International Journal Software Engineering and Computer Science (IJSECS)
4 (3), 2024, 1210-1218
Published Online December 2024 in IJSECS (http://www.journal.lembagakita.org/index.php/ijsecs)
P-ISSN: 2776-4869, E-ISSN: 2776-3242. DOI: https://doi.org/10.35870/ijsecs.v4i3.3031.

RESEARCH ARTICLE Open Access

Development of an Educational Game for Food Capture Based on Augmented Reality Using Face Mesh Detection and Computer Vision

Muhammad Arib Umar Sadid
Information Systems Study Program, Faculty of Computer Science, Sekolah Tinggi Ilmu Komputer Cipta Karya Informatika, East Jakarta City, Special Capital Region of Jakarta, Indonesia.
Email: mazadid76@gmail.com.

Dadang Iskandar Mulyana *
Information Systems Study Program, Faculty of Computer Science, Sekolah Tinggi Ilmu Komputer Cipta Karya Informatika, East Jakarta City, Special Capital Region of Jakarta, Indonesia.
Corresponding Email: mahvin2012@gmail.com.

Dedi Gunawan
Information Systems Study Program, Faculty of Computer Science, Sekolah Tinggi Ilmu Komputer Cipta Karya Informatika, East Jakarta City, Special Capital Region of Jakarta, Indonesia.
Email: aldedi@gmail.com.

Received: August 1, 2024; Accepted: November 15, 2024; Published: December 1, 2024.

Abstract: This study aims to propose an educational game for newborns around 4 months old who do not yet know how to distinguish objects that should not be put in their mouths. This seems very normal when it occurs during this stage of life, but it should be encouraged with educational tools — because eating objects that are not food can cause choking or suffocation. AR technology provides an interactive and engaging learning environment by overlaying digital information on the physical environment. The game also uses Computer Vision technology such as Face Detection and Recognition to control user interaction based on body movements. By combining computer vision, the game provides a new and dynamic way to increase user engagement, introducing new opportunities for the development of interactive educational games for young children.

Keywords: Educational Games; Early Age; Recognizing Food; Augmented Reality (AR); Computer Vision.

1. Introduction

The period from 0 to 8 years is considered the golden age of children, and early childhood is a very important phase of human development. Throughout this period children become physically, emotionally, and socially developed which has a significant impact on their personality development in later life. This age group has distinct developmental characteristics and only happens once in a human's life [1]. At this point, children start learning things around them like the ability to recognize food and other objects that can be put in their mouths. Hence, education at this age should be taken seriously as it plays an important role in child growth. Positive and enjoyable learning experiences are greatly influential to establish fundamental skills which will become the groundwork to children cognitive and socioemotional development [2]. But, traditional methods that are commonly used to learn do not catch children's attention and are usually boring for them. The advancement of technology, particularly computer systems, has brought numerous possibilities of exploring more interactive and engaging learning processes for preschoolers. One such technology that holds a lot of promise is Augmented Reality (AR), which overlays digital components in the physical world to enhance the experience even further. Augmented reality (AR) has been applied in diverse fields since it tends to enhance the engagement level of the learning process and the efficiency of the learners in their education [8]. In early childhood learning, AR can be utilized effectively to provide an entertaining and engaging introduction to a variety of objects, including an instructional journey into the world of food. For instance, the kids will learn, by interacting directly with the objects that surround them, and through electronic devices like a smartphone or tablet, by playing with the tools to eat, safely and fun.

Alongside AR, computer vision technology may also play a great potential in supporting children's learning. Vision Machine is a part of AI, which helps to make computers interpret and analyze visual data from the immediate environment. Among all the cool applications of computer vision, one othem is facial recognition — the ability of a device to identify human faces within an image or video. In Early Childhood Education games, deploying facial recognition technology can lead to more personal and interactive learning experiences. For example, this technology can also be used in educational games that teach children what food they can and cannot eat, in which the child can touch any object around them and receive certain feedback based on the object they touch [3]. In addition, with this technology, more interesting games can also be developed in which the objects can adapt to children's body movements so that they can learn while playing. There are many challenges faced in designing educational games using AR and computer vision, from engaging game design to the realization of appropriate technology for children. Nevertheless, in spite of these great difficulties, using AR and 3D/visual computing in young child teaching has certain positive effects that should not be ignored. This technology also encourages children to learn in a playful and interactive way, making educational games more interesting. Moreover, this game, can also aid children develop basic skills which are very important for their lives, including the fine motor skilIs, object recognition, social and emotional skilIs.

Effective AR software has become an educational game to teach animals and their food such as; 5% of isotonic solution. In a study conducted by Mufida *et al*. (2021), they created an educational game with augmented reality (AR) to teach children about animals and their food. It uses fun and interactive visual elements that make it easier and more enjoyable for children to understand basic concepts [1]. Similarly, a study conducted by Irliando *et al*. (2023) proposed the introduction of traffic signs by creating an avatar game using AR. This game shows how AR can make learning a more enjoyable and engaging experience [2]. According to Saraswati *et al* (2023) AR technology has also been used to introduce early childhood to various professions [3], which creates AR snapshot-based educational media to familiarize children with various professions in interactive mobile applications. With AR technology and facial recognition, children will be able to recognize more people and objects in their environment, such as food, and interact with them in a more enjoyable way. In addition, this technology is also able to develop creative and innovative games that attract children's interest in using interactive ways to learn more about their environment. This technology opens up new possibilities for creating interesting and effective media for early childhood education. Applications that imply AR technology and computer vision for early childhood education will greatly improve education in the future and provide more meaningful experiences for children.

2. Research Method

The method used in developing this educational game is the Waterfall method. The Waterfall method is a linear approach consisting of a series of stages carried out sequentially, each stage must be completed before proceeding to the next stage. The stages in this method include needs analysis, system design, implementation, deployment, and maintenance. Each stage has a very important purpose and role in ensuring that the system being developed can meet the goals that have been set.

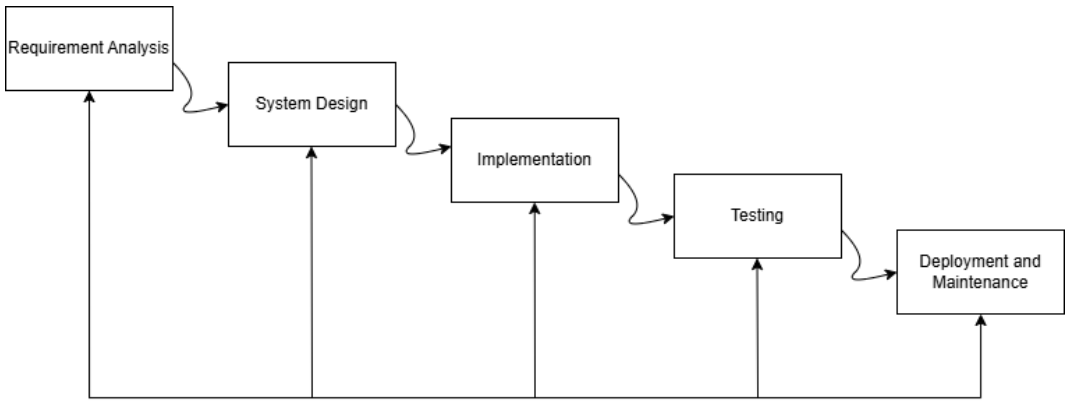

Figure 1. Waterfall Method

2.1 Needs Analysis

In the first stage, a needs analysis is conducted to identify the system requirements that must be met in the development of this educational game. This needs analysis includes work related to determining the conditions and specifications that must be present in a new product or product change, taking into account the various needs of the stakeholders involved. The requirements resulting from this stage must be feasible, measurable, testable, and closely related to the identified business needs. This process ensures that the system to be built truly meets user needs and can meet the desired goals. At this stage, meetings are held with various stakeholders to explore information related to what features and functions are desired in the game, as well as the technical requirements underlying its development. These needs are then defined in detail so that they can be used as a basis for system design in the next stage..

2.2 System Design

Once the system requirements are clearly identified, the next stage is system design. At this stage, the system designer will create a design that describes how the system will work to meet the needs that have been set. System design includes not only technical aspects, but also the design of the user interface, interaction flow, and business processes that will be run in the educational game. The main purpose of system design is to create a system that is efficient, easy to use, and can meet the learning objectives that have been set. One of the main aspects that needs to be considered in designing this game is the use of facial recognition technology and Augmented Reality (AR) which will detect the condition of the child's mouth whether it is open or closed. The use of this technology aims to increase interactivity in the game, so that children can learn to recognize edible objects in a fun way. In the design process, mathematical formulas are also prepared to calculate the ratio of mouth opening and the position of objects that fall in the game. For example, the ratio between the position of the upper and lower lips (Updown) and the left and right lips (LeftRight) is used to detect whether the child's mouth is open or closed. In addition, the position of the falling object also needs to be measured to determine whether the object is in the edible category. All of these components will form a data structure that facilitates information processing and program code compilation at the implementation stage. Several components need to be considered when structuring the commands for the program to be executed, such as the detector for determining whether the mouth is open or closed. The ratio/area of points created by the mouth's outline must be adjusted, as shown in the formulas below:

$$R = \frac{UD}{LR}$$

Where:

r = ratio of the mouth's opening (whether large or small)

UD = (Updown) the coordinate distance between the upper lip and the lower lip

LR = (LeftRight) the coordinate distance between the left lip and the right lip

Once the ratio is determined, commands can be input by defining the size of the ratio to detect whether the mouth is open or closed. The condition we will apply is that if the mouth is open, any object the user "eats" will not count as a point, and similarly, if the mouth is closed, any object "eaten" will also not count as a point. In addition to the components mentioned above, we also need to integrate distance control or recognize the condition where the user is "eating" something. However, before that, we need to identify the position of the falling object to include it in the calculation, as shown in the following formula analogy:

$$E = \frac{r}{d}$$

Where:
E = Condition for "Eating Object"
r = ratio of mouth's opening (whether large or small)
d = distance between the center of the object and the center of the "Mouth"

From the analogy above, we can determine the size of the "Eating Object" condition by considering the factors described above.

2.3 Implementation

Implementation is the stage where all designs that have been prepared at the design stage are applied in the form of program code that can be run. This process involves translating concepts and designs that have been created into a real software application or system. This implementation aims to create educational games that are in accordance with previously established plans and needs. In addition, testing is also carried out at this stage to ensure that all features and functions in the game work as desired. Testing includes aspects of functionality, such as face detection and object recognition, as well as interactivity in games that involve the use of AR technology. Implementation also includes integrating software with the hardware used, such as smartphones or tablets, to ensure that the application can run properly and can be used smoothly by children. This implementation ensures that the system developed can function properly in real-world conditions and is ready to be tested at the deployment stage.

2.4 Deployment and Maintenance

After the implementation stage is complete, the next step is deployment, which is the process of implementing a system or application into a real operational environment. At this stage, the application that has been developed will be installed and used by end users. This deployment also involves monitoring and evaluating the performance of the application after it is installed. Any problems or errors that arise at this stage will be addressed immediately to ensure the application runs smoothly. In addition, feedback from users is also very important for further improvement. Software maintenance is an equally important stage in the software life cycle. Maintenance is carried out to fix errors, improve application performance, and adapt the software to changes that occur during use. At the maintenance stage, updates and adjustments are made so that the application remains relevant to technological developments and user needs. Maintenance also includes adding new features that can improve the user experience in using this educational game. This maintenance process is important to ensure that the game continues to perform well and can continue to provide benefits to users throughout its lifetime.

3. Result and Discussion

3.1 Results

The augmented reality game developed by the author uses Python programming language and incorporates Face Mesh Detection from computer vision technology, which is utilized as an interaction medium between the user and the game. To detail the steps involved in completing this augmented reality game project using computer vision, based on the theory and materials learned by the author, the following steps are taken:

3.1.1 Program Implementation

Several objects were created and exported in .PNG format and stored in a folder. These assets were measured in pixel size to facilitate the computer's reading and calculations when executing commands in the program.

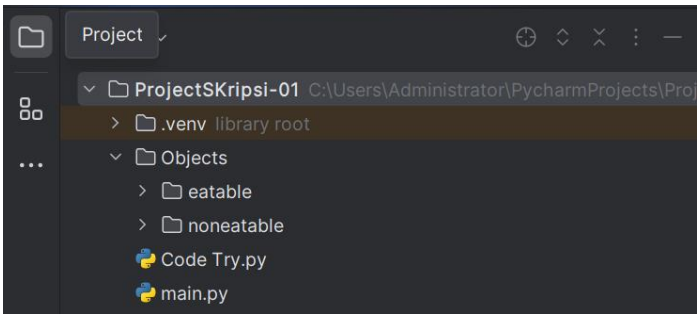

Figure 2. Importing Assets Object

In this stage Installing Packages, several libraries need to be installed before executing commands or writing the code that will be used to run the program. Among these libraries are OpenCV, Mediapipe, and CV Zone. In this stage Importing Face Mesh Detector and Camera Testing, Face Mesh Detector is integrated with the camera used. Additionally, camera testing and screen size optimization for the recording are performed.

Figure 3. Results of Face Mesh Detector Integration and Camera Optimization

Once all components are available, this stage involves combining the Face Mesh Detector program with the previously created game program.

3.1.2 Development Workflow

The following steps outline the process to complete the game development:

1) Problem Analysis
   The program used by the user is based on augmented reality, with computer vision functions applied. This program was built using the Python programming language and developed through the Pycharm application. It integrates the Face Mesh Detector as an interaction tool within the game. In addition to incorporating the Face Mesh Detector into the game, the author has also included an educational element in the research as part of the game's final outcome. This addition aims to clarify the purpose of the game, making it easier for readers to understand the game's purpose and its educational benefits.
2) Estimating Work Progress
   Creating an accurate work estimate is an essential part of project management to ensure success and efficiency. This process includes a detailed analysis of the tasks to be performed, the resources required, and the time needed to complete them. An accurate estimate helps to identify potential obstacles, set priorities, and optimize resource allocation. It also aids in managing the expectations of both the client and the team, providing a strong foundation for better decision-making. Therefore, creating a work estimate is crucial for achieving the best and most satisfying results.
3) Design and Architecture of the Model
   Designing the model and architecture is a critical step in the development of complex systems. This process involves determining the structure and key components of the system, as well as how these

components interact. The primary goal of design and model architecture is to create a strong framework that can support the functional and non-functional objectives of the system. During this phase, various technical aspects such as scalability, security, and performance are considered. A systematic and structured approach to model and architecture design helps develop a more efficient, reliable, and future-proof system.

4) Game Application Testing

Game application testing is an essential process to ensure the quality and performance of the game before its release. This phase involves testing the functionality, performance, and compatibility of the game across various devices. Testers look for bugs, glitches, and other issues that could affect the user experience. Additionally, testing evaluates aspects such as gameplay balance, control responsiveness, and user satisfaction. Through thorough testing, developers can deliver a more stable, enjoyable, and bug-free game. Below is a screenshot of the user's experience when playing the food capture game (Figure 4) and Below is a screenshot of the game when a "Game Over" event occurs (Figure 5).

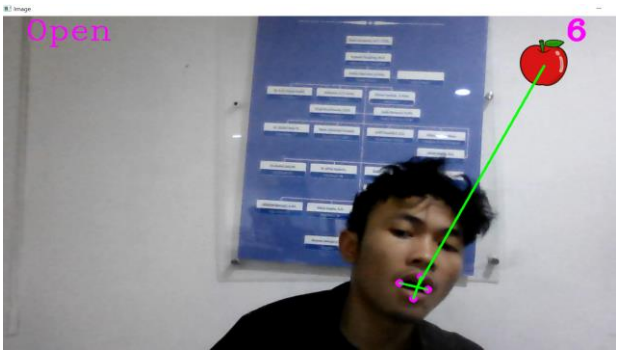

Figure 4. Event of Playing The Food Capture Game

Figure 5. "Game Over" Condition

3.2 Discussion

This study introduces the development of an augmented reality game that aims to create an interactive learning environment for children. Children use Facial Mesh Detection from computer vision to touch objects around them, allowing them to learn what is safe to eat. The use of AR layered with computer vision allows for a unique experience that combines educational and engaging elements for children. The game addresses the need for children to learn to identify food and non-food items so that inappropriate behaviors do not occur that could lead to choking on non-food substances. So where does Facial Mesh Detection come in? It is key to making the game more interactive and responsive. When children open their mouths, the game uses this facial information to provide real-time feedback. For example, if a child's mouth is open, whatever they are trying to "eat" will be considered out of bounds and will not count as a point. This real-time feedback gives children insight into the cause and effect of what they are doing (opening their mouths) and what they should or should not put in their mouths. This means that the detection system ensures that the game sequence reacts directly to the child's movements, forming a direct cause-and-effect relationship that helps in reinforcing the same learning objective of the game. This brings another important step forward with AR technology for educational games. AR can overlay digital content on top of the real world to make the overall learning experience more interactive and engaging. Here AR is used to overlay virtual food that interacts with children in the context of their real-world environment. Face Mesh detection with AR enhances the learning experience by providing an interactive and passive experience where children participate in the game based on their activity. Such a combination also opens the door for further exploration in developing educational games beyond just food recognition, such as learning about animals, shapes, and numbers.

Using python, and libraries like OpenCV, Mediapipe, and CV zone turned out to be a good choice for building the game. Python's flexibility and seamless integration with computer vision and AR technologies made the development process smooth. With the requirement of facial recognition and AR, these libraries were key in bringing the game to life and making it an enjoyable experience for the user. The project contributes to the growing body of research exploring the potential of AR in early childhood education, as developing augmented reality games for educational purposes is still a relatively new field. That said, there are a few things that need to be improved in future installments of the game. The accuracy and responsiveness of face detection in different lighting conditions or for children with different facial characteristics, for example, could be improved. Additionally, having more interactive objects in the game and more sophisticated educational content could help improve it as an educational tool. These changes would allow for a more

tailored presentation that accommodates different speeds and methods of deployment. The project is an augmented reality game that aims to promote early childhood education around food safety. Technology combines computer vision with AR, resulting in a dynamic, immersive, and immersive educational experience that can be developed as the game progresses.

4. Related Work

Many studies have explored AR and computer vision-based educational games for children, and while they certainly reveal parallels with our study, there are also some differences. Arumsari *et al*. (2021) used animated images in an educational game to increase student engagement, reinforcing the power of visual elements, an idea that resonates with our implementation of AR for interactive visual feedback [4]. Rusdi *et al*. (2021) used AR for interactive teaching in an elementary school, demonstrating the potential of AR to increase student engagement [5], similar to how AR was used in our study to teach food recognition. Although they were for thematic learning, our study focused on food safety education for young children. Jaya *et al*. (2023) and explored mobile games from an early childhood education perspective; their focus was on an Android-based educational game to teach letters and numbers [6]. Our study also introduced a mobile game, but it is unique in that it uses computer vision and AR to detect mouth movements, which appears to be absent from their game. Sholeh *et al*. (2021) examined AR in education and concluded that AR is beneficial for education because it promotes immersive learning [7], which is consistent with our own use of AR to engage children in the learning process. Our work primarily focuses on providing food safety recognition features for young children using AR and computer vision technologies, while their work is generalized towards education.

Another study by Yuniza *et al*. (2022) designed a parser-based video game to help learners learn Indonesian that also utilized interactive game-based learning [8]. Although somewhat similar methodologically, their technology was aimed at language learning, unlike our study, which focused on food safety education for children and involved human facial recognition as the mode of interaction. Wabula *et al*. (2022) showed that AR can be used in a high-context setting for children learning about the COVID-19 pandemic [9]. However, unlike their application, which was health-centered, our study focused specifically on food safety awareness. Faiza *et al*. (2023) compared two knowledge acquisition methods in social sciences, one of which evaluated AR as an educational tool; our study was conducted online using AR for educational experiential purposes [10]. Its communicative effects were targeted and intended to be educational, but its focus was on social studies, and our game focused directly on food safety with an interactive AR experience.

Prasetya *et al*. (2023) examined the need for AR-based learning media in the context of computer hardware teaching, emphasizing the importance of developing effective educational tools [11]. Their study also emphasized the need to have appropriate educational content, but our focus is on providing tools to develop AR-based food recognition tools for young children. Pradhana (2023) explored the use of AR in teaching Tajweed as a research in the field of Tajweed studies [12], which shows the application of AR in various fields of study. While their work suggests the use of AR in religious education, our study suggests the use of AR to teach food safety to children. Hidayani *et al*. (2024) found AR used as an interactive tool to provide cognitive skills for children, which directly supports the use of AR in our study [13], but our context places the focus specifically on food safety education. Sonita and Susanto (2022) have applied AR to teach script detection, which is somewhat similar to our use of AR for learning purposes [15], but our game uniquely includes face detection to recognize actions related to food. Anas *et al*., as they discuss the potential of AR to enhance pedagogical skills among teachers, whereas our study focuses on the use of AR to engage young children to teach a specific curricular subject, food safety [14]. Sidiq *et al*. (2022) while the AI-based game developed by Shamsudin *et al*. (2022) uses a visit to the national heroes museum as a teachable event [17], our study relies on computer vision through facial recognition which is a 'direct' and 'sensory' interaction with the learning object, namely food safety. Utomo *et al*. (2023) are still very different in content and target audience as they use AR for science teaching in secondary schools [18]. Our study focuses on food safety education for young children, a very specific and developmentally appropriate topic. Subroto *et al*. (2024) investigated AR-based educational games for middle school students, focusing on broad educational outcomes, while our research targets early childhood education with a specific focus on food safety, distinguishing our work in terms of both content and developmental appropriateness [19].

This shows that AR and computer vision have broad applications in educational contexts, with research focusing on their contributions to everything from general education to specific subject areas such as language, science, health, and social studies. Our research is different in that we provide food safety education from a young age through AR and computer vision to promote an engaging and immersive environment. The novelty

of the approach lies in its intense focus on early childhood education and real-time interactivity through machine vision-based facial detection, in contrast to previous efforts that have addressed much broader or completely different educational content.

5. Conclusion and Recommendations

This study successfully created an informative game based on augmented reality (AR) with face mesh detection as a medium of interaction between individuals and the game. The interesting thing about this game is that body movements can be part of the interaction that can create an interesting and dynamic game. Therefore, by using computer vision algorithms, this game applies face mesh to track the user's mouth movements and provide them with feedback tailored to it in real-time. AR encourages engagement, the game becomes interactive, meaning children become active participants in the learning process, making it easier for them to stay engaged and understand the information. In this scenario, children realize that food objects are different from non-food objects (and vice versa) when they take direct actions in the game, which intrinsically makes this a more engaging way of learning than standard methods. When integrated into game development, computer vision opens new doors to more advanced and specialized educational games, including new ways to facilitate effective learning more broadly across subjects. By using AR in this study, it can create interactive experiences that deeply connect the virtual and physical worlds. Such techniques not only engage children's minds but also provide them with resources to ensure they learn while playing. For example, similar to how AR+Computer vision technology in this game will help teach various aspects of life such as shapes, animals, colors, and so on in various educational settings—using the same immersive interactive characteristics.

In addition, AR-based learning tools will also allow for future enhancements, as previous research has shown. The potential for using augmented reality in educational applications for children is enormous as AR technology continues to become more accessible, especially through smartphones and tablets. The same principle applies not only to game development but also to other educational contexts, as AR has the potential to create more engaging and effective learning experiences. It is hoped that the contributions of this research will enhance the dimensions of game development, game technology, and computer vision. In particular, the use of AR and computer vision technologies in early childhood education can teach teachers a lot about the future of interactive learning and the development of tools that can provide substantial, impactful, and enjoyable learning experiences for children using these technologies.

References

[1] Mufida, B. A., Putra, F. N., & Yusron, R. D. R. (2021). Pembuatan games edukasi pengenalan hewan berdasarkan makanannya berbasis augmented reality. *Journal Automation Computer Information System, 1*(2), 120-130. https://doi.org/10.47134/jacis.v1i2.20

[2] Irliando, A. R., Rahmanto, Y., & Putra, A. D. (2023). Game augmented reality (AR) untuk pengenalan rambu-rambu lalu lintas. *Swarnadwipa, 1*(1), 14-21. https://doi.org/10.58602/mediaswarnadwipa.v1i1.25

[3] Saraswati, I. D. A. I., Putra, I. M. A. W., & Gunawan, I. M. A. O. (2023). Pengembangan media edukasi pengenalan profesi bagi PAUD melalui augmented reality menggunakan Assemblr. *Jurnal Informasi dan Teknologi, 5*(4), 348-357. https://doi.org/10.60083/jidt.v5i4.463

[4] Arumsari, R., Rohmat, C. L., Herdiana, R., & Hayati, U. (2021). Media gambar animasi pada game edukasi untuk meningkatkan minat belajar. *KOPERTIP: Scientific Journal of Informatics Management and Computer, 5*(2), 42-46. https://doi.org/10.32485/kopertip.v5i2.164

[5] Rusdi, M. I., Prasti, D., & Rais, A. (2021). Pendampingan dan pengenalan metode ajar interaktif dengan augmented reality untuk pembelajaran tematik kelas 1 sekolah dasar. *Jurnal Ilmu Pengetahuan dan Teknologi Bagi Masyarakat, 1*(3), 157-161. https://doi.org/10.54065/ipmas.1.3.2021.104

[6] Jaya, K. T., An'Ars, M. G., & Surahman, A. (2023). Game edukasi berbasis Android sebagai media pembelajaran pengenalan huruf dan angka untuk anak usia dini. *Jurnal Media Borneo, 1*(1), 12-20. https://doi.org/10.58602/mediaborneo.v1i1.7

[7] Sholeh, M., Triyono, J., Haryani, P., & Fatkhiyah, E. (2021). Penggunaan dan pengembangan aplikasi berbasis augmented reality untuk dunia pendidikan. *JMM (Jurnal Masyarakat Mandiri, 5*(5), 2524-2536. https://doi.org/10.31764/jmm.v5i5.5285

[8] Yuniza, I. P., Syahputra, E. R., & Khowarizmi, A. (2022). Media game edukasi bahasa Indonesia dengan metode LALR parser. *Jurnal Media Informatika, 4*(1), 56-62. https://doi.org/10.55338/jumin.v4i1.429

[9] Wabula, D. F., Widodo, D. W., & Kasih, P. (2022, August). Implementation of augmented reality technology on COVID-19 educational media for children. In *Prosiding SEMNAS INOTEK (Seminar Nasional Inovasi Teknologi)* (Vol. 6, No. 2, pp. 172-177). https://doi.org/10.29407/inotek.v6i2.2580

[10] Faiza, M. N., Yani, M. T., & Suprijono, A. (2022). Efektivitas penggunaan media pembelajaran IPS berbasis augmented reality untuk meningkatkan kompetensi pengetahuan siswa. *Jurnal Basicedu, 6*(5), 8686-8694. https://doi.org/10.31004/basicedu.v6i5.3901

[11] Prasetya, R. N., Rivasintha, E., & Oktarika, D. (2023). Analisis kebutuhan media pembelajaran berbasis augmented reality pada materi pengenalan perangkat keras komputer. *Juwara Jurnal Wawasan dan Aksara, 3*(1), 11-19. https://doi.org/10.58740/juwara.v3i1.57

[12] Pradhana, F. R. (2023). Penerapan teknologi augmented reality sebagai media pembelajaran ilmu tajwid hukum nun sukun dan tanwin menggunakan metode MDA framework. *IJITECH: Indonesian Journal of Information Technology, 1*(1), 20-28.

[13] Hidayani, N., Rosyidah, U. A., & Abdurrahman, G. (2024). Implementasi augmented reality sebagai media interaktif edukasi anak untuk peningkatan kognitif. *Journal of Digital Literacy and Volunteering, 2*(2), 44-51. https://doi.org/10.57119/litdig.v2i2.82

[14] Waluyo, I. G., Savitri, S., & Hidayati, T. (2023). Pengenalan augmented reality kepada siswa dan siswi SMK YAPPIKA Serpong. *Praxis: Jurnal Pengabdian Kepada Masyarakat, 3*(3), 1-7. https://www.pijarpemikiran.com/index.php/praxis/article/view/526

[15] Sonita, A., & Susanto, A. (2022). Implementation of augmented reality (AR) as a media for recognition of the Ka Ga Nga Rejang Lebong script Android based. *Jurnal Komitek, 2*(2), 269-280. https://doi.org/10.53697/jkomitek.v2i2

[16] Anas, A., Djusmin, V. B., & Pasandaran, R. F. (2023). Media augmented reality: Pelatihan pada guru SMP untuk mendukung keterampilan pedagogik guru abad 21. *Madaniya, 4*(4), 1613-1620. https://doi.org/10.53696/27214834.596

[17] Sidiq, J. A., Kaslani, K., & Pratama, D. (2022). Game edukasi berbasis artificial intelligence untuk mengenal tokoh pahlawan nasional dalam rangka meningkatkan pengetahuan sejarah Indonesia. *KOPERTIP: Scientific Journal of Informatics Management and Computer, 6*(2), 54-60. https://doi.org/10.32485/kopertip.v6i2.169

[18] Utomo, S., Budiarto, S., Iswanto, I., Abdillah, S. I., & Ilhamdi, W. (2023). Implementasi augmented reality pada pembelajaran IPA siswa SMP. *Bulletin of Information Technology (BIT), 4*(4), 419-424. https://doi.org/10.47065/bit.v4i4.957

[19] Subroto, D. E., Nabilah, H., Wahyuni, I. E., & Mulyati, M. (2024). Meningkatkan semangat belajar siswa melalui penggunaan game edukasi berbasis teknologi pada siswa SMP IT Bina Bangsa. *Jurnal Pengabdian Masyarakat Sains dan Teknologi, 3*(1), 40-48. https://doi.org/10.58169/jpmsaintek.v3i1.363.

