Research Article https://doi.org/10.12973/eu-jer.11.3.1553

European Journal of Educational Research
Volume 11, Issue 3, 1553 - 1568.
ISSN: 2165-8714
https://www.eu-jer.com/

The Effectiveness of Multimedia Learning for Distance Education Toward Early Childhood Critical Thinking During the COVID-19 Pandemic

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Received: January 10, 2022 ▪ Revised: March 31, 2022 ▪ Accepted: May 19, 2022

Abstract: The government has imposed social restrictions during the COVID-19 pandemic, affecting the education sector, including the early childhood school. Distance education offers different methods from the conventional methods, as the students are expected to gain the same skills, including critical thinking skills. Therefore, teachers must provide distance learning innovations using relevant learning media, such as multimedia-based learning. This research aims to assess the efficacy of multimedia learning in early childhood distance learning. This research is a quantitative model with a quasi-experimental pretest and posttest design. The data collection technique utilized questionnaires given to 30 samples of early childhood children. The data were statistically analyzed using SPSS software. The results confirmed that multimedia-based learning for distance learning could develop critical thinking skills in early childhood children during the COVID-19 pandemic. The results of this study offer exploration of learning strategies to improve children's critical thinking.

Keywords: *Critical thinking, distance education, early childhood, multimedia learning.*

To cite this article: Choiriyah, Mayuni, I., & Dhieni, N. (2022). The effectiveness of multimedia learning for distance education toward early childhood critical thinking during the COVID-19 pandemic. *European Journal of Educational Research, 11*(3), 1553-1568. https://doi.org/10.12973/eu-jer.11.3.1555

Introduction

Early childhood education is characterized as learning to support the growth and development of children aged 0–8 years, holistically engaged in different interrelated areas of care and education (National Association for the Education of Young Children, 2012). According to Agnihotri et al. (2021), the early years of childhood mark an essential stage for the development of basic personalities, values, and attitudes to support children's critical thinking, emotion processing, and socialization throughout their lives. To support childhood learning during the early years, playing activities are considered one of the most suitable methods (United Nations Children's Fund, 2017).

The implementation of the learning system had experienced adjustment almost in all countries since March 2019 due to the COVID-19 outbreak (Kuhfeld et al., 2020). The globally-spreading pandemic firstly emerged in Wuhan, China (Zhao, 2020). The World Health Organization (WHO) then declared the outbreak a global pandemic (Yasenov, 2020). The spread of the COVID-19 has led to numerous changes in life (Jaramillo, 2020), including in the education sector (Tan et al., 2020). The global authorities have responded to the crisis by implementing travel bans, lockdowns, workplace hazard controls, and facility closures. Around 172 countries decided to shut down preschools, schools, and universities, affecting approximately 98.5% of the global student population (United Nations Educational, Scientific and Cultural Organization, 2020).

In Indonesia, the government has started to implement a distance learning system to continue the education process (Abidin et al., 2020). Efforts are made to ensure the implementation of distance learning for Early Childhood Education (ECE) by ensuring health and safety without sacrificing the essence of learning (Organisation for Economic Co-operation and Development, 2020). Distance learning requires innovations to properly achieve the designated learning objectives (Unger & Meiran, 2020). Distance learning can be facilitated through online networks, such as WhatsApp groups, text messages, and phone calls (Sever et al., 2019). The application of various learning strategies is a solution to determine the right strategies for transforming knowledge for ECE distance learning (Almadani et al., 2011).

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Learning activities nowadays are set to help students develop critical thinking skills, as one of the higher-order thinking (HOT) areas (Amolloh et al., 2018). Zukhairina et al. (2020) stated that critical thinking skills are essential for lifelong skills. Critical thinking reflects a mental process in managing relevant data, including making analysis, explanation, hypothesis, argumentation, and development (Alosaimi et al., 2019; Guiller et al., 2008).

In the 21st century, critical thinking skills are considered urgent, as one of the primary objectives of education in Indonesia. However, the development of critical thinking skills is hindered by the current condition (Atiyah et al., 2020). Critical thinking can be boosted by playing activities and children's interactions with their environment (Wang et al., 2021). Bliss (2019) mentioned that not only adults but also children can develop critical thinking skills, suggesting the development of critical thinking since early childhood (Fernández & Feliu, 2020). Teachers can help the development of critical thinking skills during classroom activities with various teaching strategies (Roggman et al., 2006). Several studies have also shown that critical thinking can be developed through teaching (Han & Brown, 2017).

The results of observations and interviews conducted with one of the ECE teachers revealed that the prevailing learning strategies have not facilitated students to practice critical thinking skills. The conventional methods also hindered the students in developing their abilities. Conventional learning methods are no longer a solution for 21st century education, as the era demands more on the use of technology in every learning process (Van Laar et al., 2020).

For the ECE level, learning is holistically performed through play-based teaching to encourage children's development stage (Woolley & Rhoads, 2019). According to Piaget, children face their pre-operational stage without symbolic thinking (Baharun et al., 2016). The early childhood stage also marks children's low concentration, so it requires proper strategies and learning media that can attract children's interest (Cibralic et al., 2021).

The problem challenges the educators to continue distance learning for developing children's critical thinking skills. Thus, teachers must provide crucial innovation for distance learning by using relevant learning media, including multimedia-based learning media (Unger & Meiran, 2020). Multimedia is perceived as a material presentation that combines two or more elements, for instance, graphics, images, photos, audio, and animation (Ratheeswari, 2018).

Multimedia-based learning can create a positive classroom environment and improve children's participation (Bhatti et al., 2017). Interactive multimedia is equipped with a controller that enables users to operate the activities during the learning process (Khan & Masood, 2015; Leszczyński et al., 2018). The utilization of multimedia offers several benefits, including more interesting and interactive activities, the efficiency of the teaching period, the improvement of teaching quality, and the flexible implementation of the learning process (Majid, 2012; Sirait et al., 2017). Multimedia can also present complex and complicated objects or events that may happen sooner or later (Dwiqi et al., 2020; Primamukti & Farozin, 2018).

The findings of previous research stated that multimedia could assist students' learning activities (Khamparia & Pandey, 2017). Another research finding also stated that learning multimedia could encourage students' motivation and their learning outcomes (Kalyuga, 2011). Research by Burris (2020) confirmed the advantage of multimedia in developing children's critical thinking skills through imagining, creating, and communicating. Multimedia can also boost children's social development and improve their readiness to enter primary school (Shilpa & Sunita, 2013).

Previous research by Lauc et al. (2020) using image-based multimedia proved the increasing interest and learning outcomes in early childhood. Another research from Leszczyński et al. (2018) suggested that interactive multimedia can improve children's literacy skills. Several studies have provided information that the advantages of multimedia can enhance children's interest to focus and create a comfortable learning atmosphere (Zulfitrah, 2020). Children will also be encouraged to establish inquiries due to their high curiosity regarding the display of the multimedia used during their learning activities (Suardi et al., 2021). This research, however, only visualizes multimedia with images and text. Meanwhile, research on children's critical thinking is still limited and has not been fully touched. Most of the research focuses on learning outcomes, motivation, and interest in children's learning.

Several multimedia theories explain that the synergy between learning content and technology as an interactive learning medium can accommodate children with audio-visual learning styles. Its implementation can meet the children's learning needs, such as the change of paradigm, in which early childhood requires a real way of thinking about the phenomena around them. This process will continue to develop and encourage children to think critically. Some theories say that children can perform critical thinking due to challenging stimuli. However, the importance of teacher's strategies and learning content that involves activities, such as playing is in great demand.

The utilization of digital technologies for online learning among young children in the early years has sparked debates among scholars, educators, and policymakers in the past decades (Dong et al., 2020). Some scholars Clements and Sarama (2003), and Stephen et al. (2008) have confirmed that multimedia learning could help young children understand abstract concepts and engage them in collaborative learning, reasoning, and problem-solving activities. Recently, Arnott and Yelland (2020) suggested that reconceptualizing digital technologies in a child's reality can contribute to their learning ecologies. Learning and development by providing technology and digital media in early childhood can affect the quality and quantity of online learning opportunities and learning experiences that children receive at home (Erdogan et al., 2019).

The development of a multimedia learning ecology for children should be encouraged to make online learning more prevalent in the future (Koehler et al., 2017). A few research have addressed online learning in the early years. This study will fill this gap by conducting experiments in implementing online multimedia-based learning for early childhood during the COVID-19 pandemic. In particular, the sudden shift to online learning during the COVID-19 pandemic has presented new opportunities and unexpected challenges to the affected young children and their parents. This study can provide a significant theoretical contribution to understanding young children's online learning habits during the lockdown, as a unique study in terms of time and place. Therefore, the current research particularly aims to determine the effectiveness of multimedia learning for distance education toward early childhood critical thinking during the COVID-19 pandemic.

Literature Review

Early Childhood Critical Thinking During the COVID-19 Pandemic

Critical thinking is characterized by the habit of comprehensive exploration of the prevailing problems, ideas, and real evidence (Rhodes, 2010). Critical thinking skills are rooted in constructivist learning theory, which focuses on enhancing the learning experience (Cowden & Santiago, 2016). It reflects one's learning and development of meta-awareness (Colley et al., 2012). Critical thinking skills are demonstrated when children express their curiosity by asking questions, proposing explanations, planning and performing simple investigations, and communicating final explanations or conclusions (National Association for the Education of Young Children, 2012). Children who are accustomed to critical thinking have an approach to solve certain problems and questions. Several indicators of early childhood critical thinking skills from Facione (2016) in the Table 1.

Table 1. Indicators of Early Childhood Critical Thinking During the COVID-19 Pandemic

Indicator	Sub Skills
Interpretation	Children can classify objects based on colors, functions, utilities
	Children can respond to a question by providing simple explanations
	Children can respond to a question by correctly describing ideas/opinions
Analyzing	Children know the solution to certain problems
	Children can make observations and consider the results
	Children can provide an assessment of certain arguments/statements
Evaluation	Children can independently solve certain problems
	Children can make logical reasonings
	Children can make appropriate judgments about certain topics
Inference	Children can respond to certain questions by giving logical conclusions
	Children can form assumptions (hypotheses)
	Children can question the prevailing answers and evidence
Explanation	Children can provide compelling reasons
	Children can justify answers that they believe should be corrected by the statements from themselves or their peers
	Children can make convincing arguments
Self –Regulation	Children can review and consider the prevailing answers and conclusions
	Children can test for similarities and conclusions
	Children can question, correct, and validate certain answers or statements

Critical thinking is the ability to understand concepts, apply, synthesize, and evaluate particular information (Dekker, 2020; Florea & Hurjui, 2015). Critical thinking plays a role in moral, social, mental, cognitive, and scientific development (Fernández & Feliu, 2020). According to Liu et al. (2014), critical thinking assessment involves the integration of all available information, such as questions and phenomena in the form of accountable hypotheses and conclusions. Himmatussolihah et al. (2020) proposed the characteristics of critical thinking, including the ability to learn how to ask, when to ask, and what to ask; the ability to learn how to reason, when to reason, and what method of reasoning to use. To sum up, critical thinking is an ability in finding information, facts, and events through logical reasoning.

Distance Education During the COVID-19 Pandemic

Distance education is generally seen as part of non-formal education since the emergence of the COVID-19 crisis (Mishra et al., 2020). Research from EdSource (2020) the pandemic is considered a hurdle in life aspects from the preschool to college level. Research by Abidah et al. (2020) have confirmed that the condition has created challenges for educational institutions and worsens the learning process. Cavanaugh et al. (2004) in his research stated several countries have adapted to distance education as a means of defense. Distance education has been implemented to

tackle the crisis (Al Lily et al., 2020). Education is now deploying online media. It is not easy to handle the post-COVID-19 learning situation by only using online platforms (Efriana, 2021).

Therefore, compromising the online and offline learning classes is a temporary solution for post-COVID-19 education (hybrid mode) (Mishra et al., 2020). From research conducted by Festiawan et al. (2021) stated that COVID-19 can support students' critical thinking development according to the design applied. El Firdoussi et al. (2020) in his research stated that assessing distance learning during the COVID-19 Pandemic encourage students to think critically in understanding the surrounding environment. Some research on critical thinking is rarely done during COVID-19, must be aware that distance learning is an alternative solution to face-to-face learning. This learning process requires the utilization of technology and online-based networks to link the communication between teachers, students, and the learning content. Harnish and Reeves (2000), characterized the form of distance education evaluation, particularly in terms of:

1. Training (programming skills, barriers, availability, identification of needs, costs),
2. Implementation (administration, fees, course credit costs, institutional ownership, priority of use, integration, coordination),
3. System utilization (information collection, electronic data collection, accuracy),
4. Communication (internal, local, and regional issues related to distance education),
5. Support (fiscal, staff, faculty, instructional, administrative resource allocation).

Multimedia Learning During the COVID-19 Pandemic

Multimedia is the combination of media, such as text (alphabetical or numeric), symbols, pictures, images, audio, video, and animation (Guan et al., 2018). Using static and dynamic images (Alemdag & Cagiltay, 2018), multimedia engages hardware and software to build and run applications (Kapi@Kahbi et al., 2017). There are several features, such as integration, diversity, and interaction that allow individuals to communicate their ideas with digital and print elements. Information and Communication Technology (ICT) has been changing various aspects of human endeavor, especially the education sector, mostly in digital form (Guan et al., 2018). It involves a combination of several technologies to provide the best format, package, and size of information.

However, O'Doherty et al. (2018) expressed their concerns about the learning quality through multimedia and highlighted the main difficulties in establishing online learning communities with high levels of social presence and engagement. Dong et al. (2020) revealed several phenomena, such as social isolation, lack of interactivity and participation, and the amount of delayed feedback. Some scholars Radesky et al. (2016) highlighted their concerns about the risks and dangers of multimedia-based online learning, video addiction, social isolation, and physical health problems. However, all of these concerns have not stopped online learning from expanding rapidly over the last decade (Almarzooq et al., 2020; Karthi & Devi, 2021). Smith et al. (2016) stated that more online programs have been developed and delivered to offer learning flexibility.

Previous research by Masingila et al. (2004) stated that engaging students with multimedia resources incorporating teaching cases overcomes some of these recognised limitations of practice teaching experiences. Research by Grandgirard et al. (2002) the multimedia resources were seen as a key component in our teaching strategies and supported the construction of understanding of effective teaching practices in a student-centered environment. While research from Watters and Diezmann (2007) stated that multimedia learning will not have an impact, when the teacher is not the material according to the students' needs. (Mohd & Badioze, 2011) in his research stated that students will feel addicted if multimedia learning is combined with games.

Therefore, multimedia learning can be understood as a learning strategy that utilizes technology assistance to deliver innovative learning activities efficiently and understand the students' needs. Multimedia learning requires high creativity in modifying the delivery of information, which signifies its advantage. In addition, the facility is acceptable to the early childhood learning environment both for offline and online conditions.

Methodology

Research Design

This research applies a quantitative model through a quasi-experimental pretest and posttest design. It involves a one-group pretest and posttest design. It aims to answer the research question of "What is the effect of collaborative mobile borderless learning applications on students' critical thinking?".

Multimedia learning was performed online by highlighting the subject of science through animated videos. Each meeting consisted of preliminary activities, in which the teacher began an apperception by explaining the rules of learning. The core activities were marked by implementing multimedia-based learning, conducting discussions with children based on the given topics, giving problem-solving tasks, and having the children present the topic. For the final

activity, the teacher invited children to recall the topic, reflect on their learning-by-playing activities, sing, and invite them for rewards. This learning process was performed according to the designated procedures, while the evaluation was performed by stakeholders to provide input for the upcoming class meetings.

Pretest-posttest designs are widely used in behavioral research, primarily to compare groups and/or measure changes resulting from experimental treatments. The focus of this article is to compare groups using pretest and posttest data and related reliability issues (Dimitrov & Rumrill, 2003). Through the questionnaire method as the data collection technique, this research is categorized as a quasi-experimental (quasi-experimental) method using a pretest-posttest non-equivalent group design.

Table 2. Quasi Experimental Design in Early Childhood Critical Thinking

Group	Pretest	Treatment	Posttest
A	O^{A1}	X^{1}	O^{A2}
B	O^{B1}	X^{2}	O^{B2}

Where A: Experimental group, B: Control group, O^{A1}: Experimental group pretest, O^{B1}: Control group pretest, X^{1}: experimental group treatment, X^{2}: control group treatment, O^{A2}: experimental group Posttest, and O^{B2}: control group Posttest.

Participant

This research was conducted in December 2020. Students of the Al-Fikri Kindergarten in Bekasi were involved as the population with a total of four classes. The samples were taken randomly, in which one class was selected and divided into two groups. The multimedia learning method for distance education was tested on 30 ECE children. The samples were then filtered purposively by considering children with adequate internet and computer access. The children aged 5-6 years were considered in a concrete operational period, where they required the teacher's assistance in introducing and learning the context using the real media. In one class consists of 30 children, 17 children are female and 13 children are male. Most of the children come from a fairly adequate economic level. Previous child's mindset based on traditional learning such as, role playing, color drawing, singing, and playing puzzle games. At the end of the lesson, children are given homework assignments.

Instrument

The instruments consisted of test and non-test instruments. The preparation of the instrument was built by referring to the lesson plan determined by the school. The preparation procedure is based on three stages of learning activities, namely: preliminary activities for children's learning, core activities, and final activities for children's learning. We note that the instrument is the main key in the success of the research, in addition to the guidelines from the school. other guidelines than Gudmundsson (2009) are used with stages, namely: the instrument is designed according to the needs, conducts discussions with qualified experts with the instrument material, and applies appropriate methods to investigate bias and check validity.

The instrument for testing critical thinking skills was a multiple-choice questionnaire regarding critical thinking skills, consists of three questions illustrated through pictures according to the learning topic. Meanwhile, the non-test instrument was another questionnaire regarding their opinions when learning using multimedia-based learning, which was applied with a Likert scale. Before the treatment, all students in the class were asked to fill out a questionnaire with their opinions about learning using multimedia-based learning. Following treatment, the students were instructed to fill out the next questionnaire about multimedia-based learning and work on posttest questions.

Table 3. Number of Questions

Construct	Cognitive Level	Item No.	Total of Items
Critical thinking elements (Facione, 2016)	Interpretation	1, 2, 3	3
	Analyzing	4, 5, 6,	3
	Evaluating	7, 8, 9	3
	Inference	10, 11, 12	3
	Explanation	13, 14, 15	3
	Self-Regulation	16, 17, 18	3
Total			18

Procedure

The multimedia-based learning activity for early childhood was performed online through the Zoom application. Two class groups were selected, namely the students who were treated with a multimedia-based learning approach and

those with conventional learning. Before the research, the two classes were given a pretest with the same questions to determine the level of early critical thinking in early childhood before the treatment. The result of the pretest report facilitated to determine the classes with multimedia and conventional learning. In multimedia learning, teachers and students had different roles, in which the students were the center f the learning activities, while the teacher served as a facilitator. In contrast, conventional learning was centered on the teacher and the students became the learning subjects.

The learning activities were performed for eight meetings. At the fourth and eighth meetings, the students were given a posttest to determine the effectiveness of multimedia learning in encouraging their cognitive levels of critical thinking in early childhood compared to conventional learning. Early childhood critical thinking is integrated with multimedia learning. Science learning was chosen as a challenge to encourage early childhood learning. Overall, the duration required in the application of multimedia learning in the classroom is two hours, with details of preliminary activities, core activities in learning, and final learning activities.

The teacher prepared a lesson plan several days before the class teaching. During the meetings, science was chosen as the subject of discussion with the highlight regarding the surrounding natural environment, such as the process of rain, rainbows, and others. The class teaching implemented the following procedures:

1. The learning was performed online, in which one day before the lesson, the teacher sent a learning video based on the designated topic of discussion;
2. During learning, the teacher led several activities through the Zoom application, namely:
   a. Initial reflection activity, in which the teacher greeted the children and led them to sing together;
   b. Core activities, in which the multimedia-based approach was performed for the delivery of lessons through the audio-visual videos, such as the screening of "the process of rain".
   c. After the completion of the learning activities, the teacher instructed the children to ask questions related to the phenomena they saw. This process was performed through a play-based discussion to encourage children in analyzing the lessons.
   d. The children were allowed to argue against the phenomena under the guidance of the teacher.
   e. The teacher allowed the children to retell the "process of rain" using their sentences, while the teacher instructed them to write the process on the paper.
   f. The teacher appreciated the children's works by presenting them randomly via Zoom.
   g. At the final activity, the teacher guided the children to conclude the topic of the day.

The results of the children's responses were analyzed using the criteria that were previously described. The data analysis utilized the SPSS 24 software to determine the differences between the two experimental groups' initial and final conditions in terms of students' critical thinking skills through multimedia learning.

Findings/Results

The analysis was performed to review the validity and reliability of the instruments to measure the students' critical thinking. The SPSS calculation result was summarized in the Table 4.

Table 4. Result of Validity and Reliability Test

Cognitive Level	Item No.	Total Correlation item	Cronbach's Alpha
Interpretation	1, 2, 3	0.719-0.884	0894
Analyzing	4, 5, 6,	0.662-0.851	0866
Evaluating	7, 8, 9	0.765-0.815	0.887
Inference	10, 11, 12	0.735-0.919	0.937
Explanation	13, 14, 15	0.688-0.735	0.815
Self-Regulation	16, 17, 18	0.726-0.804	0.869

There were 18 items with six cognitive levels. The total correlation of items at each cognitive level was above 0.60. Pretz et al. (2016) provided a guide of a strong correlation value in the range of 0.82-0.96. To sum up, the items of the instrument signified a strong correlation, thus the items were considered valid and acceptable to measure the target (Fraser et al., 2020; Niccols et al., 2020). The validity of the items also served as an important factor in determining the accuracy of measuring the target (Meijer et al., 2016).

The Cronbach's Alpha value at each cognitive level was above 0.80, while the cognitive level "Inference" had the greatest Cronbach's Alpha value of 0.937. Several literature reviews examined the instrument reliability with a high

internal consistency of 0.98 (Pretz et al., 2016; Reitz & Smith, 2019). The findings signified that the instrument had a high-reliability value and confidence level for a measuring tool (Leite et al., 2021). An extensive measurement was based on the results of the pretest and posttest. Reliability is defined as the consistency of the measuring instrument in different conditions (Galle & Gana, 2019). The details of the conditions are provided in the Table 5.

Table 5. Results of the Pretest and Posttest

Level	Range of Marks (%)	Number of Students	
		Pretest	Posttest
Excellent	80-100	1	18
Good	60-79	17	11
Moderate	40-59	8	1
Weak	20-39	4	0
Very Weak	0-19	0	0
Average		60.1	83.7
Minimum		22	59
Maximum		86	98
Standard Deviation		17.7	10.8

Before further testing, it is important to know the influence of the pretest and posttest on the study. There was an increase in the abilities of early childhood respondents after the implementation of multimedia learning. Previously, the results of the pretest data showed that only one child scored in the range of 80 to 100 at the Excellent level, while 17 children's abilities were at the Good level and four children at the Weak level. The average pretest value was around 60.1. The result indicated that the children's abilities had not been stimulated by the new knowledge before the implementation of multimedia-based learning. Although the benefits of pretest are commonly limited to memory for directly tested materials (Toftness, Carpenter, Geller, et al., 2018; Toftness, Carpenter, Lauber, & Mickes, 2018) the transfer of learning to the materials that were not directly tested sometimes has also been observed (Carpenter & Toftness, 2017; Lusk et al., 2009).

In contrast to the results of the posttest data analysis, the ability increased to an Excellent level based on the responses of 18 children. The average value of 83.7 indicated the continuous encouragement of mindset and abilities by external stimuli (Turhan, 2017) and new knowledge (Kumpulainen et al., 2020). Pan and Rickard (2018) emphasized that in addition to enhancing recall, posttest can improve the transfer of learning as well. The significant increase is detailed in the following figure.

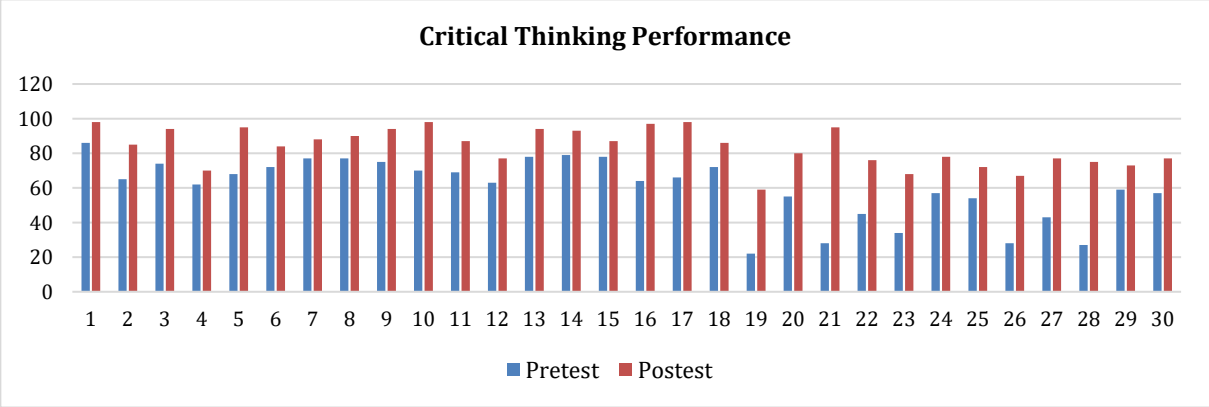

Figure 1. Critical Thinking Performances in Early Childhood

The figure reflects different increases in each child's response ability. The response abilities of 30 children signified a slight difference between the pretest and posttest. Children's response abilities in number 19 and number 21 showed a rapid increase, indicating the effect of multimedia-based learning. According to Drigas et al. (2015), an increasing emphasis on kindergarten education for children with the support of mobile multimedia has been reinforced through the utilization of technologies to overcome learning barriers. After a descriptive explanation of the data, the results of the normality test are presented in the following table.

Table 6. Normality Test

One-Sample Kolmogorov-Smirnov Test	Pretest	Posttest
N	30	30
Mean	60.1	83.7
Std. Deviation	17.7	10.8
Statistical Test	0.127	0.146
Asymp. Sig. (2 tailed)	0.202	0.093

The normality test aimed to confirm if the study sample has a normal distribution. This study used the Kolmogorov-Smirnov test using SPSS for the normality test. The test was defined with the p-value, including $p < 0.05$ (abnormal); $p > 0.05$ (normal) (Ozgul et al., 2018). A hypothesis testing in this study used a paired sample t-test. A paired sample t-test was used if the data were normally distributed. Independent sample t-test was one of the testing methods to assess the effectiveness of pretest and posttest treatments (Nunaki et al., 2019). The basis to accept or reject the H_0 in the paired sample t-test was based on the condition that if the probability $p < 0.05$, H_0 should be rejected and H_a should be accepted; while if the probability $p > 0.05$, H_0 should be accepted and H_a should be rejected.

Based on Table 5, the lowest pretest score was 22, while the highest score was 86 with an average score of 60.1. The posttest data were obtained from learning outcomes following the completion of the learning materials. Based on the posttest score of 30 students, the lowest score was 59, while the highest score was 98 with an average score of 83.7. The asymptote value of the data was normally distributed with a Sig. (2-tailed) between 0.202 and 0.093 > 0.05. The hypothesis test using the paired sample t-tests through the SPSS 24.0 resulted in a significance level of 0.05 (Yafie et al., 2020). The results are summarized in the Table 7.

Table 7. Hypotheses Test Using the t-Test

Cognitive Level	t	Sig. (2-tailed)	Explanation
Interpretation	5,131	0.000	Significant
Analyzing	5,674	0.000	Significant
Evaluating	3,417	0.000	Significant
Inference	2,819	0.000	Significant
Explanation	2,434	0.000	Significant
Self-Regulation	2,849	0.000	Significant
Critical Thinking Performances	15,750	0.000	Significant

Based on the pretest and posttest, the cognitive level was divided into two values, including the results of the t-test and the significance value to determine the categorization of the results. At each cognitive level, the t-value was above 2.40 and the largest value was 5.674 compared with the t-table value of 2.048. If the t-count was greater than the t-table, the hypothesis should be accepted (Schmid et al., 2020). It was strengthened by the significance value of 0.000 at the six cognitive levels, signifying a smaller value than 0.05, marking that each cognitive level had a significant difference.

A significant difference ($p = 0.000$, $t(30) = 15.750$, < 0.05) between the pretest scores (mean = 60.1, SD = 17.7) and posttest scores (mean = 83.7, SD = 10.8) was observed in the study using the paired sample t-test regarding critical thinking abilities. The findings also showed that the elements of critical thinking (Interpretation, Analyzing, Evaluating, Inference, Explanation, and Self-Regulation) had significant differences ($p= 0.000$) in the pretest. This study proves the significance of multimedia-based learning for distance education.

Discussion

Learning conditions that require students to interact with technology will have an impact on students' thinking skills. Through this study, alternative learning was offered online by prioritizing the needs of the students. Learning in Early Childhood Education (PAUD) was the spotlight in this study. The role of teachers and students, in addition to the facilities and infrastructure to support the learning environment during the COVID-19 conditions were emphasized as well. The multimedia-based learning approach was applied as an alternative to manifest children's thinking skills in dealing with problems (Castro et al., 2021). The concept of multimedia-based learning was carried out appropriately based on the development level of early childhood, namely in the concrete operational phase. In this phase, children could still understand various phenomena of life around them in a concrete visualization, ranging from simple to complex forms (Goertzel et al., 2014). Shilpa and Sunita (2013) presented an investigation to identify the roles of different types of multimedia devices and their positive influences on early childhood education (3-6). Drigas et al. (2015) concentrated on the support of mobile multimedia as a significant factor in the development of kindergarten learning.

The previous research was limited to the study of the role of multimedia and the multimedia devices in use. Meanwhile, the current follow-up research was conducted in an experimental study for an early childhood learning environment to

see the effectiveness of multimedia application in encouraging critical thinking in early childhood. Several preparations that the teacher made included multimedia learning procedures assisted by animated videos, science content for children, the class environment, and the design of children's critical thinking instruments. Plowman and Stephen (2005) suggested that students can learn more deeply from well-designed multimedia messages consisting of words and pictures compared to more traditional modes of communication involving words alone. Several research also confirmed that children learned more deeply from well-designed multimedia presentations than from the traditional learning approach. This experiment was performed for eight meetings that were adjusted to the lesson plan, in which the teacher served as a facilitator and controller during the children-centered activities. It was expected that children could contribute their participation optimally as learners (Liu et al., 2020).

Based on the test results, the application of multimedia-based learning for early childhood critical thinking skills was tested for its validity and reliability. Assuring that the instrument items were accurate based on the measured context (Liu et al., 2019). The reliability of the instrument at each cognitive level was tested using the Cronbach's alpha. The instrument should be reliable to ensure its consistency when tested under different conditions (Beyazit et al., 2020).

Other findings were shown through testing the hypothesis. The normality and homogeneity tests were performed before the analysis to provide strong information on the data and ensure the eligibility of the data. A pretest was conducted to map the children's critical thinking. Based on the pretest, children with low abilities were then sorted into the treatment class. The increasing result based on the posttest data indicated the boosting of early childhood cognitive level through the application of multimedia and new knowledge. The finding confirmed that the cognitive level would improve together with the stimuli provided by the teacher (Facione, 2016). Therefore, the advantages of pretest and posttest could accommodate the research on sensitive issues in early childhood (Bahaddin & Ay, 2014).

The measurement quantity from the results of the study was decided through inferential statistical testing using the SPSS software. The hypothesis was used as a benchmark for the final results of this experimental study, in which the overall significance value was $0.000 < 0.05$, indicating the acceptance of the proposed hypothesis. Cognitive levels in early childhood critical thinking increased through the application of multimedia-based learning. This result was inseparable from constraints and other factors that led to the expected results. The success was achieved due to the repetitive process of learning, determination of science as a learning topic, and prioritization of problem-solving with assignment topics for early childhood.

Based on the results, the previous research signifies differences from the current research. The previous research by Drigas et al. (2015) discussed the application of multimedia-based learning that was limited to displaying images and dialogues in delivering learning topics, while the experiment aimed to review the general learning outcomes, motivation, and children's interests. In contrast, the current research modified multimedia-based learning not only with displays, images, and dialogues but also with 3D animated images during the lesson. Additionally, critical thinking and science topics were considered new stuff that only a few researchers had discussed through experiments. The similarity rests on multimedia-based learning and experiments using pretest and posttest designs. The discussion related to children's critical thinking variables and science lessons was considered by most educators not relevant to children. However, this research confirmed that critical thinking could be an area of improvement not only for adults but also for early childhood children (Bliss, 2019).

The results of this study are devoted to looking at critical thinking in early childhood, a combination of emphasis on children's science material that is integrated with multimedia learning through 3D animated videos. The results show that the applied multimedia learning is effective in encouraging critical thinking in early childhood, not only that, children understand that they have a strong sense of self-confidence in learning, and the most important thing is that the child shows himself able to analyze a problem, and the success felt by children is one of the characteristics of the critical thinking component. If compared to previous research Zulfitrah (2020) the success of this research shows that multimedia can affect children's learning motivation, research from Khan (2010) the results show that multimedia with picture shows is successful in increasing children's reading of letter. Such as research from Lauc et al. (2020) stated that multimedia learning has a positive effect on children's learning outcomes, active child asking, and able to build new knowledge. As it is known that the success of this study with the previous one in comparison show a positive influence on multimedia learning. The success rate of each research has differences, especially critical thinking research in early childhood has not been widely carried out in Indonesia.

Conclusion

This research discusses the utilization of multimedia for early childhood by reviewing the mindset and critical thinking of children for problem-solving through the integration of creative play. The mindset of early childhood prioritizes concrete learning related to the phenomena that it encounters. The constant implementation of the conventional learning approach will result in restrictions on children's thinking. The optimization of various learning approaches and strategies can boost the children's potential growth, development, and new skills. The cognitive level is a gradual step that cannot be achieved through a single learning activity, as children aged 2 to 7 years are still at the concrete operational stage, thus an audio-visual strategy is required in maximizing their competence.

Constraints were found during the implementation of the strategy, as teachers' perceptions of learning strategies still tended to be rigid in their conventional application. The introduction of multimedia should use a relevant approach to the children's development. This research contributes to the utilization of critical thinking instruments for early childhood education. Educators and facilitators of the early childhood level can manifest the current learning strategies using digital-based technologies for the integration into the children's learning content. Multimedia as a new introduction for children can be modified with various modern learning applications.

The findings of this study mention that children's critical thinking can be explored through concrete phenomena in analyzing problems, investigating them through discussion with the teacher, and concluding. However, the delivery of online lessons might present an issue regarding the presence of children. Several literature discussions mention that such a process is an interesting scope to study. To minimize the gaps found in this study, the researcher suggests the teachers understand the characteristics of the children, discuss the lesson content with the curriculum experts based on the children's needs, and prepare a simulation before testing the application of multimedia-based learning in facilitating children's learning.

This research offers new insights for other researchers in improving learning strategies for the ECE. It also implies the challenges of experiments in early childhood children aged 5-6 years who still love to play. Teachers are required to improve their literacy in technology and the production of digital-based learning media. Teachers should not assume that children's mindsets are only limited to small children who are just learning. They can quickly adapt when stimulated by a different and interesting learning environment. For the ECE curriculum developers, this research recommends the insertion of a multimedia-based learning approach into every learning design to facilitate children's digital literacy skills.

Recommendations

The current research involves several aspects, including interpretation, analysis, evaluation, inference, explanation, and self-regulation. However, since the current research only covers the development of critical thinking skills during distance education, the researchers suggest future researchers focus on other skills and cover the negative effects of distance education on children. The emphasis on the cognitive level in critical thinking should be reviewed and re-examined at the analysis and evaluation level, as this matter has not been maximized in providing information to children. The data from the results of this study can facilitate the education sector a comparative study regarding the success of children's critical thinking through the encouragement of digital technology-based learning strategies.

Limitations

This research is only limited to the study of critical thinking in early childhood. The research findings have been discussed, basically the way of thinking of early childhood still requires a picture of real objects. To cultivate critical thinking in early childhood, the results of this study used multimedia learning. However, the limitation of the use of media is only for the context of children's science material. Other reviews can also be considered in correcting the shortcomings of this study, such as the role of parents, the learning environment at home, and children's emotional learning.

Acknowledgments

The authors would like to express sincere words of gratitude to all participants that have supported the research.

Authorship Contribution Statement

Choiriyah: Conceptualization, design, analysis, and writing in research. Mayuni: Editing / reviewing, and supervision in research. Dhieni: Editing / reviewing, and supervision in research.

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