Development of Augmented Reality Learning Media on IPAS Subject Matter of the Respiratory System

Hanik Puji Rahayu[1*], Desi Wulandari[2]

[1] Elementary School Teacher Education, FIPP, Universitas Negeri Semarang, Semarang, Indonesia.
[2] Elementary School Teacher Education Lecturer, FIPP, Universitas Negeri Semarang, Semarang, Indonesia.

Abstract: The lack of use of learning tools in science and science lesson content regarding the respiratory system in class V elementary school makes students quickly feel bored. This results in students not understanding what has been conveyed by the teacher. This investigation aims to develop augmented reality learning media for science and science lesson content on the respiratory system for class V elementary schools. This type of research is Research and Development (R&D) which refers to the Borg and Gall theory with ten stages. The data collection techniques used in this research were observation, question and answer, and questionnaires. Based on the data analysis carried out, the following results were obtained. The results of the material expert validation test were 81.60% which was included in the very feasible group; The results of the media expert validation test were 96.60% which was included in the very feasible group. Apart from that, scores were obtained before and after the use of the learning media developed. As seen from the results of these values, the media developed is declared effective if used as a learning tool in the science and science learning content regarding the respiratory system. So, it can be concluded that the tools developed are suitable and effective for use in the learning process.

Keywords: Augmented reality; IPAS; Learning media; Respiratory system material

Introduction

Education is part of the authority and necessity that must be obtained by every citizen. Be it in terms of formal, informal, or non-formal education. This is by the National Education System (Sisdiknas) Number 20 of 2003 Chapter 1 Paragraph 1 regarding education is the first step that is carried out regularly by students to foster the skills that exist in each student (Sisdiknas, 2003). Formal education here is everything that is done at school. The education stratum that must be received by students is the 9-year compulsory education. Here the earliest formal education stratum received by students is the elementary school stratum. At the elementary school stratum, students are given an understanding of the basic knowledge used to develop the skills contained in students. Both spiritual, knowledge, skills, and social. At the primary school level, the curriculum implemented in the current era has undergone many changes where grades one, two, four, and five have applied the latest curriculum which we currently know as the independent curriculum. Meanwhile, grades three and six are still applying the previous curriculum, namely the 2013 curriculum.

The independent curriculum, previously known as the prototype curriculum, is a perfect curriculum from the 2013 curriculum. Where in the independent curriculum there are at least 3 main characteristics that distinguish it from the previous curriculum. With these characteristics, it is hoped that later, it will be able to have a real impact on learning after the COVID-19 pandemic. The characteristics of the independent

curriculum are project-based learning or what we often know as project-based learning (PjBL). This characteristic aims to develop the abilities and character that exist in students by relying on projects in the learning process, focusing on basic materials that are expected to provide sufficient time for more detailed learning on basic competencies such as reading and writing, as well as the freedom possessed by an educator to carry out learning that is in line with the capacity of each student. Not only that, changes in this curriculum also have an impact on the integration of natural science (IPA) and social science (IPS) subject content. Where in elementary schools that have implemented an independent curriculum for each class the subject matter is given simultaneously under the name of natural and social science (IPAS) (Darling-Hammond et al., 2020; Dirgantara et al., 2024). IPAS is a science that analyzes organisms and non-living things throughout the universe and is a science that analyzes human life as a personal being and social being about its surroundings (Betz et al., 2023).

IPAS learning in primary educational institutions in the implementation of the independent curriculum is divided into three phases, namely phases A-C. Phase A is generally carried out by grades one and two, phase B is carried out by grades three and four, while phase C is carried out by grades five and six (Iqbal et al., 2016). Not only curriculum changes but the efficiency of learning in Indonesia is increasingly seeing many developments. One of the developments that is intensively applied is the use of technology-based learning media (Wardoyo et al., 2021). According to Wahrini et al. (2023), learning media are all existing objects that can be utilized as tools in conveying information from trusted sources so that the information obtainer can carry out the learning process efficiently and pragmatically. Then according to Syaiful et al. (2021), learning media is a place that is used to convey a message as a stimulus to the thoughts, attention, and interests of students to encourage learning to occur in themselves. Based on these two definitions, we find that learning media are all things that we utilize or use as a tool in channeling information to the recipient of information to encourage students' mindset, interest, and passion when doing successful and effective learning.

According to Hartono (2020) learning media makes the learning that takes place more captivating for students. Not only that, the application of media in a lesson in the teaching process is also able to facilitate the absorption process of students to what information is being provided by the educator (Haleem et al., 2022). So, we can get that with the existence of learning media, the learning that takes place is more colorful, not only from the lecture of an educator who tends to make students more easily bored when participating in learning.

However, the reality in the field is that IPAS learning is often carried out theoretically with lecture learning methods. This causes IPAS learning at school to feel very boring for students. Based on the results of observations at SD Negeri Ngijo 02, it was found that the application of learning media was still very unsatisfactory. This happens because of the underlying factors, namely, the first is the age factor. In this elementary school, 3 class teachers are classified as elderly so understanding related to the use of learning media is very low. Second, low mastery of technology, of the six existing class teachers, only 2 of them often use learning media, namely second-grade teachers and fourth-grade teachers for classes I, III, V, and VI teachers are very minimal in using learning media when learning takes place.

The third is facilities and infrastructure. SDN Ngijo 02 in supporting the use of technology-based learning media has 2 projectors that are permanently installed in classes IV and VI and only has 1 projector that is not permanently installed. So, in its use, it often collides with other classes. From several existing cases, this results in less-than-ideal learning outcomes produced by students. This is evidenced by the number of student grades on respiratory system material that is below the criteria for achieving learning objectives (KKTP), namely as many as 15 students have not completed. Problems like this arise because many students do not understand the material related to the respiratory system and there is no special learning media that is used to support student understanding in digesting the material.

Based on the needs analysis that has been conducted by researchers on SD N Ngijo 02 students, it is found that 19 fifth-grade students of SD N Ngijo 02 need learning media on IPAS subject content, this is indicated by the results of student responses after filling out a questionnaire which shows 91.57% of students need technology-based learning media. From the results of the existing questionnaire, students hope to get learning media that includes several elements, namely consisting of brief descriptions, 2 and 3-dimensional images, and there are bright colors (Anjarsari et al., 2020). Where these elements can be found in technology-based learning media that we often know as augmented reality. Not only that, based on the results of the question and answer, the fifth-grade teacher said that there are still students who encounter problems when digesting respiratory system material.

An augmented reality learning device is a learning device that combines the real world with the imaginary world in the form of two or three dimensions that go hand in hand that we can show in the real world or the real world (Wibowo et al., 2022). According to AlGerafi et al. (2023), Radu et al. (2023), and Bistaman et al. (2018), augmented reality is a tool that functions as a

component of assistance that is utilized by students in understanding an abstract and complex concept with their creativity and imagination of an object to be studied. In this case, the use of this learning media is very easy to access anywhere and anytime this learning media can be used by students easily.

This is the reason behind the researchers' desire to create an augmented reality-based learning tool that will enhance student learning, particularly in the IPAS subject matter related to the respiratory system. This project aims to: ascertain whether IPAS learning outcomes in grade V respiratory system material may be enhanced by employing augmented reality learning devices; Assess how well-augmented reality learning tools enhance IPAS learning results for grade V respiratory system content. This is reinforced by previous researchers, namely augmented reality-based puzzle media in science subjects on the theme of ecosystems (Nirwanto et al., 2021) in this study, it was found that the media developed on the theme of ecosystems were valid and feasible to be used as learning tools in science subject content at the elementary school level. The next research was conducted by Efendi et al. (2023) where the study states that the augmented reality application that has been developed is included in the valid level sourced from the results of reinforcement by media experts with a percentage level of 92% and feasible to use based on limited trials to 20 students with a percentage level of 89.75%.

Not only that, this device is considered successful in terms of use. In addition, studies that help this investigation are studies conducted by Priyanto et al. (2023) and Nengsih et al. (2023), where based on this research, the development of augmented reality media received an assessment from educators and student objects with a total percentage value of 92.71% and 88.07%, which proves that the device that has been developed is included in a very good level and is suitable for application in a learning process. There is also research conducted by Susetya et al. (2022) where the study states that the learning outcomes of students after utilizing augmented reality learning devices have increased from 63.67 to 82.33. Other research that participates in supporting this research is research conducted by Pramuditya et al. (2022) from this study, an augmented reality-assisted card learning media was obtained with the results of material expert authentication, with an average rate of 85% indicating exceptionally strong credentials. The average percentage of 78% in the media expert validation results indicates strong qualifications.

Method

This study is a development study using the Research and Development (R&D) approach about the 10 stages of the Borg and Gall theory that are now in existence, specifically: potential and issues; gathering information; designing the product; validating the design; improving the design; conducting a product trial; improving the product; studying its use; improving the product; and mass manufacturing. Only eight of the current stages—that is, up until the usage testing stage—were used by the researchers in this investigation. Utilizing instruments in the form of questionnaires and interviews, questionnaires and interviews are the data collection. Qualitative and quantitative data analysis is the data analysis method that this study refers to. Data gathered via questions and replies, suggestions made by material specialists and media experts who serve as validators, and monitoring findings are all considered forms of qualitative data. On the other hand, quantitative data comes from answers to a questionnaire that is distributed to teachers, students, media experts, and material experts.

Result and Discussion

Result

The result of this study is an augmented reality learning device on the selected subject content IPAS with respiratory system material. This material is material on the content of IPAS by the independent curriculum for grade five elementary school. The design of augmented reality media development is made by applying the steps of the research and development model with the following stages. The first step is analyzing potential problems. In this step, the researcher examines the problems that exist at SD N Ngijo 02 in Gunung Pati District through observation. After carrying out observations at the elementary school, it was found that in learning students often feel bored when learning takes place, the use of learning media is also very limited, especially in the content of the IPAS lesson, the learning resources used also only focus on one source, namely books, both student books and other reference books such as student worksheets (LKS), and student learning outcomes that are not optimal in the IPAS lesson content.

The second step is data collection. At this stage, the researcher interviewed the fifth-grade teacher of SD N Ngijo 02. Where from the results of the interview it was found that in the learning mechanism, there was still minimal use of learning media due to the age factor which resulted in the teacher being quite low in mastering the use of learning media, especially in the use of technology-based learning media. From the interview activities, it was also found that in the learning content

of IPAS the value of students was also quite low, especially in the material of the respiratory system. In this learning content, most of the learning is only delivered theoretically without any learning media that supports students' absorption of what has been conveyed by the teacher. So, this resulted in the enthusiasm of students in participating in learning is very low. The third step is product design. The product development design of augmented reality learning media can be seen in Figure 1.
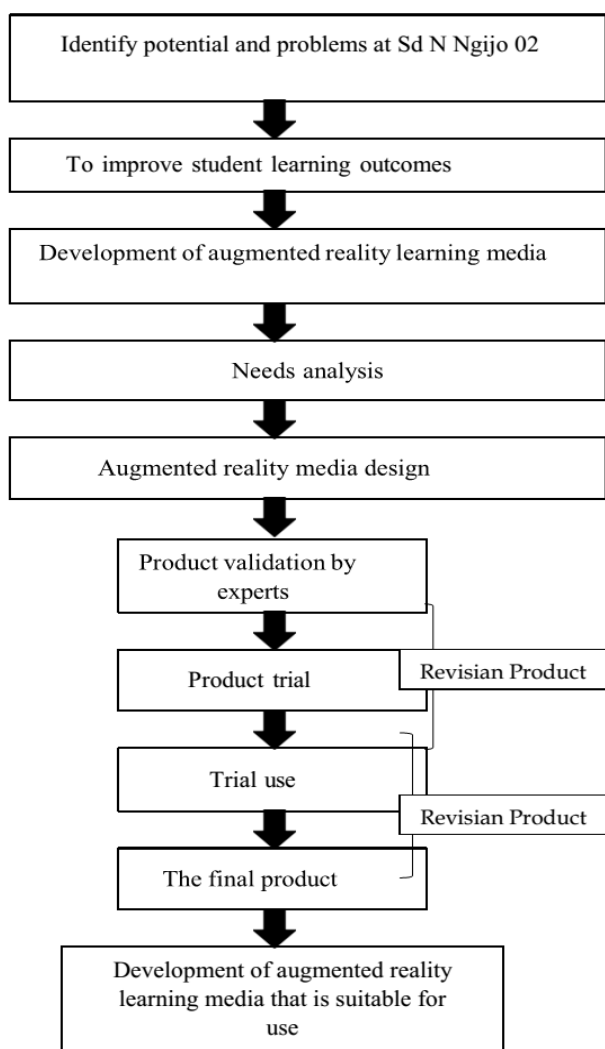

Figure 1. Augmented reality media development design

Aspect of the criticism for the next step — improving the design of augmented reality learning devices within the content of respiratory system material IPAS lessons — this is being done to measure the viability of augmented reality learning media products in the context of respiratory system material IPAS lessons. Two experts in the process of developing augmented reality learning devices have obtained results from their design validation on the content of the respiratory system material of Class V Elementary School. These results

show that a total score of 49 with a percentage of 81.60% is obtained, which is included in every feasible qualification, and a total score of 58 with a percentage of 96.60%, which is also included in every feasible qualification. This indicates that using augmented reality learning aids as one of the teaching tools for the IPAS respiratory system subject in fifth- grade elementary schools is doable. Tables One and Two reflect the findings of the feasibility test conducted by the two experts about the development of augmented reality learning media.

Table 1. Data on Product Validation Results by Material Experts

Assessment Index	Assessment Item	Value
Appropriateness to learning objectives	2	8
Appropriateness to students' thinking period	2	7
Support for learning content	2	15
Images can clarify learning objectives	5	5
Accuracy to help fulfill actual learning content, concepts, principles, or generalities	4	14
Total		49
Percentage Qualification		81. 60 very feasible

Table 2. Data on Product Validation Results by Media Experts

Assessment Index	Item Evaluation	Mark
The design validation phase is the fourth. Two professionals, media experts, and material experts, perform design checking. To gather feedback, ideas, and degree of content and purpose	5	20
Instructional aspects	5	18
Technical aspects	5	20
Total		58
Percentage Qualification		96.60 Very feasible

After carrying out the validation test on the two experts, the criticism, suggestions, and directions obtained by the researcher were then used as a reference at the next stage, namely design improvement. At the design improvement stage, what the researchers did was only limited to what had been recommended by the material expert validators and media experts. The input and direction from the validators are presented in Table 3.

Table 3. Validator Feedback

Validator Feedback		Summary
Material Expert	Media Expert	Researchers made design improvements by adding instructions for use as well as developer profiles and supervisor profiles on the main page, for markers researchers made improvements by making them card. sized and combining them with key chains to make them more attractive and easy to store and researchers also made improvements to the writing of the title which as originally "respiratory system to respiratory system" according to the rules of language, and changed added information usingthe Indonesian language that is easily understood by students.
Writing the title of the material is adjusted to the correct language rules	Addition of instructions for use on the main page of the developed learning media	
Supporting images in the developed media are more clarified by using descriptions that are easily understood by students	Addition of developer profile and supervisor profile Each AR marker is made simpler and as attractive as possible	

The following is a picture of the design of an augmented reality learning device for science learning content regarding the respiratory system before and after revising.

Table 4. Design of Augmented Reality before and after Revision

Before Revision	After Revision
Change all non-standard words in the augmented reality media developed according to the KBBI.	

The developer profile icon and usage instructions have been added to the main page such as CP icons, materials, markers, and AR cameras

In the material section, the validator suggested that the writing be made left-aligned or left right-aligned, then for supporting images it is recommended to use Indonesian, and in each material given questions such as triggering questions.

The AR image that has been created is added with the right, left, up, and down sliding settings

The results obtained from the product trial were also strengthened by the questionnaire responses of teachers and students. In the teacher's response questionnaire, there are 15 questions with each item of the questionnaire assessment ranging from four with a very good group, three that are included in the good group, two with sufficient holongan, and one with a less group. Based on the results of the teacher response questionnaire, the total score was 59 with a percentage of 98.3% with a very feasible category. Meanwhile, the student response questionnaire given to 6 targets in this step contains 15 questions with each item of assessment in the while the answer "no" gets a value of zero.

Table 5. Results of the Effectiveness Test of the Small Group Usage Trial

Data(α)	Dk	t_{count}	t_{table}	Information Pretest
5%	6	8.51	1.94	H_a accepted Posttest

Table 6. Effectiveness Test Results of the Large Group Usage Trial

Data(α)	Dk	t_{count}	t_{table}	Information Pretest
5%	13	7.83	1.77	H_a accepted Posttest

Based on the data obtained from the student response questionnaire, the total score is 83 with a percentage of 92.20% which is included in the very feasible qualification. Thus, the augmented reality learning device developed received a positive response from both teachers and students. Then, after passing the product trial with 6 selected target students. The next stage carried out is the product improvement stage. At this stage the researcher did not makeany improvements to the learning tools developed, all the researcher did was direct other students to change the existing settings of each student also given the same student response questionnaire given at the product trial stage. The

overall score of 13 students obtained a total of 185 with a percentage of 94.87% where the percentage was included in the category of feasible. The following is a picture of the usage trial questionnaire the answer "yes" gets a value of one.

Table 7. N - gain Average Increase Test in Small Groups

Pretest Average	Posttest Average	Maximum Score	Average Difference	N-Gain Score	Criteria
46.66	79.16	100	32.50	0.63	Medium

Table 8. N - gain Average Increase Test in Large Group Usage Trial

Pretest Average	Posttest Average	Maximum Score	Average Difference	N-Gain Score	Criteria
50.76	69.23	100	18.47	0.36	Medium

Used in tables 5 and 6 above, it is known that *tcount* > *ttable* which shows that there is an influence in the development of augmented reality learning media on the learning outcomes of class V students at SD N Ngijo 02 Gunung Pati District. This is proven by the *tcount* results in the small group of 8.51 the *tcount* in the large group of 7.83 the results of the *ttable* for the small group as much as 1.94 and the *ttable* for the large group as much as 1.77 and based on the table 7 and 8 above, it is known that the value of student knowledge before and after the use of the developed learning tools has increased. Where before the use of the developed learning tools obtained an average value of 46.66 while after learning to apply the developed learning tools the average value obtained was 79.16 with a difference of 32.50 increase. In the large group, the value obtained before the use of the developed learning media was 50.76, while after learning to apply the developed learning tools, the average value obtained was 73.84. This proves that there is an increase before and after use with an average difference of 23.08 with the N-Gain value obtained of 0.63 and 0.44 respectively which is included in the moderate category.

The development research produced augmented reality educational tools on the topic of the human respiratory system, namely class V SD N Ngijo 02. Augmented reality learning media was developed based on the results of observations and the results of questions and answers that have been conducted by researchers in primary schools. this is because the use of learning media at the elementary school is still low, especially in class V of the IPAS subject matter. To support the achievement one of the crucial aspects of learning that we must pay attention to is the attainment of learning objectives. A calm classroom atmosphere and adequate facilities make it easy for students to capture the learning that has been delivered (Nuryani & Surya Abadi, 2021). Augmented reality learning media developed specifically for grade V elementary schools have the intention that students can digest the concepts that exist in the material of the respiratory system in humans through the 3- dimensional images provided, so that students during the learning process do not feel bored, and the purpose of developing this learning media is to help students improve poor knowledge scores through understanding the material that has been provided (Carolina, 2022).

One of the indicators that we can use in knowing the success obtained by students includes an increase in both knowledge, interests, and attitudes, as well as skills that exist in students (Effendi et al., 2021). For this reason, it is necessary to provide a learning media that is used as an intermediary in delivering material, especially in the learning content of IPAS class V elementary school (Lestari, 2023). So that an augmented reality-based learning tool was developed that was able to help students digest human respiratory system material through 3- dimensional images, where the media combined the real world with the imaginary imagination of students which could facilitate the interpretation carried out by students (Kaimara et al., 2022).

The presentation of material in the learning media developed in it contains two-dimensional and three-dimensional images with a combination of colors that are quite interesting so that students will not get bored quickly when learning is running. Then the content of the material presented a brief, concise, and clear statement supported by supporting images. Where it is intended that students easily digest the material provided. The presentation of material on the developed media is also adjusted to the formulation of learning outcomes, learning objectives, and instructions for using learning media which will make it easier for students to digest the ideas in the media being developed. Not only that, the instructions for use are intended so that students are facilitated in operating the use of the media developed (Dwivedi et al., 2023).

In terms of media development design. The augmented reality learning media that is being developed is designed by adding concrete images. Where the purpose of adding concrete images is to help students digest material that tends to be abstract (Dianawati, 2019). Not only that, the markers used to display 3-dimensional images of respiratory system material are designed to be the same size as toy cards

and combined with key chains. So that it makes it easier to use and storage that does not take up much space (Sukasih et al., 2022). The application of learning media here can increase the desire and stimulus for learning that exists in students, sometimes even the use of learning media during learning can have an impact on children's psychology (Muhaimin et al., 2023). Which can stimulate the development of mindsets and learning imaginations in students (Maulidah & Aslam, 2021). Augmented reality learning media makes it easier for students to understand the ideas that are being explained. Students become active when learning takes place because the existing media is supported by many 2-dimensional and 3-dimensional images that feel very real (Listiyani et al., 2021; Liang et al., 2023; Zhao et al., 2023).

So that this has a direct impact on the high learning value of students. Based on the analysis, of the augmented reality learning device developed, the device can be said to be feasible and effective as learning support in the content of the respiratory system material of grade V elementary school. The effectiveness of the use of learning devices developed is indicated by an increase in the learning outcomes obtained by students. In this study, learning outcomes are the final acquisition of students of what they have done during the learning process (Ariyani & Kristin, 2021). In this study, the learning outcomes in question are limited to cognitive matters only. Cognitive learning outcomes are learning outcomes obtained through a combination of the effectiveness of the brain's work in terms of remembering and the speed at which it accepts the learning material that has been delivered (Nurrita, 2018). This is further emphasized by a previous study which explained that augmented reality in the world of education has a good influence, which can attract students to participate in learning, make students active during learning, increase the accessibility of educational content, and turn something abstract into concrete (Atmajaya, 2017).

Learners also feel more interested when the learning tools provided are technology such as augmented reality learning media (Supriyanto et al., 2023; Utami et al., 2021). The learning media developed can also mobilize the mindset that exists in students so that it can increase the learning value obtained by students (Sonmez Cakir & Adiguzel, 2020). In addition, the developed learning tools can also motivate students to participate in learning more actively (Zulfa et al., 2020). Unfortunately, there are also limitations in the application of the use of augmented learning media developed. Where the network used in accessing the developed media must be stable so that the developed media can function smoothly when used, educators must also have patience when implementing learning so

that learning objectives can be carried out with the highest results. Through this, it is hoped that the learning tools developed can help educators in facilitating the delivery of respiratory system material through the application of augmented reality learning media.

Conclusion

The augmented reality learning media developed by researchers has proven to be feasible and effectively used in supporting science and science learning for Class V elementary schools with respiratory system material. This is proven by assessments from material experts and media experts. Consecutively, scores were obtained with percentages of 81.60% and 96.60%. Then Augmented reality learning media is declared effective in improving student learning outcomes Class V Science and Science lesson content at Ngijo State Elementary School 02, respiratory system material. These results are appropriate with pretest and posttest results. On the learning outcomes of fifth- grade students at Ngijo State Elementary School 02 using augmented reality learning media in the posttest obtained results with the average is 69.23 with the N gain calculation result being 0.36 with medium criteria. The main conclusions of the study may be presented in a short Conclusions section, which may stand alone or form a subsection of a Discussion or Results and Discussion section.

References

AlGerafi, M. A. M., Zhou, Y., Oubibi, M., & Wijaya, T. T. (2023). Unlocking the Potential: A Comprehensive Evaluation of Augmented Reality and Virtual

Reality in Education. *Electronics*, *12*(18), 3953. https://doi.org/10.3390/electronics12183953

Anjarsari, E., Farisdianto, D. D., & Asadullah, A. W. (2020). Pengembangan Media Audiovisual Powtoon pada Pembelajaran Matematika untuk Siswa Sekolah Dasar. *JMPM: Jurnal Matematika Dan Pendidikan Matematika*, *5*(2), 40–50. https://doi.org/10.26594/jmpm.v5i2.2084

Ariyani, B., & Kristin, F. (2021). Model Pembelajaran Problem Based Learning untuk Meningkatkan Hasil Belajar IPS Siswa SD. *Jurnal Imiah Pendidikan Dan Pembelajaran*, *5*(3), 353. https://doi.org/10.23887/jipp.v5i3.36230

Atmajaya, D. (2017). Implementasi Augmented Reality Untuk Pembelajaran Interaktif. *ILKOM Jurnal Ilmiah*, *9*(2), 227–232. https://doi.org/10.33096/ilkom.v9i2.143.227-232

Betz, U. A. K., Arora, L., Assal, R. A., Azevedo, H., Baldwin, J., Becker, M. S., Bostock, S., Cheng, V., Egle, T., Ferrari, N., Schneider-Futschik, E. K., Gerhardy, S., Hammes, A., Harzheim, A., Herget, T., Jauset, C., Kretschmer, S., Lammie, C., Kloss, N., & Zhao, G. (2023). Game changers in science and technology—Now and beyond. *Technological Forecasting and Social Change*, *193*, 122588. https://doi.org/10.1016/j.techfore.2023.122588

Bistaman, I. N. M., Idrus, S. Z. S., & Rashid, S. A. (2018). The Use of Augmented Reality Technology for Primary School Education in Perlis, Malaysia. *Journal of Physics: Conference Series*, *1019*, 012064. https://doi.org/10.1088/1742-6596/1019/1/012064

Carolina, Y. D. (2022). Augmented Reality sebagai Media Pembelajaran Interaktif 3D untuk Meningkatkan Motivasi Belajar Siswa Digital Native. *Ideguru: Jurnal Karya Ilmiah Guru*, *8*(1), 10–16. https://doi.org/10.51169/ideguru.v8i1.448

Darling-Hammond, L., Flook, L., Cook-Harvey, C., Barron, B., & Osher, D. (2020). 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

Dianawati, E. P. (2019). Pengaruh Media Tebak Gambar dan Talking Stick Terhadap Motivasi Belajar Siswa. *Jurnal Ilmiah WUNY*, *1*(1). https://doi.org/10.21831/jwuny.v1i1.26855

Dirgantara, C. S., Hanifah, N., & Nugraha, D. (2024). Creation of MOPOKAR (Card Monopoly) to Enhance Learning Skills in Comparing the Social Conditions of Indonesia and Neighboring Countries in Grade 6. *Scaffolding: Jurnal Pendidikan Islam Dan Multikulturalisme*, *6*(1), 89–108. https://doi.org/10.37680/scaffolding.v6i1.4161

Dwivedi, Y. K., Kshetri, N., Hughes, L., Slade, E. L., Jeyaraj, A., Kar, A. K., Baabdullah, A. M., Koohang, A., Raghavan, V., Ahuja, M., Albanna, H., Albashrawi, M. A., Al-Busaidi, A. S., Balakrishnan, J., Barlette, Y., Basu, S., Bose, I., Brooks, L., Buhalis, D., &Wr ight, R. (2023). Opinion Paper: "So what if ChatGPT wrote it?" Multidisciplinary perspectives on opportunities, challenges and implications of generative conversational AI for research, practice and policy. *International Journal of Information Management*, *71*, 102642. https://doi.org/10.1016/j.ijinfomgt.2023.102642

Efendi, R., Ali, G., Andang Purnomo, W., Iskandar, I., & Agustin Wulandari, R. (2023). Augmented Reality Based Competency Based Learning on Computer Network Learning in Vocational Education Vocational School. *Jurnal Penelitian Dan Pengembangan Pendidikan*, *7*(2), 242–253. https://doi.org/10.23887/jppp.v7i2.62263

Effendi, R., Herpratiwi, H., & Sutiarso, S. (2021). Pengembangan LKPD Matematika Berbasis Problem Based Learning di Sekolah Dasar. *Jurnal Basicedu*, *5*(2), 920–929. https://doi.org/10.31004/basicedu.v5i2.846

Haleem, A., Javaid, M., Qadri, M. A., & Suman, R. (2022). Understanding the role of digital technologies in education: A review. *Sustainable Operations and Computers*, *3*, 275–285. https://doi.org/10.1016/j.susoc.2022.05.004

Hartono, R. (2020). Penerapan Macromedia Flash dalam Meningkatkan Kreativitas, Hasil Belajar, dan Efektivitas Pembelajaran Siswa Kelas XII di SMK Negeri 1 Kaliorang. *Diglosia: Jurnal Kajian Bahasa, Sastra, Dan Pengajarannya*, *3*(2), 221–228. https://doi.org/10.30872/diglosia.v3i2.48

Iqbal, M., Tao, Y., Xie, S., Zhu, Y., Chen, D., Wang, X., Huang, L., Peng, D., Sattar, A., Shabbir, M. A. B., Hussain, H. I., Ahmed, S., & Yuan, Z. (2016). Aqueous two-phase system (ATPS): An overview and advances in its applications. *Biological Procedures Online*, *18*(1), 18. https://doi.org/10.1186/s12575-016-0048-8

Kaimara, P., Oikonomou, A., & Deliyannis, I. (2022). Could virtual reality applications pose real risks to children and adolescents? A systematic review of ethical issues and concerns. *Virtual Reality*, *26*(2), 697–735. https://doi.org/10.1007/s10055-021-00563-w

Lestari, Y. D. (2023). Pentingnya Media Pembelajaran dalam Meningkatkan Hasil Belajar di Sekolah Dasar. *Lentera: Jurnal Ilmiah Kependidikan*, *16*(1), 73–80. https://doi.org/10.52217/lentera.v16i1.1081

Liang, L., Zhang, Z., & Guo, J. (2023). The Effectiveness of Augmented Reality in Physical Sustainable Education on Learning Behaviour and Motivation.

Sustainability, *15*(6), 5062. https://doi.org/10.3390/su15065062

Listiyani, N., Hidayat, S., & Nulhakim, L. (2021). Development of Augmented Reality Flashcard Media to Improve the Ability of Grade IV Elementary School Students in Reading Understanding of Alternative Energy Source Materials. *Jurnal Penelitian Pendidikan IPA*, *7*(4), 782–787.
https://doi.org/10.29303/jppipa.v7i4.861

Maulidah, A. N., & Aslam, A. A. (2021). Penggunaan Media Puzzle secara Daring terhadap Hasil Belajar IPA Kelas V SD. *Mimbar Ilmu*, *26*(2), 281. https://doi.org/10.23887/mi.v26i2.37488

Muhaimin, M. R., Ni'mah, N. U., & Listryanto, D. P. (2023). Peranan Media Pembelajaran Komik Terhadap Kemampuan Membaca Siswa Sekolah Dasar: Peranan Media Pembelajaran Komik Terhadap Kemampuan Membaca Siswa Sekolah Dasar. *Jurnal Pendidikan Dasar Flobamorata*, *4*(1), 399–405. https://doi.org/10.51494/jpdf.v4i1.814

Nengsih, N., Eka, A. E. S., & Sunandar, A. (2023). Development of augmented reality learning media based on assemblr studio web in ecosystem material. *JINoP (Jurnal Inovasi Pembelajaran)*, *9*(2), 277–291.
https://doi.org/10.22219/jinop.v9i2.25251

Nirwanto, B. G., Murtono, M., & Fathurrohman, I. (2021). Media Puzzle Berbantu Augmented Reality pada Muatan Pelajaran IPA Tema Ekosistem. *Jurnal Edutech Undiksha*, *9*(2), 275. https://doi.org/10.23887/jeu.v9i2.38503

Nurrita, T. (2018). Pengembangan Media Pembelajaran Untuk Meningkatkan Hasil Belajar Siswa. *MISYKAT: Jurnal Ilmu-Ilmu Al-Quran, Hadist, Syari'ah Dan Tarbiyah*, *3*(1), 171. https://doi.org/10.33511/misykat.v3n1.171

Nuryani, L., & Surya Abadi, I. G. (2021). Media Pembelajaran Flipbook Materi Sistem Pernapasan Manusia pada Muatan IPA Siswa Kelas V SD. *Jurnal Imiah Pendidikan Dan Pembelajaran*, *5*(2), 247. https://doi.org/10.23887/jipp.v5i2.32934

Pramuditya, S. A., Pitriayana, S., Subroto, T., & Wafiqoh, R. (2022). Implementation of augmented reality-assisted learning media on three-dimensional shapes. *Jurnal Elemen*, *8*(2), 480–493. https://doi.org/10.29408/jel.v8i2.5238

Priyanto, P., & Sumarwan, S. (2023). Development of Augmented Reality Learning Media in Chemistry Subject High School. *International Journal of Artificial Intelligence Research*, *7*(2), 123. https://doi.org/10.29099/ijair.v6i2.912

Radu, I., Huang, X., Kestin, G., & Schneider, B. (2023). How augmented reality influences student learning and inquiry styles: A study of 1-1 physics remote AR tutoring. *Computers & Education: X Reality*, *2*, 100011. https://doi.org/10.1016/j.cexr.2023.100011

Sonmez Cakir, F., & Adiguzel, Z. (2020). Analysis of Leader Effectiveness in Organization and Knowledge Sharing Behavior on Employees and Organization. *SAGE Open*, *10*(1), 215824402091463. https://doi.org/10.1177/2158244020914634

Sukasih, S., Wulandari, D., & Permana, Z. F. (2022). The Effectiveness of Augmented Reality Book to Improve Critical Thinking Ability At Elementary School Students. *Journal of Education for Sustainability and Diversity*, *1*(1), 18–28. https://doi.org/10.57142/jesd.v1i1.2

Supriyanto, S., Joshua, Q., Abdullah, A. G., Tettehfio, E. O., & Ramdani, S. D. (2023). Application of Augmented Reality (AR) in vocational education: A systematic literature review. *Jurnal Pendidikan Vokasi*, *13*(2), 205–213. https://doi.org/10.21831/jpv.v13i2.54280

Susetya, B. E. F., & Harjono, N. (2022). Pengembangan Media Filter Instagram Berbasis Augmented Reality sebagai Media Pembelajaran IPA untuk Meningkatan Hasil Belajar Siswa Sekolah Dasar. *Jurnal Basicedu*, *6*(6), 10056–10072. https://doi.org/10.31004/basicedu.v6i6.4228

Syaiful, S., Kamid, K., Kurniawan, D. A., & Rivani, P. A. (2021). The Impact of Students' Learning Interest on Students' Process Skill in Mathematics. *Journal of Education Research and Evaluation*, *5*(4), 558. https://doi.org/10.23887/jere.v5i4.37183

Utami, F., Rukiyah, R., & Andika, W. D. (2021). Pengembangan Media Flashcard Berbasis Augmented Reality pada Materi Mengenal Binatang Laut. *Jurnal Obsesi : Jurnal Pendidikan Anak Usia Dini*, *5*(2), 1718–1728. https://doi.org/10.31004/obsesi.v5i2.933

Wahrini, R., & Peng, C. G. (2023). Development of Interactive Learning Media in Occupational Health and Safety Subjectin Vocational High School. *Jurnal Pendidikan Teknik Sipil*, *5*(1), 31–41. https://doi.org/10.21831/jpts.v5i1.59820

Wardoyo, C., Satrio, Y. D., Narmaditya, B. S., & Wibowo, A. (2021). Do technological knowledge and game-based learning promote students achievement: Lesson from Indonesia. *Heliyon*, *7*(11), e08467. https://doi.org/10.1016/j.heliyon.2021.e08467

Wibowo, V. R., Eka Putri, K., & Amirul Mukmin, B. (2022). Pengembangan Media Pembelajaran Berbasis Augmented Reality pada Materi Penggolongan Hewan Kelas V Sekolah Dasar. *PTK: Jurnal Tindakan Kelas*, *3*(1), 58–69. https://doi.org/10.53624/ptk.v3i1.119

Zhao, X., Ren, Y., & Cheah, K. S. L. (2023). Leading Virtual Reality (VR) and Augmented Reality (AR)

in Education: Bibliometric and Content Analysis From the Web of Science (2018–2022). *SAGE Open*, *13*(3), 21582440231190821. https://doi.org/10.1177/21582440231190821

Zulfa, E., Nuroso, H., & Reffiane, F. (2020). Keefektifan Model Pembelajaran Terpadu Tipe Sequenced Berbantu Media Puzzle Terhadap Hasil Belajar Siswa. *Jurnal Penelitian Dan Pengembangan Pendidikan*, *4*(1), 18. https://doi.org/10.23887/jppp.v4i1.24938