PROCEEDING
ICONTESS
Volume 1 No 2, 2025
https://jurnal.unissula.ac.id/index.php/icontess

Analysis of the Implementation of 3D Media on Higher Order Thinking Skills

Yunita Sari*[1], Arita Marini[2], Jupriyanto[3]

[1,3]*Elementary School Teacher Education Study Program, Faculty of Teacher Training and Education, Universitas Islam Sultan Agung*

[2]*The State University of Jakarta, Faculty of Education, Department of Elementary School Teacher Education, Jakarta, Indonesia*

yunitasari@unissula.ac.id

Abstract. The objective of this research is to find the relationship between the implementation of 3D media and higher-order thinking skills in elementary school students. This research uses a descriptive quantitative method. The data collection technique in this study was through a test instrument. The data collected comes from fifth-grade elementary school students, divided into experimental and control classes. The control class had 104 students during the pretest and posttest, while the experimental class had 103 students during the pretest and 104 during the posttest. In the control class, there was an increase in the average score from an initial value of 44.6 to 73.6. In the experimental class, there was a difference in the increase in the pretest results with an average student score of 55.8 and an average score of 84.2. This research indicates that the experimental class achieved a higher maximum score compared to the students in the control class. Implementing interactive 3D media has a positive impact on elementary school students because it provides them with direct visualization. The developed interactive learning media helps students independently explore and be creative in processing the information they receive, understanding the content of the learning material, and drawing conclusions. The learning activities supported by this 3D interactive media positively contribute to students' efforts to enhance higher-order thinking skills.

Keywords: 3D animation; higher order thinking skills; media feasibility; media effectiveness

INTRODUCTION

The application of Higher Order Thinking Skills (HOTS) is a 21st-century demand that students must possess as a level of thinking process developed as concepts, cognitive methods, and learning taxonomies. [1]. The development of higher-order thinking skills is important to accustom students to facing difficult challenges, producing outstanding and intelligent learners in problem-solving [2].HOTS is measured through Bloom's Taxonomy, which has levels C4 to C6 [3].

In Indonesia, there are almost no students who excel in the field of science, which means they are proficient at Level 5 or 6 (OECD average: 7%). This indicates the difficulty students face in mastering higher-order thinking skills, considering that PISA questions not only require the ability to apply concepts but also the ability to analyze, evaluate, and create their solutions [4]. One of the causes of the low higher-order thinking skills of students at the international level is the lack of student involvement in each learning process [5] [6]. The role of students who are not involved in the information-seeking process will make students bored [7]. This will certainly hinder students' motivation to learn, making it difficult for them to acquire higher-order thinking skills [8]. Furthermore, the lack of media usage in the learning process can reduce higher-order thinking skills, and students will tend to feel bored with lessons that only

use minimal media [9], especially for elementary school students, because for elementary school students, learning must use concrete and varied media [10]. Since learning media are tools used or utilized to ensure that teaching can proceed well [11], they help to bring closer or facilitate the path toward the planned goals. [12]. In addition to attracting students' interest in learning [13], teachers can arrange learning media in such a way that it stimulates students' thinking abilities [14]. The necessity of using media in the learning process can be an effective solution by engineering the learning conditions to make them more realistic [15].

Therefore, the importance of developing innovative learning media is crucial for the continuity of the learning process. One alternative as a solution in this case is to combine technology-based learning media. Currently, the use of 3D animation media is still very limited among elementary school teachers in applying it as a learning medium[16]. Because the transformation from designing 2D animations to 3D requires strong technological skills, the resulting learning media can be enjoyed by students[17]. [18] The animation can enhance students' understanding when used in accordance with the cognitive theory of multimedia learning. Additionally, research by [19] reports that incorporating 3D visualization and 3D simulation into other teaching materials creates a new immersive environment, where learners can acquire knowledge and develop higher-order thinking skills.

Basically, critical thinking skills have a complex problem influenced by many factors. One of the main factors is the teaching approach that emphasizes memorization rather than the development of critical and analytical thinking skills in students [20][21][22]. This teaching method often limits students' ability to think creatively, solve problems, and analyze data, which impacts their analytical skills [23]. Another factor affecting low analytical skills is the lack of opportunities for students to engage in learning activities that develop their critical thinking abilities. The lack of opportunities for students to engage affects the development of critical thinking skills, such as analyzing information, evaluating arguments, and drawing conclusions [24] [25]. In line with [26], conventional teaching methods that emphasize rote memorization and recall of knowledge are not sufficiently effective in promoting analytical thinking. On the contrary, teaching approaches that encourage active engagement, problem-solving, and the application of knowledge may be more successful in developing these essential skills [27]. Moreover, the teaching and learning process in many elementary schools is still dominated by a teacher-centered approach, with students playing a passive role in the learning process. This can lead to a lack of student engagement and a lack of opportunities for students to actively practice and develop their analytical skills[28].

Based on the discussion above, this research is oriented towards the development of 3D animation-based learning media in the context of science subjects. The developed media product aims to enhance the higher-order thinking skills of elementary school students.

RESEARCH BACKGROUND

Preliminary studies through interviews with students have been conducted, and the results of these interviews revealed that students still need help to absorb the learning material presented. Students consider that the science curriculum material is something to be memorized. The teaching materials used in the learning process are based on the 2013 curriculum textbooks. The media used by teachers to support learning include images and PowerPoint presentations, which are less engaging for students. Additionally, interviews with teachers provided information that in delivering the material, teachers use the 2013 curriculum textbooks. The media supporting learning in schools is limited, with the development of media mostly consisting of images and PowerPoint presentations. Therefore, there is a need for learning media designed to provide concrete examples, such as animations, photos, and images.

Regarding higher-order thinking skills, teachers in developing test instruments have not fully utilized questions that hone higher-order thinking abilities. The proportion of questions is

PROCEEDING
ICONTESS
Volume 1 No 2, 2025
https://jurnal.unissula.ac.id/index.php/icontess

still dominated by level 1 questions at 50%, level 2 questions at 30%, and level 3 questions at 20%. The results of the pre-research test, which involved giving 5 essay questions to measure the higher-order thinking skills of fifth-grade students, are as follows:

Table 1. Students who can answer the questions

No	School Name	Number of Students	Students who can answer the questions				
			1	2	3	4	5
1	SDN 1	34	41%	52%	47%	76%	58%
2	SDN 2	28	35%	57%	50%	64%	42%
3	SDN 3	26	30%	46%	53%	69%	46%
4	SDN 4	25	48%	52%	48%	72%	32%
5	SDN 5	23	39%	43%	34%	60%	34%
Total			38%	50%	46%	68%	40 %

RESEARCH METHODS

This research uses a descriptive quantitative method. This research aims to discover and explain the implementation of 3D interactive media on students' higher-order thinking skills through collected numerical data [29]. The data collection technique in this research was through a test instrument distributed to all students, where the instrument contained multiple-choice questions. The data collected comes from fifth-grade elementary school students divided into experimental and control classes. The control class had 104 students during the pretest and posttest, while the experimental class had 103 students during the pretest and 104 during the posttest. The use of control and experimental classes will later provide an overview of the initial conditions of the students tested with the pretest and determine the effectiveness of the implementation of learning media on higher-order thinking skills with the posttest.

RESULTS AND DISCUSSION

Results of Students' High-Level Skills

Based on the pretest results that have been collected, a number of data have been obtained that provide an in-depth picture of the student's abilities on questions with a HOTS weight. This data reveals important insights that can serve as a basis for further analysis. The test questions given consisted of 15 items with 3 types of Bloom's taxonomy levels, namely C4 (Analysis), C5 (Synthesis), and C6 (Creation), with each type containing 5 questions. Here is the table of the average scores obtained in the pretest and posttest for the experimental and control classes:

Table 2 Result of Pretest and Posttest Score

Type of Question	No	Control Class		Experimental Class	
		Average Pretest Score	Average Posttest Score	Average Pretest Score	Average Posttest Score
C4	1	52,3	62,7	55	71
	2	34,2	62	43	71
	3	78,1	76,2	79	88
	4	50,2	87	62	95
	6	59,0	101,9	67	118
C5	5	45,8	77,6	67	85

	7	30,4	62,3	48	67
	8	60,4	75,5	66	86
	10	31,7	71,9	53	81
	12	31,7	70,3	46	82
C6	9	32,5	71,9	34	79
	11	31,9	68,9	42	87
	13	44,6	74,5	51	83
	14	31,5	68,9	61	85
	15	54,2	72,4	63	85
Average		44,6	73,6	55,8	84,2

Based on the table above, it is known that overall, all students showed an improvement in scores after being given treatment, both in the control and experimental classes. This can be seen in the average scores of the students in the control class, where there was an increase that can be observed through the average scores obtained by the students. The control class had an average score of 44.6 and achieved a score of 73.6. In this control class, there was a variation in improvement for each type of question. For the C4 type question, the initial score was 54.8 and increased to 63.6. Next, for the C5 type question, the initial average score was 40 and increased to 58.4, and finally, for the C6 type question, the students had an initial score of 39.0, which increased to 58.2. For more clarity, please refer to the following graph:

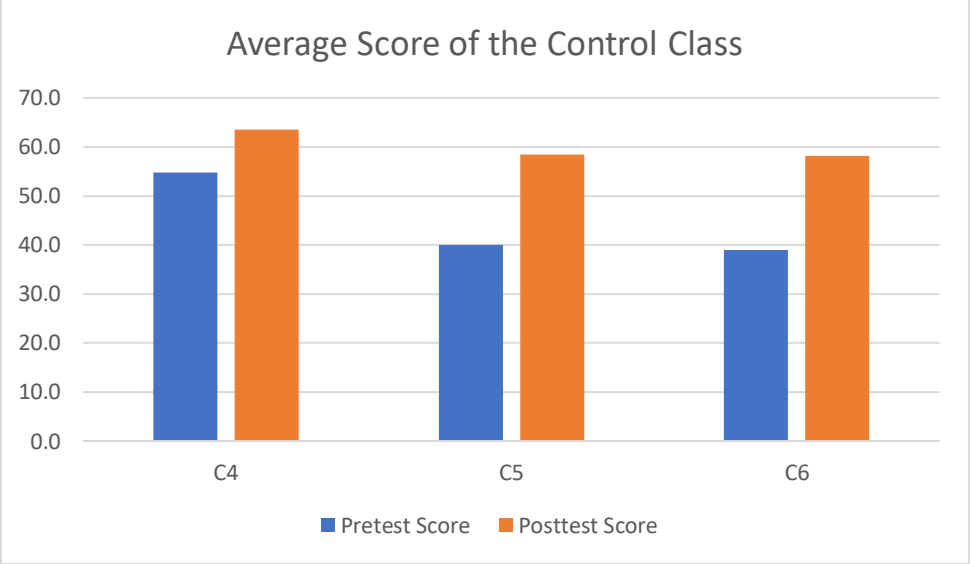
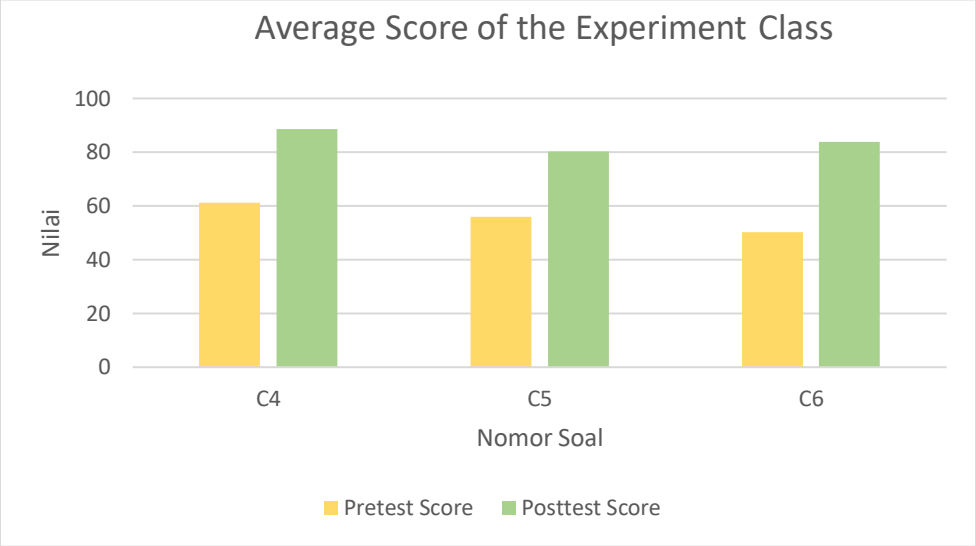


Figure 1 Score of The Control Class

Next, the experimental class also showed different variations. Initially, students had an improvement of 50.8% from the initial average score of 55.8, with a post-test score of 84.2. For the C4 type questions, students initially had an average score of 61.2, which increased to 88.6. Then, for the C5 type questions, students' pretest average score was 56, which increased to 80.2. Finally, for the C6 type questions, this type showed the highest improvement among all types, with a 66.9% increase from the initial average score of 50.2 in the pretest to 83.8 in the posttest. For more detailed information, please refer to the following graph:

PROCEEDING
ICONTESS
Volume 1 No 2, 2025
https://jurnal.unissula.ac.id/index.php/icontess



Media Interactive 3D

The learning media used in this research is Digestive System, which is a 3D Android-based game application containing educational material related to the digestive system of humans and animals. (Ruminansia). In this game, there are quite a few features offered, such as learning materials as the main content of the game. In addition, the simple user interface of this application can make it easier for users to understand the application well. The application, especially in the sub-menu section, is equipped with 3D anatomy featuring content about the digestive system in animals, the digestive system in humans, and diseases that affect the human digestive system, as well as how to care for them. In this application, users can rotate 360˚, zoom in and zoom out, and on the anatomy section, there is also a button. By pressing this button, it will display the name and function of the organ. This application also provides interactive games, namely Gimabar and Gimaru, which aim to engage users in exploring students' knowledge through games independently according to their creativity.

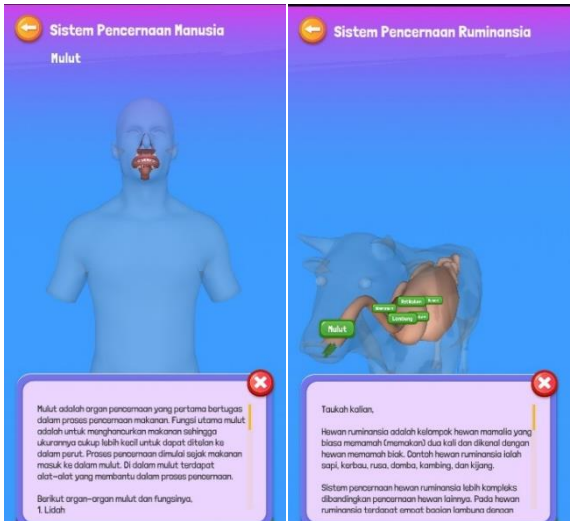


Figure 2 The display on the digestive system game application

PROCEEDING
ICONTESS
Volume 1 No 2, 2025
https://jurnal.unissula.ac.id/index.php/icontess

DISCUSSION

The purpose of this research is to find the relationship between the implementation of 3D media and higher-order thinking skills in elementary school students. 3D animation learning media as teaching materials in interactive subjects can be considered suitable for helping students who struggle to develop their critical thinking skills. The use of animations, videos, and also audio makes students more interested in learning compared to just using textbooks. Furthermore, the implementation of teacher support and skills in mastering media in teaching affects the improvement of students' grades as well as their learning experience[30], [31].

Based on the pretest and posttest results obtained above show the correlation between the use of learning strategies that involve students through information processing on applications and how students can conclude to answer multiple-choice questions. In the control class, there was an increase in the average score from an initial value of 44.6 to 73.6. Meanwhile, in the experimental class, there was a significant increase in the pretest results, with an average score of 55.8 and an average score of 84.2. This test indicates that the experimental class achieved a higher maximum score compared to the students in the control class. These results affirm that the implementation of 3D animation learning media has an impact on higher-order thinking skills in elementary school students.

The outcome of using interactive 3D media positively affects elementary school students because it provides them with direct visual representations. The use of 3D interactive learning media also encourages students to explore the material further through applications. This proves that conventional learning without innovation in the selection of teaching strategies is not sufficient to hone students' critical thinking skills, hence the need for it. The low level of students' critical thinking is related to [20], [21], [22]. The selection of strategies in learning its very influences the development of students' thinking skills. In other words, the integration of learning strategies with synergistic learning media can optimally help improve higher-order thinking skills.

CONCLUSION

The development of higher-order thinking skills is greatly influenced by the teaching strategies chosen by the teacher. The developed interactive learning media helps students to independently explore and be creative in processing the information they receive, understanding the content of the learning material, and how to conclude. The selection of learning strategies assisted by 3D interactive media has a positive contribution to students' efforts to enhance higher-order thinking skills. This research emphasizes that in an effort to improve higher-order thinking abilities in students, the use of 3D interactive learning media can enhance students' higher-order thinking skills.

REFERENCES

[1] T. Gupta and L. Mishra, “Higher-order thinking skills in shaping the future of students,” *Psychol Educ*, vol. 58, no. 2, pp. 9305–9311, 2021.

[2] R. G. Aniceto, “Higher-Order Thinking Skills-Based Assessment in English for Academic and Professional Purposes”.

[3] R. Rasol, S. L. S. Mahadi, F. Z. M. Khalid, N. Syimalâ, S. R. S. Aris, and W. R. W. A. Razak, “Performances in English Proficiency Course with Studentsâ€™ Ability in Answering Higher Order Thinking Skills Questions,” *Environment-Behaviour Proceedings Journal*, vol. 5, no. SI1, pp. 157–162, 2020.

[4] O. Pisa, "Creative Thinking Framework," 2019, *OECD: Paris, France*.

[5] M. Heron and D. M. Palfreyman, "Exploring higher-order thinking in higher education seminar talk," *College teaching*, vol. 71, no. 4, pp. 252–259, 2023.

[6] K. Lu, H. H. Yang, Y. Shi, and X. Wang, "Examining the key influencing factors on college students' higher-order thinking skills in the smart classroom environment," *International Journal of Educational Technology in Higher Education*, vol. 18, pp. 1–13, 2021.

[7] C. K. S. Singh *et al.*, "Teachers' self-assessment of and perceptions on higher-order thinking skills practices for teaching writing," *Pegem Journal of Education and Instruction*, vol. 13, no. 3, pp. 337–349, 2023.

[8] N. Mafarja, M. M. Mohamad, H. Zulnaidi, and H. M. Fadzil, "Using of reciprocal teaching to enhance academic achievement: A systematic literature review," *Heliyon*, 2023.

[9] K. F. Hew, M. Lan, Y. Tang, C. Jia, and C. K. Lo, "Where is the 'theory' within the field of educational technology research?," *British Journal of Educational Technology*, vol. 50, no. 3, pp. 956–971, 2019.

[10] Y. D. Puspitarini and M. Hanif, "Using Learning Media to Increase Learning Motivation in Elementary School.," *Anatolian Journal of Education*, vol. 4, no. 2, pp. 53–60, 2019.

[11] T. Tafonao, S. Setinawati, and E. Tari, "The Role of Teachers in Utilizing Learning Media as A Learning Source for Millenial Students," in *Proceedings of the 1st Asian Conference on Humanities, Industry, and Technology for Society, ACHITS 2019, 30-31 July 2019, Surabaya, Indonesia*, 2019.

[12] L. Darling-Hammond, L. Flook, C. Cook-Harvey, B. Barron, and D. Osher, "Implications for educational practice of the science of learning and development," *Appl Dev Sci*, vol. 24, no. 2, pp. 97–140, 2020.

[13] C. Coman, L. G. Țîru, L. Meseșan-Schmitz, C. Stanciu, and M. C. Bularca, "Online teaching and learning in higher education during the coronavirus pandemic: Students' perspective," *Sustainability*, vol. 12, no. 24, p. 10367, 2020.

[14] C. Oranç and A. C. Küntay, "Learning from the real and the virtual worlds: Educational use of augmented reality in early childhood," *Int J Child Comput Interact*, vol. 21, pp. 104–111, 2019.

[15] R. Roemintoyo and M. K. Budiarto, "Flipbook as innovation of digital learning media: Preparing education for facing and facilitating 21st Century learning," *Journal of Education Technology*, vol. 5, no. 1, pp. 8–13, 2021.

[16] P. A. Facione, "Critical thinking: What it is and why it counts," *Insight assessment*, vol. 1, no. 1, pp. 1–23, 2011.

[17] K. Demir and E. Akpinar, "The Effect of Mobile Learning Applications on Students' Academic Achievement and Attitudes toward Mobile Learning.," *Malaysian Online Journal of Educational Technology*, vol. 6, no. 2, pp. 48–59, 2018.

[18] J. C. Castro-Alonso, B. B. de Koning, L. Fiorella, and F. Paas, "Five strategies for optimizing instructional materials: Instructor-and learner-managed cognitive load," *Educ Psychol Rev*, vol. 33, no. 4, pp. 1379–1407, 2021.

[19] O. Piatykop, O. Pronina, I. Tymofieieva, and I. Palii, "Using augmented reality for early literacy," 2021.

[20] K. Naidoo, R. Naidoo, and K. Ramdass, "Comparing a hybrid mathematics course with a conventional mathematics course: A case study at a University of Technology," *International Journal of Educational Sciences*, vol. 15, no. 3, pp. 392–398, 2016.

[21] Y. N. Demssie, H. J. A. Biemans, R. Wesselink, and M. Mulder, "Fostering students' systems thinking competence for sustainability by using multiple real-world learning approaches," *Environ Educ Res*, vol. 29, no. 2, pp. 261–286, 2023.

[22] C. Chu, J. L. Dewey, and W. Zheng, "An Inorganic Chemistry Laboratory Technique Course using Scaffolded, Inquiry-Based Laboratories and Project-Based Learning," *J Chem Educ*, vol. 100, no. 9, pp. 3500–3508, 2023.

[23] C. D. S. Indrawati, A. Subarno, W. Winarno, S. Permansah, A. W. Wirawan, and D. Rusmana, "Influence of Work Motivation, Interpersonal Skills, and Knowledge Construction on the Work Readiness of Vocational Students," *Educ Res Int*, vol. 2023, no. 1, p. 4956337, 2023.

[24] H. Mohamed Nor and A. J. Sihes, "Critical Thinking Skills in Education: A Systematic Literature Review," *International Journal of Academic Research in* [1] T. Gupta and L. Mishra, "Higher-order thinking skills in shaping the future of students," *Psychol Educ*, vol. 58, no. 2, pp. 9305–9311, 2021.

[2] R. G. Aniceto, "Higher-Order Thinking Skills-Based Assessment in English for Academic and Professional Purposes".

[3] R. Rasol, S. L. S. Mahadi, F. Z. M. Khalid, N. Syimalâ, S. R. S. Aris, and W. R. W. A. Razak, "Performances in English Proficiency Course with Studentsâ€™ Ability in Answering Higher Order Thinking Skills Questions," *Environment-Behaviour Proceedings Journal*, vol. 5, no. SI1, pp. 157–162, 2020.

[4] O. Pisa, "Creative Thinking Framework," 2019, *OECD: Paris, France*.

[5] M. Heron and D. M. Palfreyman, "Exploring higher-order thinking in higher education seminar talk," *College teaching*, vol. 71, no. 4, pp. 252–259, 2023.

[6] K. Lu, H. H. Yang, Y. Shi, and X. Wang, "Examining the key influencing factors on college students' higher-order thinking skills in the smart classroom environment," *International Journal of Educational Technology in Higher Education*, vol. 18, pp. 1–13, 2021.

[7] C. K. S. Singh *et al.*, "Teachers' self-assessment of and perceptions on higher-order thinking skills practices for teaching writing," *Pegem Journal of Education and Instruction*, vol. 13, no. 3, pp. 337–349, 2023.

[8] N. Mafarja, M. M. Mohamad, H. Zulnaidi, and H. M. Fadzil, "Using of reciprocal teaching to enhance academic achievement: A systematic literature review," *Heliyon*, 2023.

[9] K. F. Hew, M. Lan, Y. Tang, C. Jia, and C. K. Lo, "Where is the 'theory' within the field of educational technology research?," *British Journal of Educational Technology*, vol. 50, no. 3, pp. 956–971, 2019.

[10] Y. D. Puspitarini and M. Hanif, "Using Learning Media to Increase Learning Motivation in Elementary School.," *Anatolian Journal of Education*, vol. 4, no. 2, pp. 53–60, 2019.

[11] T. Tafonao, S. Setinawati, and E. Tari, "The Role of Teachers in Utilizing Learning Media as A Learning Source for Millenial Students," in *Proceedings of the 1st Asian Conference on Humanities, Industry, and Technology for Society, ACHITS 2019, 30-31 July 2019, Surabaya, Indonesia*, 2019.

[12] L. Darling-Hammond, L. Flook, C. Cook-Harvey, B. Barron, and D. Osher, "Implications for educational practice of the science of learning and development," *Appl Dev Sci*, vol. 24, no. 2, pp. 97–140, 2020.

[13] C. Coman, L. G. Țîru, L. Meseșan-Schmitz, C. Stanciu, and M. C. Bularca, "Online teaching and learning in higher education during the coronavirus pandemic: Students' perspective," *Sustainability*, vol. 12, no. 24, p. 10367, 2020.

[14] C. Oranç and A. C. Küntay, "Learning from the real and the virtual worlds: Educational use of augmented reality in early childhood," *Int J Child Comput Interact*, vol. 21, pp. 104–111, 2019.

[15] R. Roemintoyo and M. K. Budiarto, "Flipbook as innovation of digital learning media: Preparing education for facing and facilitating 21st Century learning," *Journal of Education Technology*, vol. 5, no. 1, pp. 8–13, 2021.

[16] P. A. Facione, "Critical thinking: What it is and why it counts," *Insight assessment*, vol. 1, no. 1, pp. 1–23, 2011.

[17] K. Demir and E. Akpinar, "The Effect of Mobile Learning Applications on Students' Academic Achievement and Attitudes toward Mobile Learning.," *Malaysian Online Journal of Educational Technology*, vol. 6, no. 2, pp. 48–59, 2018.

[18] J. C. Castro-Alonso, B. B. de Koning, L. Fiorella, and F. Paas, "Five strategies for optimizing instructional materials: Instructor-and learner-managed cognitive load," *Educ Psychol Rev*, vol. 33, no. 4, pp. 1379–1407, 2021.

[19] O. Piatykop, O. Pronina, I. Tymofieieva, and I. Palii, "Using augmented reality for early literacy," 2021.

[20] K. Naidoo, R. Naidoo, and K. Ramdass, "Comparing a hybrid mathematics course with a conventional mathematics course: A case study at a University of Technology," *International Journal of Educational Sciences*, vol. 15, no. 3, pp. 392–398, 2016.

[21] Y. N. Demssie, H. J. A. Biemans, R. Wesselink, and M. Mulder, "Fostering students' systems thinking competence for sustainability by using multiple real-world learning approaches," *Environ Educ Res*, vol. 29, no. 2, pp. 261–286, 2023.

[22] C. Chu, J. L. Dewey, and W. Zheng, "An Inorganic Chemistry Laboratory Technique Course using Scaffolded, Inquiry-Based Laboratories and Project-Based Learning," *J Chem Educ*, vol. 100, no. 9, pp. 3500–3508, 2023.

[23] C. D. S. Indrawati, A. Subarno, W. Winarno, S. Permansah, A. W. Wirawan, and D. Rusmana, "Influence of Work Motivation, Interpersonal Skills, and Knowledge Construction on the Work Readiness of Vocational Students," *Educ Res Int*, vol. 2023, no. 1, p. 4956337, 2023.

[24] H. Mohamed Nor and A. J. Sihes, "Critical Thinking Skills in Education: A Systematic Literature Review," *International Journal of Academic Research in Business and Social Sciences*, vol. 11, no. 11, Oct. 2021, doi: 10.6007/ijarbss/v11-i11/11529.

[25] M. Izzatin, S. B. Waluya, N. Dwidayati, and N. R. Dewi, "Students' proportional reasoning in solving non-routine problems based on mathematical disposition," in *Journal of Physics: Conference Series*, IOP Publishing, 2021, p. 042114.

[26] M. Armstrong, *ARMSTRONG'S HANDBOOK OF HUMAN RESOURCE MANAGEMENT PRACTICE i*, Thirteenth Edition. London: Kogan Page, 2014. [Online]. Available: www.koganpage.com

[27] K. M. Yusoff, N. S. Ashaari, T. Wook, and N. M. Ali, "Analysis on the requirements of computational thinking skills to overcome the difficulties in learning programming," *International Journal of Advanced Computer Science and Applications*, vol. 11, no. 3, pp. 244–253, 2020.

[28] L. Jin, "Investigation on potential application of artificial intelligence in preschool children's education," in *Journal of Physics: Conference Series*, IOP Publishing, 2019, p. 012072.

[29] A. S. Dewi, A. Rusilowati, W. Sumarni, A. Mufid, and K. Naim, "ANALYSIS OF ELEMENTARY SCHOOL STUDENTS' CRITICAL THINKING SKILLS IN THE SUBJECTS OF NATURAL SCIENCE AND SOCIAL STUDIES," *EDUSAINTEK: Jurnal Pendidikan, Sains dan Teknologi*, vol. 10, no. 3, pp. 1167–1180, Jul. 2023, doi: 10.47668/edusaintek.v10i3.953.

[30] R. Rachmadtullah, Z. Ms, and M. S. Sumantri, "Development of computer-based interactive multimedia: study on learning in elementary education," *Int. J. Eng. Technol*, vol. 7, no. 4, pp. 2035–2038, 2018.

[31] M. Liu, Y. Shi, Z. Pan, C. Li, X. Pan, and F. Lopez, "Examining middle school teachers' implementation of a technology-enriched problem-based learning program: Motivational factors, challenges, and strategies," *Journal of Research on Technology in Education*, vol. 53, no. 3, pp. 279–295, 2021.