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Development of Digital Twin-based Learning Videos in Early Childhood Learning Media Courses

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ABSTRACT

This research aims to develop a learning video based on Digital Twin technology for the Early Childhood Learning Media course. This learning media is designed to increase students' understanding, active involvement, and learning motivation by utilizing realistic and interactive virtual representations. This research used the Research and Development (RnD) method with the DDD-E development model (Decide, Design, Develop, Evaluate). 10 students were selected as research subjects for a pilot study. The evaluation involved multimedia experts, material experts, and students, with the average validation results showing high feasibility (above 89%). The results showed that the Digital Twin-based learning video facilitated the visualization of abstract concepts, increased enthusiasm, and facilitated students' independent learning through integration with the Learning Management System (LMS). This study recommends using this media to support more effective, innovative, and relevant education in the era of the Industrial Revolution 4.0. For future research, it is recommended to expand the scope of implementation in other courses to increase its validity and benefits.

Introduction

Early childhood education (ECE) plays a crucial role in shaping the foundation of children's cognitive, social, emotional and motor development. Innovative and interactive learning media is one of the key elements to support an effective learning process at the ECD level (Chung & Walsh, 2022). The development of technology has encouraged the birth of various innovations in the field of education, including the utilization of the Digital Twin concept. This technology enables the virtual representation of physical objects to support immersive visualization and simulation in learning (Tao et al., 2018).

Initially developed in the manufacturing and high-tech industries, the Digital Twin concept is now being adapted to education. The Digital Twin creates a realistic and interactive learning environment, allowing learners to understand abstract concepts through more tangible visualizations (Jones et al., 2020). In the context of Early Childhood Learning Media courses, developing Digital Twin-based learning videos can provide an innovative solution in presenting complex material in a way that prospective early childhood educators can more easily understand.

Interactive learning videos based on Digital Twin help visualize real situations and encourage active student engagement. Learning through interactive digital representations can improve students' understanding and retention of material (Norris et al., 2019). Using media that is different from usual is a unique attraction for children

because children feel a different learning atmosphere, making it easier for them to accept and understand the material (Khairiyah & Pasaribu, 2024). Furthermore, the development of this learning media is in line with the era of the Industrial Revolution 4.0, which demands maximum utilization of digital technology in learning (Chen, 2021). Using digital-based media allows the integration of visuals and sounds that strengthen student memory, making the learning process more interactive and fun (Lesta & Pransiska, 2023). Learning media becomes an alternative tool used in every lesson, helping to stimulate children to develop their thoughts, feelings, attention, and interest in learning (Elan et al., 2023).

In the context of higher education, the active involvement of students is one of the factors determining the success of learning. Technology-based interactive learning media allows students to play a more active role than traditional lecture methods. Using digital-based interactive teaching media facilitates learners' learning anywhere and anytime and develops their critical thinking skills (Nikmati, 2024). Interactive technology in learning videos can facilitate in-depth learning experiences and improve critical thinking skills and collaboration. With Digital Twin technology, students can explore real situations through digital simulations, allowing them to learn contextually and practically.

Digital Twin-based learning videos allow visualization of complex and abstract concepts to be more authentic and easily understood. For example, in the Early Childhood Learning Media

course, students can learn how children's learning environment can be presented virtually through interactive videos. Visual representation in digital learning media can increase students' absorption of the material and extend the memory of the information conveyed (Kustandi et al., 2021).

In addition, developing media based on Digital Twin technology also increases student learning motivation. Developing interactive multimedia in simulation learning and digital communication improves effectively student learning outcomes. This interactive multimedia facilitates understanding concepts through simulations close to reality, motivating students to engage in learning (Ferdiansyah et al., 2021). This technology provides a different learning experience from conventional methods because students can interact directly with digital representations in learning videos.

Furthermore, using Digital Twin technology supports the implementation of learning that aligns with the needs of the Industrial Revolution 4.0 era. Integrating digital technology into learning is important in preparing students to face global challenges, where technological skills are essential. Using digital technology in learning can improve the quality of education and prepare students to face the industrial era 4.0 (Putrawangsa & Hasanah, 2018).

Therefore, developing Digital Twin-based learning videos offers an innovative solution for delivering learning materials and can also improve understanding, material retention, active involvement, and

student learning motivation. This media is relevant and follows the demands of education in the digital era, making learning more effective, engaging, and contextual.

Despite its great potential, research on the application of Digital Twin in developing learning media, especially in the field of ECD, is still limited. Therefore, an in-depth study on developing Digital Twin-based learning videos for the Early Childhood Learning Media course is needed. This research aims to contribute to developing innovative and effective teaching methods and to answer the challenges of education in the digital era.

Thus, this research focuses on developing Digital Twin-based learning videos as learning media that can improve the quality of learning and student understanding in the Early Childhood Learning Media course.

Methods

This research uses the Research and Development (RnD) method with the development model developed by (Judijanto et al., 2024), namely *the Decide, Design, Develop,* and *Evaluate Model* (DDD-E Model).

In the *Decide* stage, the needs of early childhood learning media courses are identified in terms of student and lecturer needs. Data acquisition at the early stage is carried out through interviews with lecturers and students. A storyboard for the learning video based on the Digital Twin is prepared at the *design* stage. Digital Twin-based learning videos are developed at the *Develop* stage based on the design

results. At the E*valuate* stage, the feasibility and effectiveness of Digital Twin-based learning videos are evaluated by 1 multimedia expert, 1 material expert, and 10 students to get feedback on the learning experience using Digital Twin-based learning videos.

Data collection is done through observation, interview, and questionnaire methods. The data was used to evaluate the feasibility of Digital Twin-based learning video products in early childhood learning media courses from an expert perspective, which includes 1 multimedia expert and 1 material expert in early childhood learning media courses, and tested on 10 students. The students in the limited trial enrolled in the Early Childhood Learning Media course during the odd semester of the 2024-2025 academic year. Data analysis techniques involve qualitative analysis for descriptive data and quantitative analysis for questionnaire results that measure the feasibility level and satisfaction with the developed learning videos. The eligibility criteria for interactive learning videos based on Digital Twin are as follows.

Table 1
Assessment Criteria for Interactive Learning Video Based on Digital Twin

No.	Percentage Range	Criteria	Description
1	80%-100%	Very good	Ready to use (without revision)
2	66%-79%	Good	Ready to use (without revision)
3	56%-65%	Enough	Revised
4	40%-55%	Less	Revised

Source: Arikunto in (Cahyanto et al., 2020) ‘

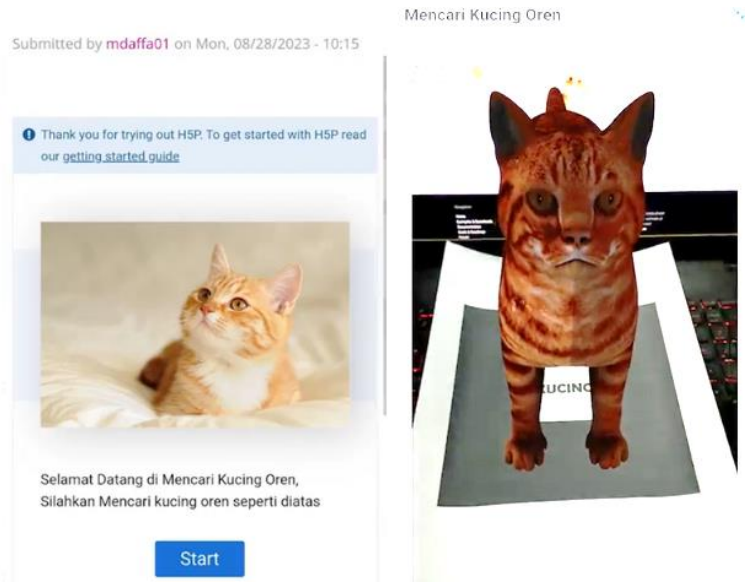
Results and Discussions

This Digital Twin-based learning video was developed using the *Decide, Design, Develop,* and *Evaluate Model* (DDD-E Model) developed by (Judijanto et al., 2024). The stages of development carried out in this study include:

The *Decide* stage. At this stage, the needs of students and lecturers teaching early childhood learning media courses are identified and analyzed through interviews and distributing questionnaires. From this activity, data was obtained that lecturers need media that can help transfer learning media material to students interestingly and interactively. From this activity, data was also obtained that students prefer to learn independently with learning resources that can be accessed anywhere, anytime, and students can set their own learning pace. Based on these findings, it is necessary to accommodate learning media, one of which is an interactive learning video based on Digital Twin. This Digital Twin-based interactive learning video can also be linked to the learning management system (LMS) to support independent learning. That way, students can freely determine how, when, where and what topics will be studied (Oishi, 2020).

The *Design* stage, which is in the development of interactive learning videos based on Digital Twin, aims to make it easier for students to understand the material because this learning video is designed to have material explanations, illustrative videos, and simulation videos and is equipped with evaluations to measure student

understanding. At this stage, learning video design is planned, including preparing learning scenarios that combine Digital Twin technology to present interactive and realistic learning materials. Another convenience offered is that students do not need to install software because it can be accessed directly through the LMS, so students can easily access it from anywhere and anytime. The video is designed to attract attention by combining visuals and audio that is interesting and interactive.



Picture 1. Sample Pictures of Digital Twin-Based Learning Videos

At the *Develop* stage, the initial product in a Digital Twin-based interactive learning video is developed using specialized software that can represent real objects virtually. At this stage, the video is tested internally to ensure the material flow is following the curriculum.

Evaluate stage: The initial product of the Digital Twin-based interactive learning video was tested through the expert validation test and the limited student trial. The initial product of the Digital Twin-based interactive learning video was tested on a limited basis by experts, including multimedia experts to assess the technical quality and appearance of the video and subject experts in early childhood learning media courses to ensure the relevance of content in the course to the needs of Early Childhood Education Teacher Education (PG-PAUD) students. Based on the evaluation results from the initial trial, the product was revised according to the experts' feedback. The learning video was improved to ensure that interactivity, visualization of Digital Twin, and material clarity are more optimal. The questionnaire used for the expert validation test consists of a media validation questionnaire and a material validation questionnaire. The eligibility criteria for interactive learning videos based on Digital Twin are as follows.

Table 2
Multimedia Expert Validator Assessment Results

No.	Assessment Aspect	Score	Criteria	Description
1	User Interface	88%	Very good	
2	Layout/Display	91%	Very good	
3	Audio	90%	Very good	
4	Innovation/novelty	91%	Very good	
	Average	90%	Very good	Ready to use (without revision)

Based on Table 2, multimedia experts give an average score of 90% for the user interface quality, layout/appearance, audio, and

innovation/expansion. Therefore, the Digital Twin-based learning video is ready to use (without revision).

The results of a reasonably high assessment from multimedia experts are based on the user interface, appearance, audio, and novelty/innovation. Interactive learning videos based on Digital Twin are considered easy to use even by beginners with the help of VR tools. Likewise, the display features contrasting and attractive colors, accompanied by clear and clear audio. This Digital Twin-based interactive learning video is also considered innovative because not many media outlets have raised the issue of Digital Twin. As stated (Kristanto, 2016), learning media elements should be varied or diverse because each has advantages and disadvantages.

Table 3
Material Expert Validator Assessment Results

No.	Test Subject	Score	Criteria	Description
1	Suitability of Material with Curriculum	89%	Very good	
2	Suitability of Material with Learning Outcomes	90%	Very good	
3	Linguistics	95%	Very good	
	Average	91,3%	Good	Ready to use (without revision)

Based on Table 3, it can be concluded that the material expert gave an average score of 91.3% for material suitability to the curriculum, material suitability to learning outcomes, and language, so the Digital Twin-based learning video is ready to use (without revision).

The high assessment results from material expert validators are based on the suitability of early childhood learning media material (UAD) contained in the Digital Twin-based interactive learning video following the curriculum of Early Childhood Education Teacher Education (PG-PAUD), Universitas Adi PGRI Buana Surabaya study program, learning outcomes, and learning objectives imposed on early childhood learning media courses. Learning objectives are also delivered at the beginning of the learning video so students can learn about them. It aims to help students focus more on relevant and important material (Sanjani, 2021).

In terms of language, the content of interactive learning video material based on a Digital Twin is arranged using language that is easy to understand, simple, and contextual so that students can easily understand the material content. As stated (Kristanto, 2016), learning media must be adjusted to the learning content/material and objectives to be achieved.

The student trial aims to obtain *feedback* regarding media appearance, ease of use, and material clarity. From observations during the limited trial on students, it was seen that students also reacted well when using interactive learning videos based on Digital Twin. Students looked enthusiastic and actively discussed during the lecture process.

Table 4
Student Limited Trial Assessment Results

No.	Test Subject	Score	Criteria	Description
1.	Media display	89%	Very good	
2.	Ease of use	90%	Very good	
3.	Clarity of material	90%	Very good	
	Average	89,6%	Good	Ready to use (without revision)

The development results show that the Digital Twin-based learning video positively impacts the student learning process in the Early Childhood Learning Media course. Some significant findings include Improved Student Understanding. Students stated that the material presented through Digital Twin-based videos helped them understand abstract concepts more easily through detailed and interactive visualizations and active Student Engagement. Interactive videos increase students' participation during learning. They are more enthusiastic about exploring and discussing the material because the video provides a simulation close to reality.

Thus, developing interactive learning videos based on Digital Twin in early childhood learning media courses is declared feasible and effective for use as an innovative learning media in the digital era.

This study's findings align with research (Selim et al., 2024), which shows that using this technology, especially in higher education, effectively plans a more adaptive and efficient educational process. It is also added that Digital Twin can manage student academic information,

such as grades, attendance, and participation, with a web-based interface that facilitates access for all users (lecturers, academic staff, and students). Students can not only understand the concept of early childhood learning media material through explanations from lecturers but can also learn the material through visual simulations. For example, this material discusses the steps of making educational game tools for early childhood; students are presented with visual simulations that are close to realistic.

Previous research has shown that the use of technology-based interactive learning media can increase the active involvement and enthusiasm of students in the learning process (Alisyafiq et al., 2021; Dewi & Haryanto, 2019; Juniari & Putra, 2021; Junpahira & Pahlevi, 2023; Kamaghe et al., 2020; Kotiash et al., 2022). Digital Twin-based learning videos in early childhood learning media courses can be developed to facilitate interactive learning experiences that encourage students to discuss and explore the material in more depth. It can be seen from the students' enthusiasm during the limited trial, during which they actively participated in the learning process.

The relevance of using Digital Twin-based interactive learning video technology in learning also supports the needs of education in the era of the Industrial Revolution 4.0. This technology allows students to learn flexibly through the Learning Management System (LMS) (Suartama et al., 2020; Widodo et al., 2022, 2023), so students do not need to bother installing additional software. This finding shows that

developing interactive learning videos based on Digital Twin improves students' understanding of abstract concepts and provides a more enjoyable and relevant learning experience to the demands of the digital era. By utilizing this technology, educational institutions can create a more interactive and practical learning environment that supports student learning.

Conclusion

Based on the discussion results, it is concluded that the Digital Twin-based learning video in the early childhood learning media course is declared feasible and effective for use as an innovative learning media in the digital era. It is indicated by the results of the validation of multimedia experts, who gave an average score of 90%; material experts, who gave an average score of 91.3%; and limited trials of students, who gave an average score of 89.6%. So, the Digital Twin-based learning video is ready to use (without revision). Trials conducted with Early Childhood Education Teacher Education (PG-PAUD) students revealed that Digital Twin-based videos improve understanding of abstract concepts and provide a more enjoyable and memorable learning experience. For future research, Digital Twin-based learning videos can be applied to other courses and tested by involving more students to expand the research scope and increase the results' validity.

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