Jurnal Penelitian dan Pengembangan Pendidikan
Volume 8, Number 3, Tahun 2024, pp. 449-458
P-ISSN: 1979-7109 E-ISSN: 2615-4498
Open Access: https://doi.org/10.23887/jppp.v8i3.77156

Integrated Card Learning Media with Augmented Reality Based on Android for Elementary School Learning

A. Fatimah Nurhikmah[1], Wawan Krismanto[2*], Nurul Mukhlisa[3], Abdul Halik[4], Muh. Faisal[5]

[1,2,3,4,5] Department of Elementary Teacher Education, Makassar State University, South Sulawesi, Indonesia

ARTICLE INFO

Article history:
Received April 06, 2024
Accepted September 10, 2024
Available online October 25, 2024

Kata Kunci:
Augmented Reality, *Media Pembelajaran, Pembelajaran IPA, Transformasi Pembelajaran*

Keywords:
Augmented Reality, Learning Media, Learning Transformation, Science Learning

ABSTRAK

Pembelajaran IPA di sekolah dasar seharusnya mendorong siswa untuk bereksplorasi, menyelidiki, dan memahami lingkungannya, namun hal ini terhambat karena kurangnya dukungan media yang memfasilitasinya. Berangkat dari kebutuhan akan inovasi dalam metode pembelajaran di era digital saat ini. Di sekolah dasar, banyak siswa mengalami kesulitan dalam memahami konsep abstrak yang disampaikan melalui metode pembelajaran konvensional, yang umumnya bersifat tekstual dan visual statis. Pendekatan tradisional seringkali kurang menarik bagi siswa yang tumbuh di lingkungan yang sudah akrab dengan teknologi canggih. Penelitian ini bertujuan untuk membuat produk media pembelajaran untuk sekolah dasar menggunakan Augmented Reality *(AR) untuk memfasilitasi pembelajaran IPA yang ideal. Penelitian dan pengembangan ini menggunakan model Borg and Gall. Partisipan penelitian adalah siswa kelas empat di tiga sekolah dasar beserta gurunya. Pengumpulan data melalui observasi, wawancara, dan tes. Data dianalisis secara deskriptif untuk mendeskripsikan data kuantitatif dan kualitatif. Peneltian berhasil mengembangkan produk media pembelajaran untuk sekolah dasar berbasis* Augmented Reality *(AR) bernama Media Karotena. Hasil utama penelitian menunjukkan bahwa media termasuk dalam kategori layak dan cocok untuk siswa dan guru. Produk pengembangan ini berimplikasi pada transformasi pembelajaran sains berbasis teknologi. Implikasi penelitian ini adalah penggunaan teknologi AR dalam pembelajaran dapat meningkatkan keterlibatan siswa. Dengan menggabungkan media visual yang interaktif, siswa lebih tertarik dan termotivasi untuk belajar, sehingga pembelajaran menjadi lebih menyenangkan dan efektif.*

ABSTRACT

Science learning in elementary schools should encourage students to explore, investigate and understand their environment, but this is hampered by the lack of media support that facilitates this. Departing from the need for innovation in learning methods in the current digital era. In elementary school, many students experience difficulty in understanding abstract concepts conveyed through conventional learning methods, which are generally textual and static visuals. Traditional approaches are often less attractive to students who have grown up in environments familiar with advanced technology. This research aims to create learning media products for elementary schools using Augmented Reality (AR) to facilitate ideal science learning. This research and development uses the Borg and Gall model. Research participants were fourth grade students in three elementary schools and their teachers. Data collection through observation, interviews and tests. Data was analyzed descriptively to describe quantitative and qualitative data. The research succeeded in developing a learning media product for elementary schools based on Augmented Reality (AR) called Media Karotena. The main results of the research show that the media is included in the appropriate category and is suitable for students and teachers. This development product has implications for the transformation of technology-based science learning. The implications of this research are The use of AR technology in learning can increase student engagement. By combining interactive visual media, students are more interested and motivated to learn, so that learning becomes more fun and effective.

*Corresponding author.
E-mail addresses: fatimah.nurhikmah.pgsd@gmail.com (A. Fatimah Nurhikmah)

1. INTRODUCTION

Learning science and social studies (in the Merdeka Curriculum called IPAS) is a type of learning that has an important role in equipping students in elementary schools because it facilitates students to see and study social and natural phenomena around them in a complete, concrete and inseparable manner. manners. IPAS helps foster students' curiosity about phenomena that occur around them. This curiosity can trigger students to understand how the universe works and interacts with human life. Ideally, science learning in elementary schools needs to provide opportunities for students to explore, investigate and develop an understanding of the environment around them. Science and technology learning should be designed by considering students' current stage of development and level of achievement, taking into account learning needs and reflecting the diversity of students' characteristics and development so that learning becomes meaningful and enjoyable (Darling-Hammond et al., 2023; Kemendikburistek, 2019).

However, the ideal conditions expected in the curriculum are apparently different from the actual conditions in the implementation of science and science learning in schools. Teachers in elementary schools still lack skills in creating an active and enjoyable learning atmosphere for students, have not been able to realize science learning according to the characteristics and objectives of science learning contained in the Independent Curriculum, and there is still minimal use of technology. which are relevant to the latest developments in society. So that learning activities are more focused on providing as much content as possible without considering students' developmental stages, learning styles and individual differences.

Therefore, it is necessary to improve the learning process by paying attention to developmental psychology in order to overcome the challenges and problems that have been mentioned. One effort that can be made is to develop fun learning media that involves games and is appropriate to students' cognitive development stages. Media has the benefit of creating interactive and interesting learning to motivate students to learn and reduce boredom when participating in learning (Ciampa, 2014; Plass & Kaplan, 2016; Syawaludin et al., 2018). In the modern era, technology and media-based communication can be an interesting learning medium and have a positive impact on student learning processes and outcomes (Biswas, 2017; Turan & Atila, 2020). One technology that can be used as the latest learning media innovation and is in accordance with the problems mentioned is Augmented Reality (AR). AR can increase student interest and involvement in learning while reducing the negative impact of technology misuse by elementary school students. Data shows that the penetration of gadget use among students, including those in elementary schools, has increased significantly. Elementary school students' accessibility to gadget devices should be an opportunity for teachers to develop technology-based media in the form of AR.

Previous researchers have conducted various previous studies regarding the use of AR for learning in elementary schools. Research shows that the use of AR in elementary school learning can improve students' critical thinking abilities (Syawaludin et al., 2018; Zuniari et al., 2022). Other research also shows that the use of the AR-based STEAM learning model in science learning in elementary schools can significantly improve the quality of the learning process and outcomes (Alkhabra et al., 2023; Atmojo et al., 2021). The use of AR in learning also causes a significant increase in student learning motivation (C.-H. Chen, 2020; Chin et al., 2019). Various AR developments have also been carried out by other researchers on various elementary school learning materials (Ayu et al., 2021; Hendajani et al., 2021; Mz et al., 2021; Nanda et al., 2022; Syawaludin et al., 2018).

However, from various studies, no one has developed AR with a card-shaped model that is physically easier for elementary school students to use and fun for elementary school students to play with. This characteristic is what differentiates AR-based learning media that have been previously developed by other researchers. In addition, science learning in elementary schools needs to provide opportunities for students to explore, investigate and develop an understanding of the environment around them. This learning idea cannot yet be realized optimally in the classroom; one of the obstacles is that there is no media that facilitates it. Based on the previous description, this research will complement various AR developments for learning in elementary schools.

The aim is to develop a learning media product in the form of Augmented Reality combined with picture cards with three research question formulations. The first question asked is related to things that need to be studied and is expected to become basic data for product development that suits the characteristics of needs. That way, the product developed will suit the needs of teachers and students in learning science in elementary schools. Second, things that need to be described through research and development procedures, and it is hoped that the product being developed has gone through the correct product development procedures. Thus, the steps in the product development process can be scientifically justified because they go through correct research and development procedures. Third, things that need to be studied, and it is hoped that the product being developed has gone through a series of validation processes. In this way, the suitability of the product being developed can be accounted for from the aspects of content, media and use by users.

The novelty of this research is that it develops card learning media that combines AR technology with the Android platform, allowing students to interact with learning content directly via mobile devices. This approach provides greater flexibility and accessibility compared to traditional learning methods. Second, this research focuses on the elementary school level, an educational segment that has not been widely explored in the AR context. Although several AR applications have been used in education, their application in elementary schools is still limited. Thus, this research contributes to filling the knowledge gap regarding the effectiveness of AR in children's learning. Third, this research not only develops learning media, but also evaluates its impact on students' conceptual understanding and learning motivation. This is important to ensure that the technology used truly provides educational benefits and can be integrated effectively into the elementary school curriculum. Overall, this research offers an innovative approach to learning in elementary schools by utilizing Android-based AR technology, which is expected to improve the quality and effectiveness of the teaching and learning process. The aims of this research are: to develop innovative learning media based on AR technology that is integrated with learning cards and can be used via Android devices. This media aims to make the learning process more interactive and interesting for elementary school students and increase student involvement in learning through the use of AR technology which allows the visualization of abstract concepts in a real way, so that students can more easily understand the material being taught.

2. METHOD

This research is a type of Research and Development (R&D). R&D is a step in developing or perfecting new products and can be accounted for. In other words, R&D is a research method used to produce a product and test the effectiveness of the product (Sugiyono, 2021; Sukmadinata, 2017) . The research steps adopted the Borg and Gall development model which includes ten stages and then modified into seven stages according to the researcher's time and financial capabilities. The brief procedure in this research includes several main stages. First, a preliminary study was carried out through literature review and observation to identify problems and development needs. Next, at the planning stage, the design and specifications of the product to be developed are determined, such as learning objectives and appropriate features. After that, initial product development is carried out by creating a prototype that integrates the main components, followed by expert validation to evaluate the suitability and feasibility of the product. Based on feedback from experts, product revisions are made before proceeding to limited field trials, where the product is tested on a small group of users. After the results of the trial were evaluated, further revisions were carried out, followed by wider field trials to ensure the effectiveness of the product on a larger scale. The product is then refined into a final product and ready to be disseminated or applied in a wider environment through a dissemination and implementation process, which can also be followed by ongoing evaluation. The Borg and Gall development model is a research model development that can be modified according to the needs of researchers (Gall et al., 2023; Zuniari et al., 2022). The research design is presented in Figure 1.

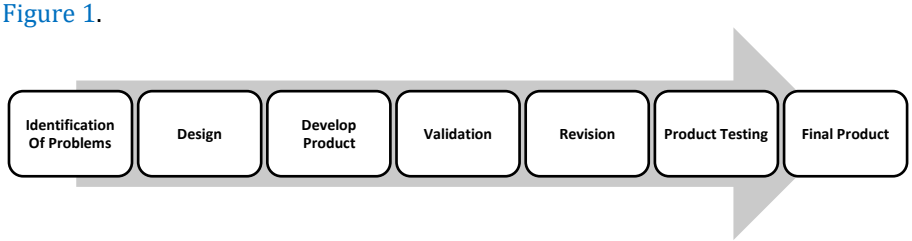

Figure 1. Research Design

Research participants were fourth grade students at three elementary schools in Parepare City, South Sulawesi (SDN 35, SDN 12, and SDN 7) as well as three teachers. Qualitative and quantitative data were collected simultaneously and analyzed to complement each other's research results. These seven stages include identifying potential problems through initial observations. So data collection is through observation, interviews and tests, initial product design (Katotena media), design validation by experts, design revisions, small group trials, and the final product.

The instruments used in this research consisted of observation guidelines, interview guidelines aimed at analyzing learning media needs, test instruments aimed at analyzing content or material, expert validation guidelines to determine the validity of the media, and questionnaires aimed at users. An observation guidance instrument was developed using indicators of media use during science learning and student learning engagement during science learning. Interview guidelines were developed using indicators: science learning media used and needed, teacher and student accessibility to gadgets, and AR-

based learning. Validation guidelines were developed to assess the feasibility of linguistic aspects, presentation, media effects, graphic design, physical media, system & user interface, and AR displays.

The data analysis techniques used in this research are qualitative and quantitative. Qualitative analysis describes the results of observations, interviews, validator suggestions, and documentation notes during implementation. Data were analyzed descriptively qualitatively; some suggestions will be used to improve the product at the revision stage, while documentation notes are outlined to determine the usefulness of the product being developed when used in learning. Quantitative analysis describes product quality based on the assessments of experts/validators, teachers and students.

3. RESULT AND DISCUSSION

Result

In the results section, development research data will be presented as an effort to answer all research problem formulations. So, this section consists of three parts. First, an overview of the need to develop science learning media in elementary schools. An overview of the needs for science learning media and technology in grade 4 elementary school was obtained through observation activities at the stage of identifying potential problems in grade 4 science learning at SDN 07, SDN 12, and SDN 35 Parepare. strengthened by the results of teacher and student interviews, while an overview of material needs or media content is obtained through student mapping tests. Based on the results of initial observations, it is known that the use of learning media at SDN 07 Parepare is still very minimal; The learning that takes place is only filled with teacher explanations and focuses on textbooks without any auxiliary media that can make it easier for teachers to convey teaching material to students. Apart from that, there is no use of technology-based teaching media. Then the results of observations at SDN 12 Parepare showed that the use of media was only limited to pictures on display, but teachers occasionally used projector media to support learning. However, the teaching media used in science and natural science learning are only textbooks. The use of technology-based media still needs to be improved. Meanwhile, at SDN 35 Parepare, learning media was found to be more diverse than the other two schools; they have started using LCD, but it is still only a medium that can be observed without any interaction with the user.

Apart from that, the media used is dominated by pictures in textbooks. To strengthen the data found from initial observations, data was collected through interviews with teachers and grade 4 students in three elementary schools regarding the use of teaching media in natural science and natural science learning, students' accessibility to gadgets and the internet, and needs. for teaching media, and the potential application of card media and integrated Augmented Reality. The results of interviews with teachers and students at the three elementary schools showed that the use of media in carrying out learning was still minimal, among them SDN 07 Parepare tended to use more textbooks; if there is use of media, the teacher chooses image display media as the main tool. Technology-based media such as LCD and video are rarely used, even though schools provide internet facilities. Meanwhile, SDN 12 Parepare has used technology-based media such as LCD and video. However, most teaching and learning activities still use image media, even though they sometimes deviate from the teaching module.

Meanwhile, SDN 35 Parepare sometimes uses LCDs when necessary but still has difficulty choosing learning media that is suitable for science and technology learning. The media needed by teachers from the three elementary schools is media that has the characteristics of not requiring large costs to manage, not difficult to carry (practical), in accordance with the objectives and material being taught, visible in shape, and allows for interaction. , based on the characteristics of science and science learning. More observations and trials make it easier for teachers to deliver teaching materials, can attract students' attention, and if necessary are concrete and technology based in accordance with the development of elementary school students. From the student side, the interview results show that media that is easy to use and not boring is media that is fun with games, makes it easier for students to learn and expand their knowledge, can be taken anywhere (asynchronous), and has objects such as 3D characters in videos. game (PUBG) or mobile legend that is often played by students.

The results of interviews with teachers and students also showed that in the three elementary schools, student accessibility to the internet and gadget devices was relatively high, including out of a total of 10 grade 4 students at SDN 07 Parepare, seven were skilled students. using a gadget device and two students are holding their smartphones. Then, 75% of SDN 12 Parepare students can use smartphones to access social media content, watch YouTube videos, study online and play games. On the other hand, all students at SDN 35 Parepare are familiar with gadgets and internet access in their daily lives, such as playing games, watching TikTok videos, and so on. Information related to accessibility and penetration of internet use by students is also used as a basis for researchers to ask further questions regarding the potential application of integrated Augmented Reality card game media for teachers and students. As a result, AR

card media is possible to be implemented in the three schools, with details that SDN 35 Parepare has very good potential to be implemented because school regulations allow students to bring smartphone devices for learning purposes, SDN 12 allows it to be implemented, and there are no problems in using the media assisted by smartphones because similar media have been used during the pandemic. For SDN 07, it also has the potential to be implemented provided that the school principal and parents obtain permission.

Next, to analyze the material/content needs for developing learning media, a multiple choice mapping test of 20 questions was given to 56 students to determine the extent of students' understanding of learning Social Sciences Chapter 1 Phase B (grade 4 elementary school). The student mapping test results in category A (very good) were 1%, category B (good) with a percentage of 5.4%, category C (fair) with a percentage of 16%, category D (not good) with a percentage of 69.6%. , and category E (very bad) with a percentage of 7%. Thus, the percentage of students with completion criteria below average exceeds the number of students who mastered the learning material tested. An overview of students' mastery of science learning Chapter 1 regarding the material is visualized in Figure 2. It can be seen (Figure 2) that the material that students have least mastered is the body parts of plants and the body parts of animals. Therefore, these two materials are used as content or material in the media that will be developed. This will have a positive impact on media use, not only in terms of media effectiveness but also the material. The frequency of student mapping results in terms of learning material is presented in Figure 2.

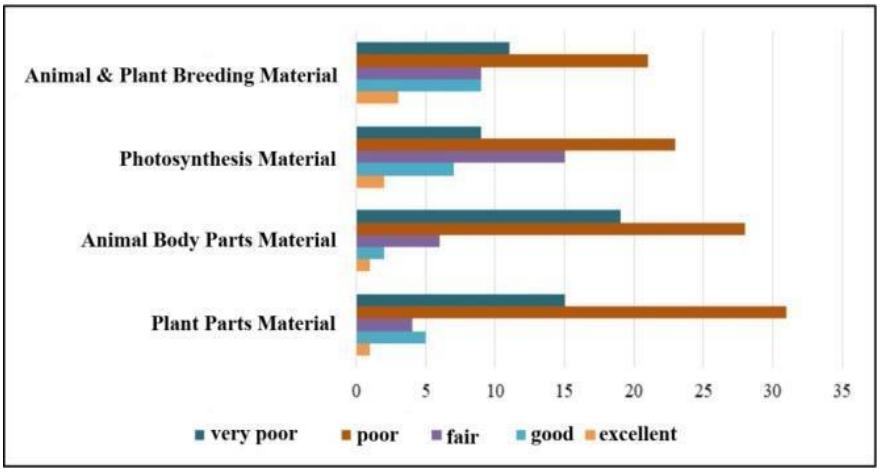

Figure 2. Frequency of Student Mapping Results in Terms of Learning Material

Second, an overview of the design and production process of carotene for science learning media. The development of the Android-based Karotena AR product was designed by taking into account the results of an analysis of teacher and student needs as well as identifying material based on student mapping tests. Carotene media consists of nine sets of cards, each set has different discussion material. This media collaborates with visual media in the form of cards and m-learning in the form of Augmented Reality as an information presenter that can be used by students and teachers by installing the related application on their cellphone. The card media used are picture cards combined with a marker function for each picture, presented in Figure 3, and Figure 4.

Figure 3. Carotene Logo Image

Figure 4. Carotene Packaging

This media development begins with designing the media design which includes the logo, packaging shape, card size and material, application appearance, visibility and function of the application menu, as well as the flow of media use. Media development was carried out using the Photoshop CS6 application for packaging design, application UI and logos, utilizing tools in Microsoft Word for picture cards, 3D Blender software to develop and create three-dimensional objects of plant and animal body parts, and the Unity Engine Alfa 2023 version to develop applications Augmented Reality scanner. The results of product development obtained logo media, card storage packaging measuring 10 cm x 8 cm x 5 cm in the form of a sliding box, a set of game cards measuring 10 cm x 8 cm, and an Augmented Reality application called Karotena which is equipped with a scanning camera feature and can be installed on Android operating system. The media display can be seen in Figure 5, and Figure 6.

Karotena media integrated Augmented Reality based on Android is used in science learning with a quartet card game system (consisting of four cards in one set). The steps for using it are first arrange the card then scan the image on the back of the card using the Karotena application installed on the Android device. The use of carotene in science learning, apart from being a learning support medium, can also provide a change in the student learning atmosphere.

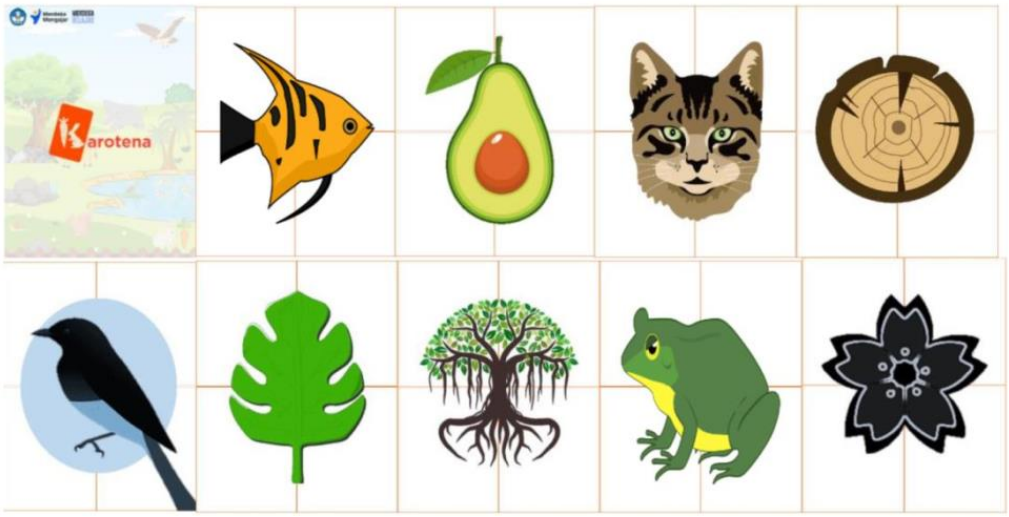

Figure 5. Scanner Card Image (Object Marker)

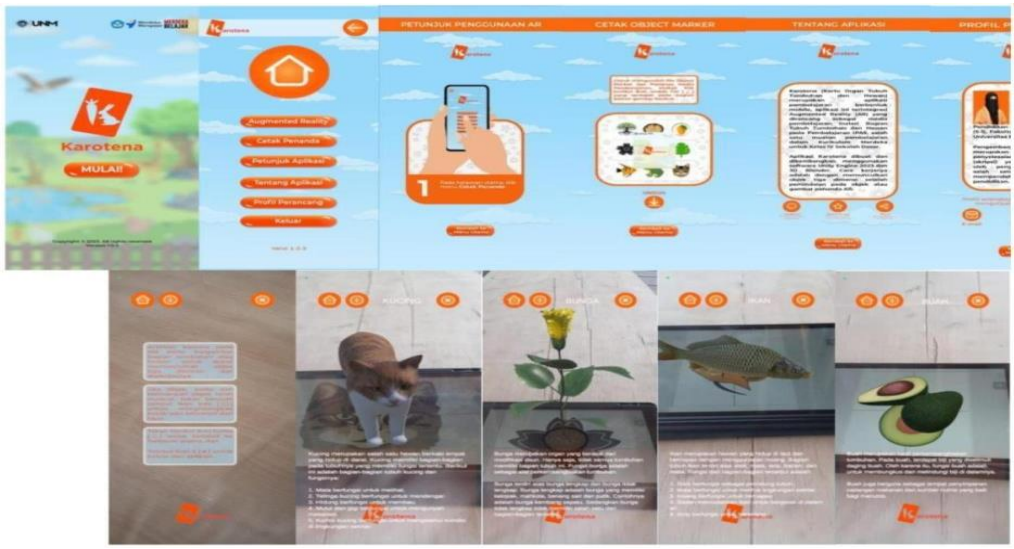

Figure 6. App UI Display and Scan Results

Third, an overview of the process and results of the validity of carotene for science learning. Media experts and material experts have tested the validity of Android-based Karotena AR media. The aim is to obtain an assessment so that the media can be said to be valid and used in the learning process, as well as to determine the suitability, shortcomings and advantages of the media being developed. The assessment

carried out refers to the assessment instrument that the researcher has created in the form of an answer range of 1 to 5, with a score of 5. The total validator score is then calculated by looking for the ideal score expected for each aspect and the validator score. overall aspect by finding the average value. The scores obtained are converted into percentages of eligibility criteria. A recapitulation of validation by media experts is presented in Table 1.

Table 1. Recapitulation of Media Expert Validation

No.	Rated Aspect	Score
1	Linguistics	4.67
2	Presentation Aspect	4.67
3	The Influence of Media on Learning Strategies	4.8
4	Overall View	4.4
	Average Overall Score	**4.6**
	Percentage Eligibility Criteria	**92%**

The validation results from media experts and material experts obtained a feasibility percentage of 92% and 89.6% with very feasible criteria. Apart from that, response questionnaires were also given to users (teachers and students) at the small group trial stage, with a teacher assessment of 100% (very feasible) and the results of the recapitulation of student response questionnaires obtained a feasibility percentage of 95.72% (very feasible). A recapitulation of material expert validation is presented in Table 2.

Table 2. Recapitulation of Material Expert Validation

No.	Rated Aspect	Score
1	Learning Material Aspects	4.5
2	Presentation Aspect	5
3	The Influence of Media on Learning Strategies	4
4	Overall View	4.4
	Average Overall Score	**4.48**
	Percentage Eligibility Criteria	**89.6%**

Discussion

The discussion section will discuss all research findings presented in the results section. Thus, this section also consists of three parts. First, an overview of the need to develop science learning media in elementary schools. The results of identifying problems related to science learning in the three schools studied show that the use of science learning media still needs to be improved. The results of observations and interviews concluded that science learning was dominated by teacher explanations which focused on textbook content, there was no maximum technology-based learning media available, limited to poster images on display, and did not facilitate student learning activities and involvement. The needs analysis also concluded that teachers in the three schools studied needed science learning media that allowed for diverse student learning interactions and provided meaningful learning experiences through observation, experimentation and exploration of different learning resources. Providing diverse learning experiences to students with learning media in science learning can produce an effective learning process and optimal learning outcomes (Chen, 2021; Liu et al., 2021). In relation to science teaching, it is emphasized that science teaching requires a variety of methods and media that can attract students' interest in learning and increase their reasoning power in understanding each material contained within the scope of learning. Apart from that, a teacher should carry out a dynamic learning process by adapting models, media and learning activities to the various characteristics of students known as the current generation.

The results of interviews with teachers and students also show that in the three elementary schools, student accessibility to the internet and gadget devices is relatively high. They are used to using smartphones to access social media content, watch YouTube videos, study online and play games. Therefore, teachers need to facilitate science learning media that utilizes technological devices to make learning more familiar to students, besides of course having the potential to increase students' learning motivation and will help science educators to expand their abilities in embracing this technology (Crompton et al., 2021; Sahin & Yilmaz, 2021; Turan & Atila, 2020). Based on the analysis of students' competencies and needs in mastering science learning, material about plant body parts and animal body parts needs to be developed in presenting the material through contextual and innovative learning media. facilitating students' experiences in the learning process for themselves and bringing the material studied closer to the phenomena they encounter every day. Studying the natural sciences, such as the study of plants and

animals, can build a scientific view of the precise and interconnected concepts related to the relationships between plants. and all species that exist in nature (including animals) as well as reducing misunderstandings about natural science (both animals and plants) among elementary school students including its benefits for students' daily lives. In addition, science learning (about animals and plants) will educate students about biological concepts such as natural life, plants, animals and microorganisms and encourage students to take steps that can preserve ecosystems on earth, and can help students understand diversity. surrounding life, including the structure of various animal and plant body parts (Jamaludin, 2020; Yangin, 2021; Yangin et al., 2013).

Second, an overview of the design and production process of carotene for science learning media. Through a series of design and development processes described in the results section, this research has produced AR-based learning media for science learning in elementary schools, especially regarding the body parts of plants and animals. The characteristics of the Karotena media developed in this research are that it presents learning that is contextual, concrete, and has the appeal of attracting students' attention in learning. In addition, Karotena media facilitates various student learning activities, starting from playing cards, exploring technology-based learning resources using AR and observing objects that appear using AR technology.

The learning media developed has the potential to bring significant changes to the science learning process in elementary schools. The monotonous science learning process with learning activities that have minimal meaning for students will change with the use of Karotena media in learning. The changes in question include students being able to more easily understand the material taught through presenting teaching materials from abstract to more concrete. with the emergence of three-dimensional objects; Teachers can more easily convey teaching material that is difficult to teach only through textbooks and requires media. Concretely, because AR integrated cards provide more real-time and real but practical learning, learning becomes more interactive because the use of Augmented Reality integrated cards is suitable for all learning styles, and learning becomes more fun with games using cards and interesting three-dimensional objects. students' interest in learning. In this way, student participation in learning which previously tended to be passive becomes more active. This change is in accordance with the opinion that Augmented Reality through card games can attract users' interest through virtual objects and real objects at the same time (Baran et al., 2020; Darling-Hammond et al., 2023). It was further explained that Augmented Reality has advantages that can be implemented in learning through the use of playing cards with real-time interactions and objects created in three dimensions as well as increasing students' reasoning power, sensitivity to imagination, and interest in independent learning (Dhiyatmika et al., 2021; Xu et al., 2023). Various studies have shown the superiority of AR technology in supporting the effectiveness and outcomes of science learning (Baran et al., 2020; Erbas & Demirer, 2020; Sahin & Yilmaz, 2021; Turan & Atila, 2020; Weng et al., 2018).

Third, an overview of the process and results of the validity of carotene for science learning. The assessment of the validity of Karotena media with Android-based Augmented Reality technology carried out by media validators, material validators, practitioners (teachers) and students shows that Karotena media is valid and suitable for use in natural science and natural science learning in elementary schools. The feasibility assessment carried out by teachers and students shows that carotene media in terms of material is in accordance with the learning objectives to be achieved, structured systematically, and packaged with clear and interesting delivery. Carotene meets the criteria for media suitable for use in learning according to experts, namely the suitability of the media to the material to be presented. In terms of presentation and language, Karotena media is easy to use, the instructions are easy to understand, and fun to apply. Meanwhile, in terms of learning media support, Karotena is considered capable of increasing students' interest in learning, increasing understanding of the material being taught, and fostering learning independence. This is because the integrated learning media Augmented Reality can increase students' reasoning power, sensitivity to imagination, and interest in independent learning. Furthermore, learning media must be able to help teachers by presenting information in a more comprehensive, interesting and clear manner using language that is easily understood by students as recipients of the information (Dhiyatmika et al., 2021; Hendajani et al., 2021; Liu et al., 2021; Nanda et al., 2022).

This research contributes to several aspects based on the description in the research results and discussion section. From the literature aspect, this development research will complement the literature on the development and use of AR technology for science learning at the elementary school level. The media characteristics developed will complement the literature on AR-based card media and games for learning. For the practical aspects of science learning in elementary schools, this research contributes by providing various alternative technology-based science learning media options that encourage a variety of meaningful science learning activities. The implication is that elementary schools need to change science learning practices by utilizing various technology-based media (AR) which are currently increasingly close to

students' daily lives (including in Indonesia). So schools and teachers need to make intensive changes to the design of meaningful and enjoyable science learning, one of which is by utilizing technological developments. However, these implications must be accompanied by creativity in providing various meaningful and enjoyable learning activities, so that it is not just about feeding and utilizing technology.

The limitation of this research is that the media developed only covers a small portion of the science teaching materials taught in elementary schools. In addition, the trial of this new product covered a small scale in three schools and has not yet investigated its impact on science learning processes and outcomes on a wide scale in elementary schools. Therefore, even though the media developed has been categorized as suitable for science learning in elementary schools, further research is needed, for example in making media teaching materials and wider trials. Future researchers can also continue effective research by using other methods with quantitative approaches in the form of correlations and experiments or qualitative research so that research into the development of AR-based science learning media can complement existing literature.

4. CONCLUSION

Based on the series of stages of the development, testing and feasibility assessment process that have been described previously, it can be concluded that teachers and students need learning media that can support a concrete science learning process, be interesting with games, and are suitable for use. learning context. This need was answered through the development of Karotena media with Android-based Augmented Reality Technology which went through a series of development stages assisted by several software developers who produced products in the form of Karotena cards, sliding box packaging and Augmented Reality applications. The validity of Karotena media is within the criteria of being very suitable for use in natural science and science learning based on the assessment of material experts, media experts, practitioners (teachers), and students as users. The results of this research complement the results of AR development for elementary school learning that have been carried out by previous researchers. Thus, this research contributes to efforts to transform learning using technology in elementary schools.

5. REFERENCES

Alkhabra, Y. A., Ibrahem, U. M., & Alkhabra, S. A. (2023). Augmented reality technology in enhancing learning retention and critical thinking according to STEAM program. *Humanities and Social Sciences Communications*, *10*(1), 174. https://doi.org/10.1057/s41599-023-01650-w.

Atmojo, I. R. W., Ardiansyah, R., Saputri, D. Y., & Adi, F. P. (2021). The Effectiveness of STEAM-Based Augmented Reality Media in Improving the Quality of Natural Science Learning in Elementary School. *AL-ISHLAH: Jurnal Pendidikan*, *13*(2), 821–828. https://doi.org/10.35445/alishlah.v13i2.643.

Ayu, R. F. K., Jannah, Z., Fauziah, N., Ningsih, T. N., Manilaturrohmah, M., Suryadi, D. A., Budiarti, R. P. N., & Fitriyah, F. K. (2021). Planetarium Glass Based on Augmented Reality to Improve Science Literacy Knowledge in Madura Primary Schools. *Child Education Journal*, *3*(1), 19–29. https://doi.org/10.33086/cej.v3i1.1768.

Baran, B., Yecan, E., Kaptan, B., & Paşayiğit, O. (2020). Using augmented reality to teach fifth grade students about electrical circuits. *Education and Information Technologies*, *25*(2), 1371–1385. https://doi.org/10.1007/s10639-019-10001-9.

Biswas, S. (2017). Digital Pedagogy: A 21ST Century Approach of School Education. *International Journal of Applied Science and Engineering*, *10*(1), 76. https://doi.org/10.30954/2322-0465.2.2021.4.

Chen, C.-H. (2021). Impacts of augmented reality and a digital game on students' science learning with reflection prompts in multimedia learning. *Educational Technology Research and Development*, *68*(6), 3057–3076. https://doi.org/10.1007/s11423-020-09834-w.

Ciampa, K. (2014). Learning in a mobile age: An investigation of student motivation. *Journal of Computer Assisted Learning*, *30*(1), 82–96. https://doi.org/10.1111/jcal.12036.

Crompton, H., Burke, D., Gregory, K. H., & Gräbe, C. (2021). The Use of Mobile Learning in Science: A Systematic Review. *Journal of Science Education and Technology*, *25*(2), 149–160. https://doi.org/10.1007/s10956-015-9597-x.

Darling-Hammond, L., Flook, L., Cook-Harvey, C., Barron, B., & Osher, D. (2023). Implications for educational practice of the science of learning and development. *Applied Developmental Science*, *24*(2), 97–140. https://doi.org/10.1080/10888691.2018.1537791.

Dhiyatmika, I. D. G. W., Putra, I. K. G. D., & Marini, N. M. I. (2021). Aplikasi Augmented Reality Magic Book Pengenalan Binatang untuk Siswa TK. *Lontar Komputer*, *6*(2), 120–126.

https://10.24843/LKJITI.2017.v08.i03.p05.
Erbas, C., & Demirer, V. (2020). The effects of augmented reality on students' academic achievement and motivation in a biology course. *Journal of Computer Assisted Learning*, *35*(3), 450–458. https://doi.org/10.1111/jcal.12350.
Gall, M. D., Gall, J. P., & Borg, W. (2023). *Educational research. An introduction* (Eighth). Pearson.
Hendajani, F., Hakim, A., Sudiro, S. A., Saputra, G. E., & Ramadhana, A. P. (2021). Tracking Visualization Of 3 Dimensional Object Natural Science Learning Media In Elementary School With Markerless Augmented Reality Based On Android. *Journal of Physics: Conference Series*, *1192*(23), 12055. https://doi.org/10.1088/1742-6596/1192/1/012055.
Jamaludin, Z. Z. (2020). E-Modul Keanekaragaman Hayati Berbasis Education for Sustanable Development Untuk Mendukung Implementasi Flipped Learning. *Jurnal Cakrawala Pendas*, *8*(4), 1550–1570. https://doi.org/10.31949/jcp.v8i4.3090.
Kemendikburistek. (2019). 1:1 mobile inquiry learning experience for primary science students: A study of learning effectiveness. *Journal of Computer Assisted Learning*, *27*(3), 269–287. https://doi.org/10.1111/j.1365-2729.2010.00390.x.
Liu, C., Zowghi, D., Kearney, M., & Bano, M. (2021). Inquiry-based mobile learning in secondary school science education: A systematic review. *Journal of Computer Assisted Learning*, *37*(1), 1–23. https://doi.org/10.1111/jcal.12505.
Mz, A. S. A., Aprillya, M. R., & Bianto, M. A. (2021). Science Augmented Reality Program Media for Elementary School Students. *JPI (Jurnal Pendidikan Indonesia*, *11*(3), 457–465. https://doi.org/10.23887/jpiundiksha.v11i3.41378.
Nanda, L. K. S., Trisniawati, T., & Muanifah, M. T. (2022). Development of Android-Based Augmented Reality 3D Card Media for Elementary School Students. *AlphaMath : Journal of Mathematics Education*, *8*(1), 88. https://doi.org/10.30595/alphamath.v8i1.12920.
Plass, J. L., & Kaplan, U. (2016). Emotional Design in Digital Media for Learning. In *Emotions, Technology, Design, and Learning* (pp. 131–161). Elsevier. https://doi.org/10.1016/B978-0-12-801856-9.00007-4.
Sahin, D., & Yilmaz, R. M. (2021). The effect of Augmented Reality Technology on middle school students' achievements and attitudes towards science education. *Computers & Education*, *144*(23), 103710. https://doi.org/10.1016/j.compedu.2019.103710.
Sugiyono. (2021). *Metode Penelitian Kuantitatif, Kualitatif, dan Tindakan*. Alfabeta.
Sukmadinata, N. (2017). *Metode penelitian pendidikan*. PT Remaja Rosdakarya.
Syawaludin, A., Gunarhadi, G., & Rintayati, P. (2018). Development of Augmented Reality-Based Interactive Multimedia to Improve Critical Thinking Skills in Science Learning. *International Journal of Instruction*, *12*(4), 331–344. https://doi.org/10.29333/iji.2019.12421a.
Turan, Z., & Atila, G. (2020). Augmented reality technology in science education for students with specific learning difficulties: Its effect on students' learning and views. *Research in Science & Technological Education*, *39*(4), 506–524. https://doi.org/10.1080/02635143.2021.1901682.
Weng, C., Otanga, S., Christianto, S. M., & Chu, R. J.-C. (2018). Enhancing Students' Biology Learning by Using Augmented Reality as a Learning Supplement. *Journal of Educational Computing Research*, *58*(4), 747–770. https://doi.org/10.1177/0735633119884213.
Xu, W.-W., Su, C.-Y., Hu, Y., & Chen, C.-H. (2023). Exploring the Effectiveness and Moderators of Augmented Reality on Science Learning: A Meta-analysis. *Journal of Science Education and Technology*, *31*(5), 621–637. https://doi.org/10.1007/s10956-022-09982-z.
Yangin, S. (2021). Pre-service classroom teachers' mislearnings of classification of the plant kingdom and the effect of porphyrios tree on removing them. *Journal of Baltic Science Education*, *12*(2), 178–190. https://doi.org/10.33225/jbse/13.12.178.
Yangin, S., Sidekli, S., & Gokbulut, Y. (2013). Prospective teachers' misconceptions about classification of plants and changes in their misconceptions during pre-service education. *Journal of Baltic Science Education*, *13*(1), 105–117. https://doi.org/10.33225/jbse/14.13.105.
Zuniari, N. I., Ridlo, Z. R., Wahyuni, S., Ulfa, E. M., & Dharmawan, M. K. S. (2022). The Effectiveness of Implementation Learning Media Based on Augmented Reality in Elementary School in Improving Critical Thinking Skills in Solar System Course. *Journal of Physics: Conference Series*, *2392*(1), 12010. https://doi.org/10.1088/1742-6596/2392/1/012010.