provide a realistic experience and directly engage children in scientific literacy learning experiences, particularly regarding natural phenomena. Therefore, augmented reality technology is needed to display animations that create a more engaging learning environment and enhance children's in-depth conceptual understanding (Şimşek, 2024).

This study offers a new approach through the use of augmented reality-assisted dioramas to introduce scientific literacy related to the environment, focusing on the theme of natural phenomena, with a sub-theme of flood disasters. Through this augmented reality-assisted diorama media, it is possible to help children learn to understand the abstract concept of flood disasters through concrete and interactive visualizations. Although augmented reality-assisted diorama media has been widely used in higher-level classroom learning, it is still minimally used in Early Childhood Education (PAUD) learning, especially on the sub-theme of flood disasters. Therefore, this study aims to fill the empty gap in the use of augmented reality-assisted diorama media in science literacy learning in PAUD. The main objective of this study is to measure the increase and magnitude of the effectiveness of the use of augmented reality-assisted diorama media in developing scientific literacy in children aged 5-6 years. The novelty of this research provides an important contribution to technology-based science literacy learning in PAUD in accordance with current technological developments.

RESEARCH METHODS

This research was conducted using a quantitative approach using a quasi-experimental method with a non-equivalent control group design. The population of this study was all 64 children at TKN V Padang and involved a sample of 34 children consisting of 2 classes, namely class B4 as the experimental class and class B2 as the control class. The sample was taken using a purposive sampling technique with homogeneity criteria for age and learning facilities. Data were collected using structured observation techniques and tests (pre-test and post-test) guided by a scientific literacy instrument consisting of 3 indicators of scientific literacy that have been validated by experts.

Table 1. Science Literacy Instrument Grid

Indicator	Sub-Indicator	Assessment Criteria			
		BB	L	C	M
Knowledge	Explains the concept of flooding in simple terms using their own words				
	Identifies the causes of flooding				
	Analyzes the impacts of flooding on the surrounding environment and human activities				
	Investigates simple ways to prevent flooding				
	Designs simple solutions to prevent flooding				
Skills	Sequences the process of flooding accurately				
	Demonstrates the process of flooding using their own words				
Attitude	Shows environmental awareness by disposing of waste in designated bins				
	Actively participates in discussion activities				
	Demonstrates alertness and simple self-protection measures to reduce the risk of accidents during flooding				

Source: (Charlesworth, 2015; Hurd, 2000; Khowiyah, Z., & Eliza, D., 2023)

The research instrument has been validated by expert lecturers, and has been tested for validity and reliability with a Cronbach alpha value of 0.903. The augmented reality-assisted diorama media treatment was given four times in the experimental class, while the control class used conventional image media. The data obtained were analyzed with the help of SPSS 23 software using normality tests (Shapiro-Wilk), homogeneity (Levene Test), independent sample t-tests to measure the significance of differences in children's abilities, N-Gain score tests to measure the magnitude of effectiveness, and effect size tests to measure the strength of the effect of the treatment.

RESULTS AND FINDINGS

Normality Test

The pre-test and post-test data obtained from the research process were first analyzed using a normality test to determine whether the data were normally distributed. The results of the pre-test and post-test normality tests are shown in the following table

Table 1 Results of Pre-Test and Post-Test Normality Tests

Tests of Normality

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Pre-test Eksperimen	,204	17	,057	,953	17	,511
Post-Test Eksperimen	,163	17	,200*	,936	17	,272
Pre-Test Kontrol	,126	17	,200*	,977	17	,928
Post-Test Kontrol	,137	17	,200*	,954	17	,517

*. This is a lower bound of the true significance.

a. Lilliefors Significance Correction

Based on Table 2, the Shapiro-Wilk pre-test significance value for the experimental class was 0.511 and the control class pre-test significance value was 0.928. Based on the pre-test values, both classes were declared normally distributed because the sig. value was >0.05. Furthermore, the post-test significance value for the experimental class was 0.272, and the control class post-test significance value was 0.517. Based on these post-test values, the data were declared normally distributed because the sig. value was >0.05. The results of the Shapiro-Wilk normality test indicate that the pre-test and post-test data for both research classes were generally normally distributed, indicating that the data met the assumptions of parametric tests for further analysis.

Homogeneity Test

After conducting the normality test, the next step was to conduct a homogeneity test to assess the similarity of data variances using the Levene test

Table 2 Pre-Test Homogeneity Test Results

Test of Homogeneity of Variance

		Levene Statistic	df1	df2	Sig.
Hasil	Based on Mean	,906	1	32	,348
	Based on Median	1,058	1	32	,311
	Based on Median and with adjusted df	1,058	1	31,994	,311
	Based on trimmed mean	,915	1	32	,346

Tabel 3 Post-Test Homogeneity Test Results

Test of Homogeneity of Variance

		Levene Statistic	df1	df2	Sig.
data	Based on Mean	,323	1	32	,574
	Based on Median	,173	1	32	,680
	Based on Median and with adjusted df	,173	1	29,902	,680
	Based on trimmed mean	,303	1	32	,586

Based on the descriptions in Tables 3 and 4, the results of the pre-test and post-test homogeneity tests between the experimental and control classes were declared homogeneous. This can be seen in the sig. Based on the mean, the pre-test homogeneity test results were 0.348 > 0.05, and the post-test homogeneity test results were 0.574 > 0.05. The Levene's homogeneity test above indicates homogeneous data variance at the beginning and end of the test. Since the data were normally distributed and had equal variance, the requirements for parametric testing were met, allowing an independent sample t-test to be conducted to determine differences between the research groups.

Independent Sample T-Test

An independent sample t-test was conducted to measure significant differences between the pre-test and post-test results in both research classes. The results of the independent test are shown in the following table:

Table 4 Independent Sample T-Test Pre-test Results

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Hasil	Equal variances assumed	,906	,348	-2,167	32	,038	-2,00000	,92308	-3,88025	-,11975
	Equal variances not assumed			-2,167	31,074	,038	-2,00000	,92308	-3,88245	-,11755

Table 5 Independent Sample T-Test Post-test Results

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
data	Equal variances assumed	,323	,574	6,490	32	,000	6,000	,924	4,117	7,883
	Equal variances not assumed			6,490	31,080	,000	6,000	,924	4,115	7,885

Based on the two-tailed sig. value in the t-test for equality of means column in the independent sample t-test, it can be seen that there is a difference in the initial and final scientific literacy abilities of the children in the experimental and control groups. This is evidenced by the two-tailed sig. value for the pre-test of 0.038 and the two-tailed sig. value for the post-test of 0.000. Both values are less than 0.05, so Ha is accepted and Ho is rejected due to the significant difference between the children's abilities after the treatment. A comparison of children's scientific literacy abilities can be seen in the following table:

Table 7: Comparison of Children's Scientific Literacy Abilities Based on Scientific Literacy Indicators

		Experiment		Control	
No.	**Scientific Literacy Indicators**	**Pre-Test**	**Post-Test**	**Pre-Test**	**Post-Test**
1.	Knowledge	10,17	18,05	10,82	15,23
2.	Skills	3,11	6,64	3,76	5,17
3.	Attitude	6,35	10,82	7,05	8,94
	Total	19,64	35,52	21,64	29,35

Based on the description in Table 7, the indicator-based assessment of scientific literacy revealed a significant difference between the pre-test and post-test abilities of children in the experimental and control classes. The experimental pre-test score was 19.64, while the control pre-test score was 21.64, confirming a 2-point difference in children's initial scientific literacy abilities. Meanwhile, in the post-test, the experimental class scored 35.52 and the control class scored 29.35, indicating a 6.17-point difference in children's final scientific literacy abilities. This indicates that the augmented reality diorama media has an effect on developing the scientific literacy of grade B kindergarten children.

Effectiveness Test

The effectiveness of the treatment in this study was evaluated using the N-Gain test to measure the level of effectiveness and Cohen’s d effect size analysis to determine the magnitude of the treatment effect. The results of the N-Gain analysis are presented in the following table:

Table 6 Comparison of Learning Outcomes of Experimental Class and Control Class

Kelas	Average Pre-Test	Average Post-Test	Increase	N-Gain	Categori
Experiment	19,64	35,52	15,88	0,77	High
Control	21,64	29,35	7,71	0,41	Medium
difference	-2,00	+6,17	+8,17	+0,37	

The effect size of the treatment can be determined using Cohen's d formula as follows :

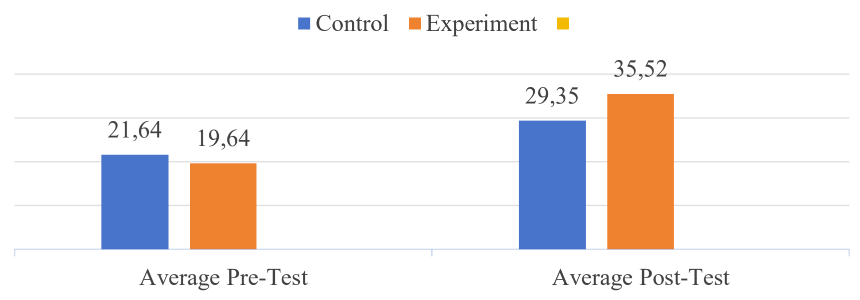
$$\text{Sspooted (Sgab)} = \frac{\sqrt{(n1\text{-}1)Sd1^2+(n2\text{-}1)Sd2^2}}{n1+n2\text{-}2} = \frac{\sqrt{(17\text{-}1)3{,}371^2+(n2\text{-}1)1{,}759^2}}{17+17\text{-}2} = 2{,}687$$

$$d = \frac{Xt\text{-}Xc}{Sspooted} = \frac{15{,}88\text{-}7{,}71}{2{,}687} = 3{,}04\ (\textit{Strong Effect})$$

Where:

- **n_1** = number of children in the experimental group
- **n_2** = number of children in the control group
- **SD_1** = standard deviation of the experimental group
- **SD_2** = standard deviation of the control group

Figure 1. Comparison of Pre-Test and Post-Test Scores Between Experimental and Control Groups



Based on Table 8 and Figure 1, both groups experienced improvements in scientific literacy scores following the learning intervention. However, the experimental group demonstrated a greater improvement, with the mean score increasing from 19.64 in the pre-test to 35.52 in the post-test, resulting in a gain of 15.88 points. In contrast, the control group improved from 21.64 to 29.35, with a gain of 7.71 points. Although the control group had a slightly higher initial score, the experimental group achieved a higher post-test score, with a difference of 6.17 points. These findings indicate that the use of augmented reality-assisted diorama media produced better learning outcomes than the instructional media used in the control group.

The N-Gain analysis further confirmed this finding. The experimental group obtained an N-Gain score of 0.77, which falls into the high category, whereas the control group achieved an N-Gain score of 0.41, categorized as medium. The difference in N-Gain values of 0.37 indicates that the improvement in scientific literacy among children in the experimental group was substantially greater than that of the control group. These results suggest that augmented reality-assisted diorama media is effective in enhancing children's scientific literacy by providing a more interactive, engaging, and meaningful learning experience.

RESULTS AND DISCUSSION

The results of this study indicate that the use of augmented reality-assisted diorama media is effective in developing scientific literacy, particularly on the topic of natural phenomena with the subtheme of flood disasters among Group B children. Children who participated in learning activities using augmented reality-assisted diorama media demonstrated greater improvements in knowledge, skills, and attitudes based on the comparison of pre-test and post-test results than those in the control group. The significance value of the independent samples t-test was 0.000 (< 0.05), indicating that the use of visual-interactive media effectively enhanced children's understanding of natural phenomena concepts, particularly flood disasters. These findings are consistent with the study by Hidayat and Wardat (2023), which reported that augmented reality-integrated media in science learning facilitate the visualization of objects and three-dimensional forms, enabling children to observe and manipulate them from various perspectives. Furthermore, Lampropoulos (2024) emphasized that augmented reality provides more concrete and contextual learning experiences in early childhood science education, helping children understand abstract concepts through three-dimensional visualization. This study also reinforces the cognitive development theories of Piaget and Bruner, which suggest that young children learn concepts more effectively through concrete, manipulative, and visual experiences.

Picture 1. Augmented Reality Assisted Diorama Media

The improvement in children's scientific literacy within the knowledge domain indicates that augmented reality-assisted diorama media helped children understand the cause-and-effect relationships associated with flood events more concretely. Children were able to explain the concept of floods, identify their causes, and analyze their impacts on the surrounding environment using their own language. These findings support the study by Arici (2024), which found that the use of augmented reality in science education enhances environmental literacy and learning motivation because digital visualizations make scientific concepts easier to comprehend. Similarly, the study by Humaira and Ninawati (2023) demonstrated that contextual diorama media effectively improve students' understanding of the water cycle in science learning, as concrete visual media help learners build stronger mental representations. However, the findings of the present study differ from those of Şakir (2025), who argued that the implementation of augmented reality in preschool education still faces challenges related to teacher readiness and limited technological infrastructure. Therefore, its effectiveness is highly dependent on teachers' ability to manage digital-based learning environments.

In terms of skills, the use of augmented reality-assisted diorama media enhanced children's ability to sequence the process of flooding and to demonstrate the phenomenon in a simple manner. Interactive animated visualizations provided opportunities for children to learn through direct observation, thereby fostering the development of scientific thinking skills more effectively. These results are in line with the findings of Demirdag et al. (2025), who reported that augmented reality increases active participation and learning retention among young children by providing engaging multisensory learning experiences. Rahmiati et al. (2025) also found that augmented reality-based diorama media improve students' cognitive and emotional engagement in science learning because the media can simulate phenomena that closely resemble real-life conditions. Moreover, Prasetya and Maisaroh (2023) emphasized that diorama media are effective for science instruction because they can stimulate students' attention and interest in learning abstract scientific concepts.

The improvement observed in the attitude domain suggests that the use of augmented reality-assisted diorama media influences not only cognitive development but also the formation of environmental awareness among children. Children became more active in classroom discussions, demonstrated proper waste disposal behaviors, and developed a better understanding of the importance of environmental conservation in preventing floods. These findings support Hurd's (2000) assertion that scientific literacy plays a crucial role in fostering environmental responsibility and informed decision-making based on scientific knowledge. The results are also consistent with the study by Khowiyah, Z., and Eliza, D., (2023), which found that the development of scientific literacy from an early age can enhance environmental awareness and environmentally responsible behaviors among children. In addition, Erwis et al. (2024) reported that the use of augmented reality in science education can increase learners' motivation, curiosity, and emotional engagement, thereby making learning more meaningful.

The high N-Gain score of 0.77 and Cohen's d effect size of 3.04 indicate that augmented reality-assisted diorama media have a very substantial impact on the development of scientific literacy among young children. The magnitude of this effect suggests that integrating digital technology with concrete learning media creates a more effective learning experience than conventional picture-based media. These findings support the literature review by Lampropoulos (2024), who concluded that augmented reality is one of the most promising innovations in early childhood science education because it enhances conceptual understanding, interactivity, and authentic learning experiences. Likewise, Murdani et al. (2024) demonstrated that diorama media positively influence elementary school students' literacy skills by presenting learning materials in an engaging and concrete manner. Therefore, this study contributes significantly to the development of technology-based instructional media in early childhood education, particularly for fostering environmental science literacy and disaster mitigation awareness.

CONCLUSION AND SUGGESTIONS

Conclusions

The use of augmented reality-assisted diorama media was found to be effective in developing the scientific literacy of Group B children at TKN V Padang. This was evidenced by the results of the independent samples t-test, which yielded a Sig. (2-tailed) value of 0.000 (< 0.05), indicating a significant difference in children's abilities after the treatment was administered. Therefore, the alternative hypothesis (Ha) was accepted, while the null hypothesis (H_0) was rejected. Furthermore, the N-Gain effectiveness test showed that the normalized gain score of the experimental group was categorized as having a high level of effectiveness, with a value of 0.78. These findings were further supported by the Cohen’s d effect size analysis, which revealed that the augmented reality-assisted diorama media had a large effect on the development of children's scientific literacy. The calculated Cohen’s d value was 3.04, which exceeds the benchmark of 0.81 commonly used to indicate a large effect size. Therefore, the treatment demonstrated a substantial impact on enhancing children's scientific literacy.

Suggestions

This study focused on the implementation of scientific literacy aspects based on the theories of Rosalind Charlesworth, Paul DeHart Hurd, and Khowiyah, Z. and Eliza, D. Therefore, it is recommended that future researchers expand their investigations by incorporating scientific literacy dimensions derived from other scientific literacy theories and frameworks. In addition, early childhood educators are encouraged to become more technologically literate by integrating scientific literacy instruction with emerging technologies that characterize learning in the twenty-first century.

REFERENCES

Arici, F. (2024). Investigating the Effectiveness of Augmented Reality Technology in Science Education in Terms of Environmental Literacy, Self-Regulation, and Motivation to Learn Science. *International Journal of Human-Computer Interaction*, *40*(24), 8476–8496. https://doi.org/: https://doi.org/10.1080/10447318.2024.2310921

Bruner, J. S. (1966). *Toward a Theory of Instruction*. Harvard University Press.

Charlesworth, R. (2015). *Math and Science for Young Children*. Cengage Learning.

Council, G. A. E. and S. (2025). Progress towards the Sustainable Development Goals. In *General Assambly Economic and Social Council* (Vol. 64782, Issue May).

Demirdag, M. C., Kucuk, S., & Tasgin, A. (2025). An Investigation of the Effectiveness of Augmented Reality Technology Supported English Language Learning Activities on Preschool Children. *International Journal of Human-Computer Interaction*, *41*(4), 2410–2423. https://doi.org/https://doi.org/10.1080/10447318.2024.2323278

Edison, S. P. D., Eliza, D., Yaswinda, & Rakimahwati. (2025). Interactive E-Modules in Life Science to Foster Scientific Literacy and Process Skills in Early Childhood. *Jurnal Pendidikan Anak Usia Dini Undiksha*, *13*(3), 491–501. https://doi.org/https://doi.org/10.23887/paud.v13i3.96648

Eliza, D., Permana, I.A., & Dhanil, M. (2025). Picture Science Story Game App : What Effects on Early Childhood Science Process Skills ? *International Journal of Information and Education Technology*, *15*(8), 1670–1679. https://doi.org/10.18178/ijiet.2025.15.8.2368

Eliza, D., Erita, Y., Yulsyofriend., Hasanah, A., Anisa, N., & Dhanil, M. (2026). Development of a Mobile Role-Playing Game Application to Enhance Scientific and Cultural Literacy in Early Childhood Education. *International Journal on Informatics Visualization*, *10*(March), 862–871. https://doi.org/https://dx.doi.org/10.62527/joiv.10.2.4709

Eliza, D., Mulyeni, T., Budayawan, K., Hartati, S., & Khairiah, F. (2024). Creation of Cultural Local Wisdom-Based Picture-Science Stories Application for the Introduction of Scientific Literacy for Early Childhood. *International Journal on Informatics Visualization*, *8*(1), 417–424. https://doi.org/10.62527/joiv.8.1.2234

Eliza, D., Mulyeni, T., Yulsyofriend, Mahyuddin, N., Erita, Y., & Dhanil, M. (2025). Implementation of Project-Based Learning in Improving Scientific Literacy in Early Childhood Education: Systematic Literature Review. *Journal of Baltic Science Education*, *24*(1), 71–91. https://doi.org/10.33225/jbse/25.24.71

Erwis, F., Jixiong, C., Rahayu, N., Raharja, A. R., & Zebua, R. S. Y. (2024). Use of Augmented Reality (AR) in Mobile Learning for Natural Science Lessons. *Journal of Social Science Utilizing Technology*, *2*(1). https://doi.org/https://doi.org/10.70177/jssut.v2i1.784

Harahap, Z. I., Isnani, R. A., Fadhil, N., & Rahmi, P. (2024). Pengembangan Sains Anak Usia Dini Berbasis Eksperimen. *Journal of Early Childhood Education Studies*, *4*(2), 307–345. https://doi.org/10.54180/joeces.2024.4.2.307-345

Hidayat, R., & Wardat, Y. (2023). A systematic review of Augmented Reality in Science, Technology, Engineering and Mathematics education. *Education and Information Technologies*, *29*(8), 9257–9282. https://doi.org/10.1007/s10639-023-12157-x

Humaira, T., & Ninawati, M. (2023). Development of Contextual Media Diorama of Water Cycle in Science Subject in Elementary School. *Jurnal Cakrawala Pendas*, *9*(4), 631–641. https://doi.org/10.31949/jcp.v9i4.5653

Hurd, P. D. (2000). *Transforming middle school science education; Foreword by James J. Gallagher*. Teachers College Press.

Januar, E., Gistituati, N., Fitria, Y., Bentri, A., & Muhammadi. (2025). EXARIS Model Development: Enhancing Elementary Scientific and Digital Literacy. *Educational Process: International Journal*, *18*(e2025450). https://doi.org/https://doi.org/10.22521/edupij.2025.18.450

Karimah, N., & Mas'ula, S. (2024). Inovasi Media Lava Pijar dalam Meningkatkan Literasi Sains Anak Usia 5-6 Tahun Siswa Bustanul Athfal. *JoLLA Journal of Language Literature and Arts*, *4*(6), 615–622. https://doi.org/10.17977/um064v4i62024p615-622

Karlsson Lohmander, M. (2022). Quality early childhood education for all children? *European Early Childhood Education Research Journal*, *30*(5), 653–657. https://doi.org/10.1080/1350293X.2022.2109857

Khowiyah, Z., & Eliza, D. (2023). Pengaruh Metode Bercerita Terhadap Literasi Sains Anak Usia Dini. *Jurnal Pelita PAUD*, *8*(1), 120–131. https://doi.org/10.33222/pelitapaud.v8i1.3440

Lampropoulos, G. (2024). Teaching and learning natural sciences using augmented reality in preschool and primary education: A literature review. *Advances in Mobile Learning Educational Research*, *4*(1), 1021–1037. https://doi.org/https://doi.org/10.25082/AMLER.2024.01.013

Maletta, R. (2023). Enthymema XXXIV 2023 Diorama , infanzia , scrittura in Durs Grünbein Rosalba Maletta Diorama , infanzia , scrittura in Durs Grünbein Rosalba Maletta. *Enthymema*, 214–239. https://doi.org/http://dx.doi.org/10.54103/2037-2426/21615

Murdani, E., Alpina, W., Wirawan, G., & Sumarli, S. (2024). Pengaruh Model Pembelajaran Inquiry Terbimbing Berbantuan Media Diorama Terhadap Kemampuan Literasi Sains Siswa Kelas V. *Jurnal Educatio FKIP UNMA*, *10*(4), 1253–1260. https://doi.org/10.31949/educatio.v10i4.9524

Murray, J. (2023). What is the purpose of education? A context for early childhood education. *International Journal of Early Years Education*, *31*(3), 571–578. https://doi.org/10.1080/09669760.2023.2238399

OCDE. (2023). Resultados de PISA 2022 (Volumen I): El estado del aprendizaje y la equidad en la educación. In *Https://Www.Oecd.Org/En/Publications/Pisa-2022-Results-Volume-I_53F23881-En/Full-Report.Html* (Vol. 1).

Piaget, J., & Inhelder, B. (2010). *Psikologi Anak (M. Jannah & E. Adinugraha, Penerj.)*. Pustaka Pelajar.

Prasetya, R. I., & Maisaroh, S. (2023). Use of Diorama Media As an Innovation in Science Learning in Elementary Schools. *Proceedings of the 2nd UPY International Conference on Education and Social Science (UPINCESS 2023)*. https://doi.org/https://doi.org/10.2991/978-2-38476-176-0_59

Rahmiati, D., Sarwi, S., Sudarmin, S., & Cahyono, A. N. (2025). The The Use of Augmented Reality Diorama Media in Natural and Social Sciences Subjects for Fourth Grade Elementary School. *Journal La Edusci*, *6*(1), 61–78. https://doi.org/10.37899/journallaedusci.v6i1.1871

Şakir, A. (2025). Augmented reality in preschool settings: a cross-sectional study on adoption dynamics among educators. *Interactive Learning Environments*, *33*(4), 2954–2977. https://doi.org/https://doi.org/10.1080/10494820.2024.2428361

Sativa, B. R., & Eliza, D. (2023). Pengembangan E-Modul Literasi Sains Anak Usia Dini. *Jurnal Obsesi : Jurnal Pendidikan Anak Usia Dini*, *7*(2), 1564–1574. https://doi.org/10.31004/obsesi.v7i2.4037

Şimşek, E. E. (2024). The Use of Augmented Reality-Supported Activities in Environmental Education for Early Childhood: A Quasi-Experimental Study. *Sustainability (Switzerland)*, *16*(23). https://doi.org/10.3390/su162310374