XR SKETCH ASSISTANTS FOR EARLY CHILDHOOD ON ART EDUCATION ENHANCING 4C

Iriaji[1], Agusta Rakhmat Taufani[2], Ike Ratnawati[3], Alby Aruna[4], Adinda Marcelliantika[5], Eka Putri Surya[6], Ginanjar Atma Wijaya[7]

[1,3,5,7]Fakultas Sastra, Universitas Negeri Malang

[2]Fakultas Teknik, Universitas Negeri Malang

[4]Fakultas Ilmu Pendidikan, Universitas Negeri Malang

[6]Fakultas Ekonomi dan Bisnis, Universitas Negeri Malang

iriaji.fs@um.ac.id

Abstract

This research focuses on the evaluation and integration of Extended Reality (XR) Sketch Assistants technology in arts education for early childhood, specifically reviewing its effect on the development of 4C skills (Critical Thinking, Communication, Collaboration, and Creativity). Through quantitative and qualitative experimental designs with the ADDIE Model instructional stages, this study implements an observation, interview and content analysis method approach to collect comprehensive data regarding the application and impact of XR technology in the context of arts education. Preliminary results show that XR Sketch Assistants substantially improve critical thinking, communication, collaboration, and creativity skills in young children. The implementation of this technology in arts teaching and learning provides an interactive platform that encourages visual exploration of sketches, creative problem solving, and innovative artistic expression. The children involved in the study demonstrated enhanced abilities to interpret, analyze, and create works of art with deeper understanding and greater creativity.

Keywords: XR Sketch, Chillhood, Education, 4C.

Abstrak

Penelitian ini berfokus pada evaluasi dan integrasi teknologi Extended Reality (XR) Sketch Assistants dalam pendidikan seni untuk anak usia dini, dengan khusus meninjau pengaruhnya terhadap perkembangan keterampilan 4C (Critical Thinking, Communication, Collaboration, dan Creativity). Melalui desain eksperimental kuantitatif dan kualitatif dengan tahapan instruksional ADDIE Model, studi ini mengimplementasikan pendekatan metode pengamatan, wawancara, dan analisis konten untuk mengumpulkan data yang komprehensif mengenai penerapan dan dampak teknologi XR dalam konteks pendidikan seni. Hasil preliminer menunjukkan bahwa XR Sketch Assistants secara substansial meningkatkan keterampilan berpikir kritis, komunikasi, kolaborasi, dan kreativitas pada anak usia dini. Implementasi teknologi ini dalam pengajaran dan pembelajaran seni menyediakan platform interaktif yang mendorong eksplorasi visual sketsa, pemecahan masalah kreatif, dan ekspresi seni yang inovatif. Anak-anak yang terlibat dalam studi ini menunjukkan kemampuan yang ditingkatkan untuk menginterpretasi, menganalisis, dan menciptakan karya seni dengan pemahaman yang lebih mendalam dan kreativitas yang lebih tinggi.

Keywords: XR Sketch, Usia Dini, Pendidikan, 4C.

INTRODUCTION

Substantial transformations have occurred in early childhood education in recent decades, largely catalyzed by the digital technology revolution (A Aruna et al., 2022). These changes highlight the redefinition of the pedagogical strategies and methods used in educating children. Arts education, as is known, is an integral aspect of the educational curriculum which functions to stimulate and develop creative, critical, collaborative and communication (4C) skills in children (Firdaus et al., 2022). However, there are still challenges faced by traditional pedagogical methods which tend to be monotonous and less interactive, thus hindering the effective actualization of 4C skills. Although traditional methods, such as drawing and coloring, have shown their effectiveness in strengthening children's motor skills and creativity, exploring innovative methods that can integrate technology in arts education is becoming an urgent need. There is a need for a transformation of teaching methodology that can maximize children's potential in the 4C context (Sukmawati et al., 2023). Refining educational strategies involves the integration of digital technologies and pedagogical innovations designed to optimize children's learning experiences and develop their 4C skills to a more advanced and comprehensive level. Thus, new and innovative approaches in arts education can be a catalyst to usher in a generation that is able to navigate and adapt to the challenges of the digital and global era.

Extended Reality (XR) technology has emerged as an innovative solution to overcome the intrinsic challenges in the modern education system. Combining Virtual Reality (VR), Augmented Reality (AR), and Mixed Reality (MR), XR increases student engagement and motivation (Iriaji et al., 2023). XR Sketch Assistants, a clear example of this innovative technology, is redefining the paradigm of art education for young children by changing the methodology used to deliver and receive educational content. Empirical studies show that implementing XR in the curriculum improves students' conceptual understanding, data retention, and students' active participation. With the help of this technology, concepts can be represented visually and interactively, allowing students to learn subject matter at a depth they have never encountered before. However, XR has not been widely studied in arts education, especially for young children. To find out how best to use this technology to address innovation and success in arts education, further research is needed (Morimoto et al., 2022).

The aim of this research is to evaluate the use of XR Sketch Assistants technology in early childhood art education, with particular emphasis on improving the 4C skills: creative, critical, communicating, and collaborating (Maarang et al., 2023). In this research, both quantitative and qualitative data collection methodologies were used, which allowed for a thorough analysis of the direct and indirect effects of XR technology adoption in arts education. Specifically, this research aims to evaluate the use of XR Sketch Assistants technology in early childhood art education, with a special emphasis on improving 4C skills (Sanjayanti et al., 2020). The methodology that will be used includes observations, interviews, questionnaires, and document analysis, within the framework of the ADDIE Model, an instructional development

model that includes the stages of Analysis, Design, Development, Implementation, and Evaluation. The results of this research are anticipated to provide empirical insight regarding the benefits and challenges associated with the integration of XR technology in arts education (Susanti & Arista, 2019). Furthermore, the results of this study will provide practical recommendations for educators and policy makers on how to implement this technology effectively in the education curriculum. In the context of the literature, these findings will be a significant contribution to existing studies on arts education, XR technology, and 4C skills development, broadening our understanding of the potential synergies between these elements in education. This research will also discuss specific aspects related to the application of XR Sketch Assistants in supporting the development of 4C skills in early childhood. The main goal is to develop a comprehensive guide that can be used by educators, policy makers, and other interested parties to maximize the use of this technology in arts education. The findings from this research will not only focus on theoretical aspects, but also applicational ones, helping relevant stakeholders to understand, evaluate and optimally utilize the potential of XR Sketch Assistants in the context of early childhood art education in the digital era. (Izza et al., 2022).

METHOD

Figure 1. ADDIE Instructional Model

Instructional Stages

1. Analysis

The initial study evaluated the needs and challenges that exist in arts learning in early childhood through MOOCs (Massive Open Online Courses). Through surveys, interviews, and literature analysis, it was found that students face difficulties in interpreting and applying art concepts in practice. XR (Extended Reality) Sketch Assistants were identified as a potential solution to bridge the gap between theory and application, by providing enhanced visualization and interactivity.

2. Design

Based on the results of the analysis, a curriculum was designed that integrated XR Sketch Assistants into MOOCs learning modules. Instructional design includes learning scenarios involving animation, simulations, and interactive exercises to facilitate understanding of applied arts concepts. Emphasis is placed on developing students' creative and analytical skills, taking into account the special needs and learning characteristics of early childhood.

3. Development

The development process involved the creation of course content,

development of the XR Sketch Assistants software, and integration of this technology into the MOOCs platform. Initial prototypes were tested to ensure functionality, usability, and effectiveness in delivering course material. Modifications were made based on feedback to improve the tools and course content.

4. Implementation

Updated MOOCs courses, with XR Sketch Assistants integration, launched for pre-schoolers. This implementation involves teacher training, orientation for parents, and ongoing technical support to ensure a seamless learning experience. Learner performance and participation metrics are monitored to inform future iterations of the course.

5. Evaluation

The evaluation involved collecting qualitative and quantitative data regarding the effectiveness of integrating XR Sketch Assistants with MOOCs in improving understanding of applied arts concepts in early childhood. Feedback from students, parents, and educators is analyzed to determine the success of this initiative and identify areas for further improvement and optimization.

Data Collection

This research study explores quantitative and qualitative data collection methods simultaneously. This method is very important to find out how effective and efficient the use of XR sketch assistants is in early childhood art education to improve 4C skills. In the qualitative part, students' interactions with the XR sketch assistant and the impact of these interactions on the development of their 4C skills were assessed through observations, document analysis, and in-depth interviews. Qualitative data was collected through field notes, interview transcripts, and video recordings, and then analyzed to find themes and patterns. Quantitative data, instruments such as surveys and questionnaires that have been validated and tested for validity are used to measure specific improvements in children's 4C skills since the use of the XR sketch assistant. The relationship and influence between the use of XR technology and the improvement of 4C skills may be evaluated using statistical analysis techniques such as analysis of variance or regression. This study aims to provide comprehensive and measurable empirical evidence regarding the role and performance of XR sketch assistants in supporting art learning and 4C skill development in early childhood through the use of this structured methodology.

Data Analysis
Media Validation Test and Material Validation Test

$$x = \frac{\sum x}{\sum xi} \times 100\%$$

Description:
X = Average Value
$\sum x$ = Total score of validator answers
$\sum xi$ = Total score of the highest answer scores
100%   = Constant

After carrying out the validation test analysis, the conclusions that have been reached are as shown in Table 1. Media Feasibility Criteria

Table 1. Media Eligibility Criteria

Achievement Level (%)	Clasification
81-100	Very Worth It
61-80	Worthy
41-60	Decent Enough
21-40	Not Worth It
0	Not feasible

Practicality Test

Practicality test data was obtained by filling in an assessment instrument consisting of 10 statement items. Practicality data was analyzed by percentage using the following formula:

$$Practicallity\ Score = \frac{Total\ score\ obtained}{Total\ score\ maximal} x\ 100\%$$

After the practicality percentage is obtained, the interpretation of the practicality level assessment can be seen in Table 2.

Table 2. Practicallity Criteria

Practicallity Score	Criteria
86% − 100%	Very Practical
76% − 85%	Practical
60% − 75%	Quite Practical
55% − 59%	Less Practical
≤ 54%	Very Impractical

RESULTS AND DISCUSSION

XR Sketch Assistants

This study looks at how XR Sketch Assistants can be used in arts education for early childhood, with particular emphasis on how they help children learn the 4C skills, critical thinking, collaboration, communication, and creativity (Partono et al., 2021). Extended Reality (XR) is a term that refers to technology that combines elements of virtual reality (VR), augmented reality (AR), and mixed reality (MR), thereby providing a platform that makes users feel engaged and interesting (Cárdenas-Robledo et al., 2022). The main focus of this analysis is to understand and evaluate how XR technology can be used in arts curricula, particularly for early childhood. The XR Sketch Assistants application is an innovative pedagogical tool that allows children to interact deeply and contextually with art content (Alam, 2021). The app facilitates learning experiences rich in creativity, engagement and exploration through virtual reality, augmented reality and mixed reality. Children are given the opportunity to access, create and interact with elements of art in ways never before possible. This helps them internalize ideas and skills to a greater extent. In order to gain a better understanding of the potential and effectiveness of XR Sketch Assistants (Al Jahwari et al., 2023), it is important to conduct a thorough assessment of how best to incorporate these applications into learning and teaching approaches. The following is the XR Sketch Assistants framework for implementing learning.


Figure 2. XR Sketch Assistant Framework by Implementing the 4Cs

This media functions to help young children learn to think critically. In teaching art with Innovative Extended Reality (XR) Sketch Assistant (Armando, 2021), children face problems and difficulties that require critical thinking and evaluation. They are invited to plan and design virtual works of art by considering composition, color and shape with the help of XR technology. They are trained to think critically, make decisions, and find creative solutions to problems. The role of this media communication is to improve the communication skills of

young children. Through the use of XR Sketch Assistant, children have the opportunity to interact with classmates and teachers in a virtual environment (Nurazka et al., 2022). They can share ideas, provide feedback, and work together to create virtual works of art together. Because children must listen well, speak clearly, and respect the opinions of others, verbal and non-verbal communication is essential in this process. Media can help children become better at communicating and building healthy social relationships. This media allows children to learn to work together and build ideas together. With the help of XR Sketch Assistant, they can work together on creating virtual artwork and talk to each other during this creative process. This medium also teaches them important teamwork skills, such as listening and understanding other people's opinions. Creativity in this media functions to encourage creativity in young children. Kids can experiment with various design elements, drawing tools, and visual effects with XR Sketch Assistant. They have the ability to create extraordinary and unique works of virtual art, using their innovation and imagination to create new and exciting art experiences. XR technology encourages kids to think outside the box, combine a variety of sound and visual elements, and create works of art that are not limited by real-world limitations. It encourages children's creativity to generate new ideas, broaden their perspective on the world, and express themselves through art.

Media Visualization XR Sketch Assistants
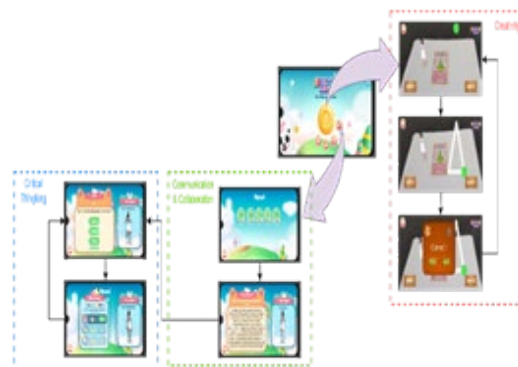
Figure 3. Use of Media XR Sketch Assistants

Data analysis
Media Validation

Based on the total scores of media expert validator answers related to all aspects of the assessment, a score of 86 was obtained from the highest total answer score, namely 100. If interpreted in percent form, a result of 85.83% was obtained with very feasible criteria. The results of the analysis for each aspect of the media validation assessment are presented in Table 3.

Table 3. Media Validation Analysis Results

No	Aspect	∑x	∑xi	%	Criteria
1	Design and Appearance	26	30	86,6	Very Worth It
2	Accessibility	35	40	87,5	Very Worth It
3	Technical Quality	25	30	83,3	Very Worth It
X				85,83	Very Worth It

Material Validation

Based on the total score of material expert validator answers related to all aspects of the assessment, a score of 88 was obtained from the highest total answer score, namely 100. If interpreted in percentage form, a result of 88% was obtained with very feasible criteria. The results of the analysis for each aspect of the material validation assessment are presented in Table 4.

Table 4. Results of Material Validation Analysis

No	Aspect	$\sum x$	$\sum xi$	%	Criteria
1	Suitability of content and material	27	30	90	Very Worth It
2	Completeness and accuracy of information	26	30	86,6	Very Worth It
3	Feasibility and Attractiveness of Presenting Material	35	40	87,5	Very Worth It
X				88 %	Sangat Layak

Practicality Test Analysis Results

Based on the results of the analysis of the results of filling out the practicality assessment instrument, the total score obtained was 1070 out of a maximum total score of 1200, resulting in an overall average score of 89.1%. When referring to the table of practicality criteria, media practicality is at a very practical level.

Discussion

The potential use of sketch assistants for early childhood art education in the XR framework leads to the integration of this application. Sketch assistant provides an innovative solution for more personalized learning in an educational world that is increasingly adapting to technology (Johnstone et al., 2022). In a learning environment tailored to each child's needs, pace and preferences, every child has the opportunity to explore and express himself. With its immersive features (Yongjae et al., 2021), XR provides a rich, multisensory learning space where children can thoroughly understand concepts and skills. This enhances their ability to critically reflect on, analyze and synthesize data. In terms of fine motor skills, coordination skills, spatial skills, and visual awareness of children are improved through their interactions with art elements and ideas in the XR environment through the sketch assistant (Alby Aruna et al., 2021). Activities designed and drawn in responsive 3D environments combine cohesive learning experiences that support cognitive and motor development. In addition, the real-time feedback mechanism in the sketch assistant allows for effective formative evaluation. This facilitates rapid identification of strengths and weaknesses, allowing for timely and relevant educational interventions that focus on individual growth and development. Overall, the incorporation of sketch assistants in XR marks a strategic shift in the approach to arts education for early childhood. It combines flexibility, interactivity, and richness of learning experiences to create a broad and responsive educational ecosystem (Wu & Lee, 2022). This supports creativity and ongoing cognitive and emotional development.

A new paradigm in education that focuses on interactivity and personalization by the use of this technology. The development of children's motor, cognitive, and emotional skills in XR-enhanced learning environments can be examined to gain a deeper understanding of how effective and efficient this technique is (Pebrianty & Pamungkas, 2023). Factors such as response time, level of engagement, and quality of the artwork produced can be used to measure the success of this integration. From a quantitative point of view, data can be collected regarding increasing academic achievement, knowledge retention levels, and developing 4C skills (Prameswari & Anik Lestariningrum, 2020). These workflow metrics can be measured and statistically analyzed to

produce objective findings regarding the impact of education within an XR structure. Long-term studies can also provide data on the long-term development of students involved in these programs, providing a squared evidence base. This research could also be expanded to include demographic variables and measure how effective these technologies are in various social, economic, and cultural contexts. There will be additional empirical evidence regarding the benefits of these additional technologies in early childhood arts education through comparative and experimental analysis, both with and without additions. This more thorough and systematic research will be key to validating and optimizing the application of assistant sketch within the XR framework (Yang et al., 2020), ensuring that this technology is not only innovative but also effective in encouraging positive learning outcomes and the holistic development of young children. early. This data-focused research will help devise better information implementation strategies, ensuring that each element of the XR framework is qualified to achieve the desired goals (Iriaji et al., 2022).

Applying the sketch assistant in teaching the 4Cs (critical thinking, communication, cooperation, and creativity) in early childhood art education, an in-depth needs analysis is carried out to determine specific learning parameters and objectives. The importance of this technology in creating interactive learning platforms and improving conventional methods is discussed in a structured pedagogical context (Muda et al., 2022). Instructional design combines pedagogical principles and educational technology, with special attention to adapting content to meet student needs and preferences. Using this technology

efficiently, training is provided to teachers (Kurniawati, 2022). The learning process is evaluated regularly through formative and summative evaluations, where data is collected and analyzed to measure how effective the use of technology is in 4C learning. The real-time feedback mechanism, which is part of Sketch Assistant, makes it possible to provide immediate estimates of student progress, enabling precise and responsive educational interventions. The assistant sketch integration process is described as a dynamic, iterative, and responsive approach that combines strategic planning, skilled implementation, and continuous evaluation (Ratcliffe et al., 2021). This creates an ideal learning ecosystem where pedagogy and technology work together to achieve the 4C skills in early childhood arts education.

Adaptation and personalization are important components of these applications, designed to meet students' different needs, preferences, and learning rates. XR technology offers extraordinary capabilities that will change the conventional learning paradigm (Marcelliantika et al., 2022). As a key part of this system, the Sketch assistant enables a more dynamic and responsive learning experience. The multisensory learning experience offered by XR improves cognitive aspects (Arsadhana et al., 2022). Sketch assistant strengthens this process by offering mechanisms that allow students to visualize, manipulate, and interact directly with art concepts. This not only optimizes students' creativity but also teaches them critical thinking skills by regularly assessing and reflecting on their work (Newbutt et al., 2020). The integration of XR and sketch assistant creates an environment that encourages the development of fine motor skills

(Hirzle et al., 2023). These skills are essential for cultivating artistic and cognitive abilities. One of the main features of sketch assistant, the real-time feedback mechanism, speeds up the formative assessment process. This allows teachers and educators to quickly discover and respond to each student's strengths and weaknesses. This also allows them to provide appropriate and timely educational interventions to ensure that students develop optimally. This creates a rich, flexible, and responsive learning environment where every student has the opportunity to explore, experiment, and develop in an environment tailored to their unique needs and potential. This environment ensures overall cognitive, emotional, and artistic development (Kern et al., 2021).

The 4C process (critical thinking, communication, collaboration, and creativity) can be accommodated by the XR sketch assistant through the application of an integrated and innovative methodology (Jafnihirda et al., 2023), the XR sketch assistant can accommodate the 4C process, which consists of critical thinking, communication , cooperation, and creativity (Fitria, 2023). As a platform that utilizes extended reality technology, XR sketch assistant provides an extraordinary learning experience and encourages the development of 4C skills in an easy-to-understand and interactive way. XR sketch assistant gives students the opportunity to see and assess concepts visually and spatially in the context of critical thinking. The ability to interact and manipulate objects and components in real-time supports reflective and analytical processes, encouraging students to make connections, evaluate variables, and gain deeper understanding. XR sketch assistant's

collaboration feature strengthens communication. Learners have the opportunity to work together in a virtual space, combining ideas and skills to create consistent and innovative works of art. The development of the ability to cooperate and interact with others is aided by these interactions. The freedom of expression provided by this technology encourages student creativity (Kuna et al., 2023). Students are motivated to innovate and discover new ways by freely experimenting with components and techniques in a 3D environment. XR sketch assistant uses immersive technology to support exploration, expression and exchange of ideas in an enriched arts education context, helping to realize the 4C skills. The resulting empirical evidence shows that the XR sketch assistant not only improves the technical and artistic skills of learners but also helps in the development of 4C skills. This research shows how interactive and immersive learning environments can encourage reflective and analytical processes, improve communication skills, encourage cooperation, and encourage creativity and innovation (Nudiyanti & Sudarmilah, 2023). This data provides a clear and detailed picture of how XR sketch assistant can change the paradigm of art education by ensuring that learning is not only transactional but also transformative, and empowering students to acquire critical skills for the 21st century.

The results of the media expert validator's evaluation of the application of XR Sketch Assistants in early childhood education show the feasibility of this technology. This shows high feasibility and shows that this media is an effective and high quality educational tool with a score of 86 out of 100, or 85.83%. To determine the effectiveness and feasibility of this

use in an educational setting, elements such as interactive design, visual quality, ease of navigation, and educational value were thoroughly evaluated. Results show that XR Sketch Assistants can provide students with innovative, enriching, and pedagogical learning experiences. Educational content presented visually and interactively allows students to better understand and internalize lessons, which supports deeper learning and long-term retention. The capacity of XR Sketch Assistants to support students' critical and creative skills shows how effective they are as a pedagogical tool. The assessment criteria show that this media encourages a learning process that encourages analysis, synthesis and reflection. They also combine technology and information in interesting and engaging ways.

Evaluation results from material expert validators show that the material presented is very feasible; it received a score of 88 out of 100, indicating that the material meets most eligibility criteria and quality expectations. In this case, a score of 88% indicates content validity and other aspects such as relevance, accuracy, and completeness in Content, presentation, and methodology criteria are components of the assessment. To ensure that information is conveyed clearly and efficiently, material presentations are assessed based on the accuracy, depth and up-to-dateness of the information presented. Instead, methodology analyzes the teaching methods used and how effective they are in facilitating student understanding and retention. The material has managed to meet most expectations and quality standards with a score of 88% in percentage interpretation. This demonstrates a commitment to providing educational content that is not only informative but

also pedagogical, enriching students' learning processes with relevant information and innovative methods. However, keep in mind that there is still room for improvement and optimization, and feedback from validators can be used for further improvements to ensure that educational materials are always at the highest standards.

The results of the practicality analysis based on filling out the assessment instrument provide an in-depth picture of the effectiveness and feasibility of the media being tested. With a total practicality score of 1070 out of 1200, the medium achieved an overall average score of 89.1%, indicating that it is not only effective but also efficient in education. Media is assessed based on practicality criteria which consist of several evaluation dimensions, such as ease of use, affordability, flexibility, and adaptability to various learning situations. They show excellent performance in terms of usability and adaptability, showing that these media are easy to use and can be adapted to specific needs. In the practicality criteria table, an average score of 89.1% places the media in the "very practical" category. This indicates that the media not only meets quality requirements, but also includes elements that help students maximize their learning experience and create an interactive, supportive, and student-centric learning environment. Additionally, this score indicates positive reception and constructive responses from users, both teachers and students, who see this medium as a useful learning tool that helps achieve academic goals. These respondents and feedback are very important for the assessment of practicality because they emphasize the importance and relevance of the media

in real classroom situations. Therefore, a score of 1070 indicates that the medium has many qualities in itself, as well as the ability to meet the needs and expectations of various educational stakeholders, which makes it a valuable and reliable learning resource.

The results of statistical data analysis carried out in SPSS for Windows with the Kolmogorov-Smirnov normality test show a significance value of 0.200, which is significantly greater than the threshold of 0.05, which indicates that the data distribution follows a normal pattern. Since the assumption of normality of data is the main requirement for parametric analysis, this in statistical terminology indicates the validity of the subsequent statistical testing process. The paired t-test was used to carry out effectiveness testing which aims to measure significant differences between conditions before and after implementing the intervention; in this case, certain learning media are used. The average value before media application was 60.40, according to empirical data from fifty samples. It represents a performance standard that can be used to evaluate the impact of an intervention. Students show a significant increase in their achievement after implementing learning media; The average score increased to 90, and this increase showed improved quantitative and qualitative indicators for better academic performance. This increase shows that the integrated learning media is very effective. Individual and group variability in responses to learning media is critical for deeper analysis. This analysis, which includes parameters such as variance and standard deviation, as well as regression and correlation analysis, can provide a more in-depth picture of the dynamics of the interaction between learning

media and student academic achievement (Rasyida, 2023). This analysis will also provide a strong empirical basis for interpreting the effectiveness of learning media and making pedagogical suggestions about how learning media can be further incorporated into educational practice.

Future projections in the use of XR Sketch Assistant in early childhood education, driven by combining new technologies with pedagogical research. More flexible, interactive, and student-centric learning methods are becoming increasingly important in today's education world. With its engaging and interactive capabilities, XR Sketch Assistant is expected to play an important role in meeting these needs. It is hoped that learning platforms that encourage students' creativity, innovation and independent exploration can help meet these needs. Continued research and evaluation of how effective XR Sketch Assistant is in improving learning outcomes, student experience, and teaching efficiency will provide important information about the further adoption and adaptation of this technology (Koukopoulos et al., 2022). A personalized curriculum should be designed to meet a student's learning needs, abilities, and preferences. From a technology perspective, innovation and improvements to XR Sketch Assistant's features and functionality will continue to occur as a result of progress and user feedback. Platform capabilities will be enhanced with the integration of more sophisticated data and analytics, artificial intelligence, and other supporting technologies, which will enable more personalized and responsive learning experiences (Johnstone et al., 2022). Creating an ecosystem that supports educational technology innovation and integration, education stakeholders, technology

developers, and regulators must collaborate with each other at the institutional and policy levels. Quality, ethical, and privacy standards will be revised and strengthened to ensure that XR Sketch Assistant not only meets academic needs but also maintains student integrity, security, and well-being. Overall, the projections of XR Sketch Assistant reflect a new era in early childhood education. Pedagogy and technology work together to create dynamic, inclusive, and innovative learning environments that help students develop holistically and prepare them to face the challenges of the 21st century with the skills and knowledge they need (Nurazka et al., 2022).

This research has demonstrated the ability to enhance the learning experience through interactive platforms that encourage critical thinking, creativity, teamwork, and effective communication. The research results show that the use of XR Sketch Assistants in art education improves the quality and effectiveness of the teaching and learning process. The young children involved in this study showed increased creativity, better critical thinking skills, better communication skills, and better collaboration skills. Apart from encouraging them to explore and try things that are not limited by the physical world, this platform allows children to communicate their ideas and emotions in a creative and visual way. This study found that adding XR Sketch Assistants to art education programs provides an unprecedented opportunity to optimize early childhood 4C skill development. These results indicate that incorporating XR technology into educational strategies is critical to enhancing learning experiences, increasing student engagement, and supporting the achievement of optimal learning outcomes. Furthermore, curriculum development and research that uses XR technology will be critical to maximizing the potential of this innovation in the education of future generations.

CONCLUSION

This research has succeeded in revealing the significant potential of Extended Reality (XR) technology in enriching arts education and improving the 4C skills of early childhood. Through the application of XR Sketch Assistants, children demonstrate improved critical thinking, communication, collaboration and creativity skills. These findings indicate that the integration of XR technology in arts education not only improves the quality and efficiency of learning, but also broadens students' creative and intellectual horizons. In line with these results, further adoption and adaptation of XR technologies in educational curricula is needed to maximize the learning potential and integral skill development of early childhood.

ACKNOWLEDEMENT

REFERENCES

Al Jahwari, L., Garaj, V., & Harrison, D. (2023). What If Xr Is Fully Utilised in Design Education? Preliminary Results From a Participatory Design Fiction

Study. *Proceedings of the International Conference on Engineering and Product Design Education (E&PDE 2023)*, September. https://doi.org/10.35199/epde.20 23.91

Alam, A. (2021). Notice of Retraction: Designing XR into Higher Education using Immersive Learning Environments (ILEs) and Hybrid Education for Innovation in HEIs to attract UN's Education for Sustainable Development (ESD) Initiative. *International Conference on Advances in Computing, Communication, and Control (ICAC3)*, 1–9. https://doi.org/10.1109/ICAC35 3642.2021.9697130

Armando, R. (2021). Mewujudkan Keterampilan 4C Siswa di Abad 21 Melalui Model Pembelajaran Berbasis Masalah. *Journal of Chemical Information and Modeling*, April.

Arsadhana, I. W. A. S., Dewi, N. K. R. S., & Kirana, N. K. J. (2022). Aplikasi pembelajaran berbasis virtual reality sebagai inovasi pendidikan berkelanjutan di era society 5.0. *Prosiding Webinar Nasional Pekan Ilmiah Pelajar (PILAR)*, 736–740.

Aruna, A, Iriaji, I., & Rini, D. (2022). DIGITAL LEARNING MEDIA FOR CULTURAL ARTS CLASS-VII PROTOTYPE CURRICULUM INTEGRATED 6C AND TPCK. *International Conference on Art, Design, Education and Cultural Studies (ICADECS)*, 4(1). http://conference.um.ac.id/index. php/icadecs/article/view/7921

Aruna, Alby, Ishlah, N. F. P., Inayah, L., & Prasetyo, A. R. (2021).

Educational Game Design "Napak Tilas Panji Asmorobangun" in "Wayang Beber" Story. *EDUTEC : Journal of Education And Technology*, 5(1), 1–25. https://doi.org/10.29062/edu.v5i 1.268

Cárdenas-Robledo, L. A., Hernández-Uribe, Ó., Reta, C., & Cantoral-Ceballos, J. A. (2022). Extended reality applications in industry 4.0. – A systematic literature review. *Telematics and Informatics*, 73, 101863. https://doi.org/https://doi.org/10. 1016/j.tele.2022.101863

Firdaus, Z., Izza, J. N., Aruna, A., Novaldi, M. D., & Setiawan, D. (2022). Pengembangan mikroskop online interaktif pada materi biologi sel guna revitalisasi pembelajaran praktikum daring. *JINoP (Jurnal Inovasi Pembelajaran)*, 8(1), 95–105. https://doi.org/10.22219/jinop.v8 i1.18997

Fitria, T. N. (2023). Augmented Reality (AR) and Virtual Reality (VR) Technology in Education: Media of Teaching and Learning: A Review. *International Journal of Computer and Information System (IJCIS) Peer Reviewed-International Journal*, 04(01), 14–25. http://www.ijcis.net/index.php/ij cis/article/view/102%0Ahttps://i jcis.net/index.php/ijcis/indexJou rnalIJCIShomepage-https://ijcis.net/index.php/ijcis/in dex

Hirzle, T., Müller, F., Draxler, F., Schmitz, M., Knierim, P., & Hornbæk, K. (2023). When XR and AI Meet - A Scoping Review on Extended Reality and

Artificial Intelligence. In *Conference on Human Factors in Computing Systems - Proceedings*. https://doi.org/10.1145/3544548.3581072

Iriaji, I., Prasetyo, A. R., Aruna, A., Putri Surya, E., Lydia Ade Vega, B., & Marcelliantika, A. (2023). Virtual Reality Trimatra and Dwimatra Laboratory Visual Art Materials for Higher Education. *KnE Social Sciences*, *2023*, 154–160. https://doi.org/10.18502/kss.v8i15.13922

Iriaji, I., Prasetyo, A., Taufani, A., Surya, E., Vega, B., Marcelliantika, A., & Aruna, A. (2022). DEVELOPMENT OF NFT ARTWORK BASED ON LOCAL CULTURAL ASSETS IN PAGELARAN VILLAGE. *International Conference on Art, Design, Education and Cultural Studies (ICADECS)*, *4*(1). http://conference.um.ac.id/index.php/icadecs/article/view/7917

Izza, J. N., Firdaus, Z., Roziqin, M. F. A., Aruna, A., & Setiawan, D. (2022). Pengembangan animal section game simulator dengan VR sebagai alternatif praktikum. *Prosiding Seminar Nasional Pendidikan Biologi*, *8*(1), 251–260.

Jafnihirda, L., Rizal, F., & Pratiwi, K. E. (2023). Efektivitas Perancangan Media Pembelajaran Interaktif E-Modul. *INNOVATIVE: Journal Of Social Science Research*, *3*, 227–239.

Johnstone, R., McDonnell, N., & Williamson, J. R. (2022). When Virtuality Surpasses Reality: Possible Futures of Ubiquitous XR. *Extended Abstracts of the 2022 CHI Conference on Human Factors in Computing Systems*, *6*, 1–8. https://doi.org/https://doi.org/10.1145/3491101.3516396

Kern, F., Kullmann, P., Ganal, E., Korwisi, K., Stingl, R., Niebling, F., & Latoschik, M. E. (2021). Off-The-Shelf Stylus: Using XR Devices for Handwriting and Sketching on Physically Aligned Virtual Surfaces. *Frontiers in Virtual Reality*, *2*(June), 1–20. https://doi.org/10.3389/frvir.2021.684498

Koukopoulos, D., Dafiotis, P., Sylaiou, S., Koukoulis, K., & Fidas, C. (2022). XR technologies for self-regulated student exhibitions in art education: survey and first design considerations. *2022 International Conference on Interactive Media, Smart Systems and Emerging Technologies (IMET)*, 1–8. https://doi.org/10.1109/IMET54801.2022.9929450

Kuna, P., Hašková, A., & Borza, Ľ. (2023). Creation of Virtual Reality for Education Purposes. *Sustainability (Switzerland)*, *15*(9), 1–19. https://doi.org/10.3390/su15097153

Kurniawati, F. N. A. (2022). Meninjau Permasalahan Rendahnya Kualitas Pendidikan Di Indonesia Dan Solusi. *Academy of Education Journal*, *13*(1), 1–13. https://doi.org/10.47200/aoej.v13i1.765

Maarang, M., Khotimah, N., & Maria Lily, N. (2023). Analisis Peningkatan Kreativitas Anak Usia Dini melalui Pembelajaran STEAM Berbasis Loose Parts.

Murhum : Jurnal Pendidikan Anak Usia Dini, *4*(1), 309–320. https://doi.org/10.37985/murhu m.v4i1.215

Marcelliantika, A., Surya, E. P., Vega, B. L. A., Aruna, A., Rini, D. R., Iriaji, I., & Prasetyo, A. R. (2022). DESIGN OF GAME-BASED LEARNING MEDIA THE HISTORY OF GENERAL SOEDIRMAN'S JOURNEY IN THE PACITAN REGENCY GERILYA WAR. *International Conference on Art, Design, Education and Cultural Studies (ICADECS)*, *4*(1). http://conference.um.ac.id/index. php/icadecs/article/view/7915

Morimoto, T., Kobayashi, T., Hirata, H., Otani, K., Sugimoto, M., Tsukamoto, M., Yoshihara, T., Ueno, M., & Mawatari, M. (2022). XR (Extended Reality: Virtual Reality, Augmented Reality, Mixed Reality) Technology in Spine Medicine: Status Quo and Quo Vadis. *Journal of Clinical Medicine*, *11*(2). https://doi.org/10.3390/jcm1102 0470

Muda, U., Aninditya, S., Putra, O., & Ardianto, S. (2022). pada Interior Museum Batik Indonesia sebagai Sarana Edukasi & Rekreasi. *Jurnal Sains Dan Seni ITS*, *11*(4), 124–129.

Newbutt, N., Bradley, R., & Conley, I. (2020). Using Virtual Reality Head-Mounted Displays in Schools with Autistic Children: Views, Experiences, and Future Directions. *Cyberpsychology, Behavior, and Social Networking*, *23*(1), 23–33. https://doi.org/https://doi.org/10. 1089/cyber.2019.0206

Nudiyanti, S. H., & Sudarmilah, E. (2023). Educational learning media by cross puzzles to improve social character in elementary school children. *AIP Conference Proceedings*. https://doi.org/https://doi.org/10. 1063/5.0141765

Nurazka, R. A., Fitriasari, N. S., & Widjayatri, R. D. (2022). Pengembangan Aplikasi Giat Bergerak sebagai Desain Pembelajaran Abad 21 bagi Anak Usia 4-6 Tahun. *Aulad: Journal on Early Childhood*, *5*(2), 242–252. https://doi.org/10.31004/aulad.v 5i2.356

Partono, P., Wardhani, H. N., Setyowati, N. I., Tsalitsa, A., & Putri, S. N. (2021). Strategi Meningkatkan Kompetensi 4C (Critical Thinking, Creativity, Communication, & Collaborative). *Jurnal Penelitian Ilmu Pendidikan*, *14*(1), 41–52. https://doi.org/10.21831/jpipfip. v14i1.35810

Pebrianty, R. D., & Pamungkas, J. (2023). Menggambar sebagai Alternatif Pendekatan Konsepsi Pendidikan Seni Rupa Anak Usia Dini. *Jurnal Obsesi : Jurnal Pendidikan Anak Usia Dini*, *7*(1), 536–547. https://doi.org/10.31004/obsesi.v 7i1.3696

Prameswari, T., & Anik Lestariningrum. (2020). Strategi Pembelajaran Berbasis STEAM Dengan Bermain Loose Parts Untuk Pencapaian Keterampilan 4c Pada Anak Usia 4-5 Tahun. *Efektor*, *7*(1), 24–34. https://doi.org/10.29407/e.v7i2.1 4387

Rasyida, R. (2023). Pembelajaran Berbasis Metaverse–Virtual

Reality Menggunakan Spatial. io dengan Model Discovery Learning untuk Meningkatkan Minat dan Pemahaman Siswa. *Jurnal Pendidikan Tambusai*, *7*(2), 15875–15882.

Ratcliffe, J., Soave, F., Bryan-Kinns, N., Tokarchuk, L., & Farkhatdinov, I. (2021). Extended Reality (XR) Remote Research: a Survey of Drawbacks and Opportunities. *Proceedings of the 2021 CHI Conference on Human Factors in Computing Systems*, 1–13. https://doi.org/https://doi.org/10. 1145/3411764.3445170

Sanjayanti, N., Darmayanti, N., Qondias, D., & Sanjaya, K. (2020). Integrasi keterampilan 4C dalam modul metodologi penelitian. *Jurnal Pedagogi Dan Pembelajaran*, *3*(3). https://doi.org/https://doi.org/10. 23887/jp2.v3i3.28927

Sukmawati, N. I., Ika, N., & Rakhmawati, S. (2023). Pengaruh Pembelajaran Steam (Science , Technology , Engineering , Art , And Mathematic) Untuk Meningkatkan Keterampilan Berpikir Tingkat Tinggi (Critical Thinking And Problem Solving) Pada Anak Usia Dini. *Concept: Journal of Social Humanities and Education*, *2*(1), 127–141.

Susanti, E., & Arista, A. (2019). Analisa Tingkat Pengetahuan Guru terhadap Kompetensi 4C. *Prosiding Seminar Nasional Ilmu Sosial Dan Teknologi (SNISTEK)*, *2*(September), 73–78. https://ejournal.upbatam.ac.id/in dex.php/prosiding/article/view/1 509

Wu, P., & Lee, R. (2022). DIGITAL ART CREATION EDUCATION FOR THE ELDERLY WITH MILD COGNITIVE IMPAIRMENT THROUGH EXPRESSIVE ART THERAPY. *ICERI2022 Proceedings*, 7999–8007. https://doi.org/https://doi.org/10. 21125/iceri.2022.2055

Yang, K., Zhou, X., & Radu, I. (2020). XR-Ed Framework: Designing Instruction-driven andLearner-centered Extended Reality Systems for Education. *ArXiv*. http://arxiv.org/abs/2010.13779

Yongjae, L., Byounghyun, Y., & Soo-Hong, L. (2021). Sharing Ambient Objects Using Real-time Point Cloud Streaming in Web-based XR Remote Collaboration. *Proceedings of the 26th International Conference on 3D Web Technology*, 1–9. https://doi.org/https://doi.org/10. 1145/3485444.3487642