# DEVELOPMENT OF AUGMENTED REALITY (AR) IPAS LEARNING MEDIA TO IMPROVE CRITICAL THINKING SKILLS OF ELEMENTARY SCHOOL STUDENTS

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**Abstract**
This study aims to: 1) analyse the characteristics and quality of Class IV AR IPAS media products based on reviewer assessments; 2) implement AR IPAS media development products to improve the critical thinking skills of Class IV students; 3) analyze the effectiveness of AR IPAS media in improving critical thinking skills of Class IV students. The method used is the ADDIE R&D model with the stages of Analysis, Design, Development, Implementation, and Evaluation. Data were collected through observation, interviews, documentation, validation sheets, assessments, and tests. Data analysis was carried out using qualitative and quantitative descriptive techniques. The results showed that AR IPAS media integrates the real and virtual worlds, and provides interactive and real-time information in 2D and 3D, made with the Assemblr Edu application. This media is effective, easy to operate, and affordable to make. However, AR media is sensitive to changes in viewing angle and requires sufficient memory capacity on the device used. The implementation of AR IPAS media at SD Negeri Nanggulan and MI Al-Huda was conducted in five meetings, students were enthusiastic and actively involved, allowing direct concept exploration. AR IPAS media products are proven to be effective, proven through paired sample t-tests on two classes showing significance $p < 0.05$, indicating a significant difference in students' critical thinking skills before and after using AR media.

**Keywords:** augmented reality (AR) learning media, critical thinking, IPAS, primary school

**Introduction**
The 2013 Curriculum has been the cornerstone of education in Indonesia since 2013. In 2020, Merdeka Curriculum replaced Curriculum 2013 as part of the government's initiative to improve the quality of the education system to make it more responsive and in line with the demands of the times (Dirgantoro & Soesanto, 2023; Sa'adah, 2020). The government began implementing the Merdeka Curriculum in 2020, reflecting their commitment to improve and enhance the effectiveness of education to make it more relevant to the needs of

society (Muharnis & Fadriati, 2023). This initiative, initiated by Minister of Education Nadiem Makarim, generated various reactions among teachers and education stakeholders (Putri, Asbari, & Hapizi, 2024). Despite facing pros and cons, the Merdeka Curriculum is considered an effort to overcome educational challenges and make it more adaptive, innovative, and by the needs of the times (Lailiyah & Imami, 2023).

The implementation of the Merdeka Curriculum refers to Permendikbud Ristek No. 56 of 2022, which regulates the guidelines for curriculum implementation in the context of learning recovery (Anggraena et al., 2022). This curriculum is designed to support Indonesia's vision of education by being more flexible, emphasizing subject matter, and developing student character and competencies (Hartoyo, Melati, & Martono, 2023). The Merdeka Curriculum aims to improve the quality of education and prepare students for future global challenges (Rahmadayanti & Hartoyo, 2022). Therefore, this curriculum emphasises the development of 21st-century skills, including environmental skills.

Changes to the Merdeka Curriculum have had a significant impact on learning in Primary Schools (SD) and Madrasah Ibtidaiyah (MI) (Fauzi, 2023). SD and MI play an important role in shaping students' character, knowledge and basic skills before they continue to higher levels of education (Mulyaningsih et al., 2022). In addition, SD and MI form the basic attitudes needed in community life (Malazonia et al., 2021). To strengthen the role of SD and MI following the concept of 'independence' students are given the freedom to manage their learning process and are trained to take responsibility for their learning process (Trias et al., 2021). Learning is focused on a student-centred approach (Gezim & Xhomara, 2020). One of the compulsory subjects taught in primary and secondary schools is Natural and Social Sciences (NSP).

In the 2013 Curriculum, science and social studies in SD / MI are separate subjects, but in the Merdeka Curriculum, they are combined into Natural and Social Sciences (IPAS) (Riner, Hur, & Kohlmeier, 2022). IPAS is designed to prepare students for science and social studies at the junior high school level and aims to promote holistic, multidisciplinary, and contextualised education. This integration teaches the interconnectedness of natural and social aspects in daily life, increases the relevance of learning to the real world, and develops 21st-century skills such as critical thinking, communicating, collaborating, and innovating (Ammar, Al-Thani, & Ahmad, 2024). However, some experts criticise that this integration risks reducing the focus on specific concepts and materials (Perignat & Katz-Buonincontro, 2019). However, the Merdeka Curriculum is still implemented in an effort to maintain the quality of learning and improve students' skills.

The IPAS learning process emphasises hands-on experience to develop students' competence in understanding natural phenomena and social interactions (Kalogiannakis et al., 2018). It aims to improve work skills, critical, creative, and innovative thinking, as well as self-understanding and the environment (Tang, Vezzani, & Eriksson, 2020). This learning is implemented through approaches that are appropriate to the learning phase, materials, student needs, and challenges of the 21st Century. Learning challenges in the 21st Century era involve the roles of government, teachers, parents and communities, with a focus on critical thinking, creative thinking, collaboration and communication (Ritonga, 2022).

Improving teachers' competence as professionals requires higher education, training, and other activities, because teachers' ability to design and implement learning greatly affects students' competence and understanding (Mak, 2019).

Education in Indonesia aims to shape self-identity in order to survive and compete in various aspects of 21st century life. However, weaknesses in teacher competence often hinder the learning process (Suharno, Pambudi, & Harjanto, 2020). Many teachers lack proficiency in designing lessons that actively engage students (Hodges, 2020). Teachers often fail to explore students' potential to develop critical, creative, and innovative thinking skills (Calavia, Blanco, & Casas, 2021). In addition, teachers often experience difficulties in mastering the material, pedagogical competence, implementing the curriculum, and utilising adequate learning facilities, including technology-based media (See, 2014).

Technology-based learning media is very important in IPAS learning (Selimi, Saracevic, & Useini, 2020). Technology makes it easier to deliver material in an interesting and fun way, increase student interest, and encourage active participation (Borokhovski et al., 2016). Interactive videos, for example, increase student motivation and attention (Khotimah & Hidayat, 2022). The use of technology improves students' understanding, creativity and learning outcomes (Tang et al., 2022). However, the utilisation of technology by teachers has not been optimal, even though the selection of appropriate media greatly affects student activity and motivation (Marca & Longo, 2017) . Especially for MI/SD students in the lower grades, visualisation of concrete material is very important because they are not yet able to think abstractly (Baroody, 2017).

The results of preliminary research at SD Negeri Nanggulan and MI Al-Huda Sleman showed some important findings: 1) 40% of students enjoy learning IPAS; 2) 40% of students consider the teacher's teaching method in IPAS learning to be interesting; 3) 60% of students have difficulty understanding the IPAS material delivered by the teacher; 4) 30% of students show enthusiasm in participating in IPAS learning; 5) 70% of students have difficulty understanding the material through teaching materials used in IPAS learning; 6) 80% of students stated that the media used by teachers in IPAS learning are pictures. The graph of student needs analysis can be seen in Figure 1.
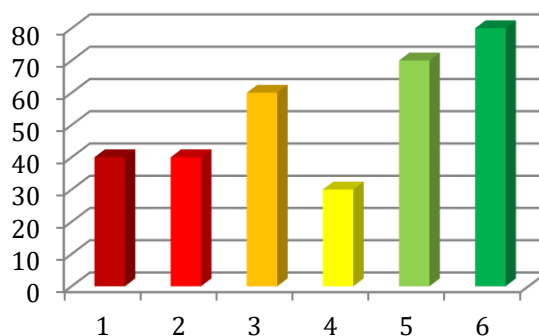


Figure 1. Student needs analysis chart

Preliminary studies through interviews with homeroom teachers IV A SD Negeri Nanggulan and IV B MI Al-Huda Sleman revealed that although both

schools implemented the Merdeka Curriculum, they faced difficulties, especially in delivering material on Living Things and Life Processes. The main obstacles include the lack of learning media, laboratory facilities, libraries, and textbooks. As a solution, the use of Augmented Reality (AR), AR integrates elements of the real world with digital (Akçayır & Akçayır, 2017; Theodoropoulos & Lepouras, 2021). AR enables interactive experiences through devices such as smartphones or tablets, displaying information or virtual objects in real environments (Coimbra, Cardoso, & Mateus, 2015). This technology can enrich learning more interestingly and effectively.

AR facilitates understanding of abstract concepts with concrete and interactive visualisations (Huang et al., 2021). AR allows complex subject matter to be visualised in three-dimensional form (Gaol & Prasolova-Førland, 2022). For example, in science learning such as molecular models or the anatomical structure of the human body (Hernandez-de-Menendez, Escobar Díaz, & Morales-Menendez, 2020). AR visualisations allow students to see and understand objects from different angles and scales, which were previously only available in flat images, thus facilitating the understanding of abstract concepts in a concrete and interactive way.

Previous research shows that AR can increase students' interest and memory, and make learning more interesting and immersive (Meletiou-Mavrotheris et al., 2020). AR also increases motivation and is effective in learning (Au & Lee, 2017). As an innovative solution, AR is being utilised across different levels of education and disciplines, with investment in the education sector expected to reach $12.6 billion by 2025 (Alahmari et al., 2019). This technology is easily accessible through smartphones and laptops, making it increasingly popular in the world of education (Huang et al., 2021).

The limitations of IPAS learning media lead to low student enthusiasm and engagement as well as difficulties in understanding the material. For the topic of Living Things and Life Processes that involves analysing parts of the human body (five senses), active media is needed and allows direct exploration of concepts. Augmented Reality (AR) media development is proposed as a solution, considering that AR has been proven effective in improving students' competence, interest, and learning outcomes. This study aims to test the effectiveness of AR in improving critical thinking skills of elementary school students and is expected to improve the quality of learning on the topic.

**Method**

This research applies a Research and Development (R&D) approach to produce and test the effectiveness of certain products (Crompton & Sykora, 2021). R&D refers to scientific activities that follow universally recognised research standards and norms. This development aims to improve the quality and quantity of an object or activity (Castelló-Climent & Hidalgo-Cabrillana, 2012). The products of this research can be useful in social sciences such as psychology, sociology, management, and education (Posso & Zhang, 2023). The development of Augmented Reality (AR) products for learning Natural and Social Sciences (IPAS) uses the ADDIE model, which consists of five structured components that are interrelated: Analysis, Design, Development, Implementation, and Evaluation (Nasir & Z, 2023). The ADDIE model can be seen in Figure 2.
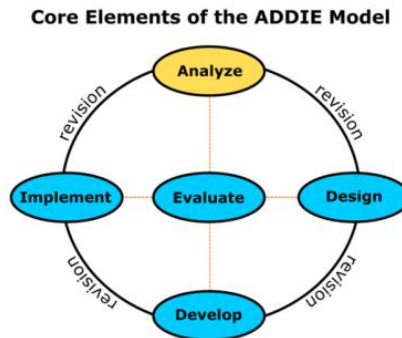
**Core Elements of the ADDIE Model**



Figure 2. ADDIE development model (Mayasariyazid, 2017)

The research and development subjects involved several groups. The first group of instrument experts validated the instruments used to reveal the development process and products. The second group consisted of media experts (V1) and material experts (V2) who provided validation, feedback, and input on the developed product. The third group involved ten teachers (P1-P10) who assessed the products that had been validated by media experts and material experts. The fourth group consisted of classroom teachers and students who trialled the developed product. The fifth group consisted of two class teachers, 27 students of class IV A SD Negeri Nanggulan, and 25 students of class IV B MI Al-Huda Sleman.

The data collection methods used include observation to observe the learning process of teachers and students in the classroom, interviews to obtain information from teachers regarding learning media needs, and documentation in the form of photos and letters as additional data sources that support the analysis and evaluation of the developed learning media. Product validation involves validation sheets from respondents such as instrument experts, media experts, material experts, and class teachers. In addition, tests were used to measure the effectiveness of the products developed through a series of questions given to the research subjects.

Data analysis in this study used qualitative and quantitative descriptive techniques. Qualitative descriptive analysis was used to interpret the results of observations, interviews, documentation, and product validation by experts. Meanwhile, quantitative descriptive analysis was used to evaluate data from product assessment by teachers as well as to measure product effectiveness by comparing pretest and posttest scores using paired sample t-test with the help of SPSS 16.0.

**Findings and Discussion**
**Initial product analysis**

The products produced in this research and development are Assemblr Edu learning media based on Augmented Reality (AR) IPAS material on the five senses to improve critical thinking skills of grade IV students. The results of this initial product development are obtained after carrying out the five stages of ADDIE as follows.

*Analysis*

Analysis is the initial stage carried out to obtain information about what is needed. This stage involves initial observations and interviews with class IV A teachers at SD Negeri Nanggulan and class IV B teachers at MI Al-Huda Sleman as follows:

*Curriculum analysis*

Analysis of the Phases, CPs, TPs, and ATPs in schools shows the urgent need to develop learning media that facilitate active student engagement and direct concept exploration, especially in the material of the five senses. Teachers at SD Negeri Nanggulan and MI Al-Huda Sleman, which began implementing Merdeka Curriculum in the 2023/2024 school year, experienced significant challenges due to limited learning resources and learning media. This finding is in line with Sinaga's research on the need to increase supporting facilities, including technology and innovation, to improve teacher competence in accordance with the Merdeka Curriculum platform issued by the Ministry of Education (Sinaga, Kuswandi, & Fadhli, 2024). According to Sutinah, teachers also face difficulties in implementing the Merdeka Curriculum, including in analysing CP, formulating TP, compiling ATP and Teaching Modules, and determining learning methods and strategies (Sutinah et al., 2024). Other constraints include a lack of technological skills, limited student books, and a lack of expertise in utilising learning methods and media (Dian et al., 2023). Therefore, technology-based learning media development is needed to support the implementation of Merdeka Curriculum, as well as additional training for teachers in analysing learning tools and developing relevant media.

*Learning analysis*

In analysing learning, interviews with teachers and learning observations show that teachers face obstacles in providing adequate learning infrastructure to support the implementation of Merdeka Curriculum. Laboratory facilities, libraries, and textbooks are not available in sufficient quantity and quality. In addition, digital and electronic learning media are also still very limited. Teachers currently only use pictures or posters that are inadequate to explain in detail the material of the five senses to students. The results of this analysis show that teachers need learning media that allows students to be actively involved in the learning process and can explore concepts directly, such as Augmented Reality (AR) learning media. Calavia's research shows that the lack of understanding and skills of teachers in applying creative and innovative learning methods, as well as the condition of the school environment, facilities and infrastructure that are less supportive, are the main factors that affect the effectiveness of the learning process in schools (Calavia, Blanco, & Casas, 2021).

*End user needs analysis*

The results of problem identification and priority assessment show the need for the use of learning media that supports a more modern learning process. Learning does not only rely on printed books, but also requires media that can keep up with the times to facilitate the explanation of material about Living Things and Life Processes. This finding is in line with Hutain's research which

asserts that in the digital era, human activities require higher speed, instantaneity, practicality, efficiency and effectiveness, including in the context of learning (Hutain & Michinov, 2022).

*Design*

After analysing the problems and needs of students, the next step is to design the IPAS Augmented Reality (AR) learning media. The AR IPAS learning media design is based on the CP, TP, and materials that have been designed previously. The design process was also assisted by Canva and Corel Draw applications to ensure the structure of AR IPAS media in accordance with the following characteristics: 1) the use of appropriate materials, colours, text, and images; 2) integration of AR media with 2D and 3D images; 3) the ability of AR media to rotate in various directions (right, left, up, down). Some of the characteristics of AR media in the design process can be seen in the following image:

1. Appropriateness of material, colours, text and images. Can be seen in (Figures 3. and 4.).
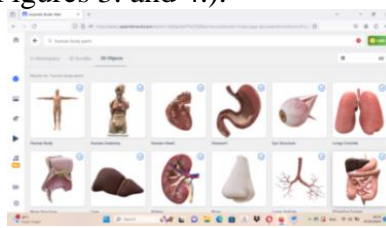


2. AR media consists of 2D and 3D images. Can be seen in (Figure 5. and 6.).
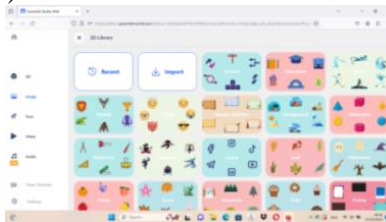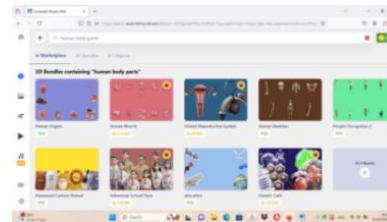


Figure 5. 2D AR        Figure 6. 3D AR

3. AR media can be rotated right, left, up and down. Can be seen in (Figure 7., 8., 9., and 10.).
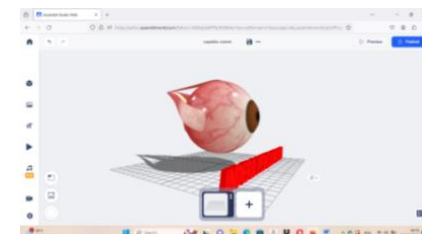


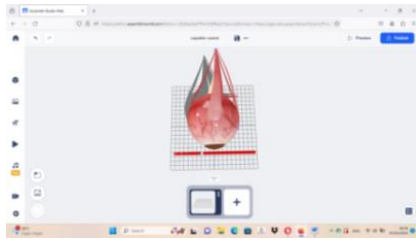Figure 7. AR left view        Figure 8. AR right view
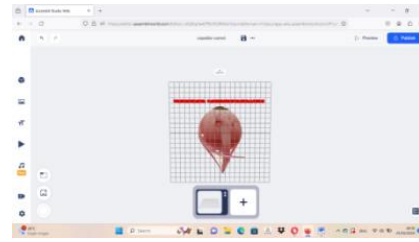
Figure 9. AR top view · Figure 10. AR bottom view

*Development*

The product design developed at this stage was validated by media and material experts, and assessed for quality by teachers. The following are the results of product validation by media experts, material experts and teacher assessments.

*Product validation by media expert*

Product validation by media experts is done face-to-face or directly. This validation is carried out to see the suitability between the material and the media developed from the technical aspect. The expert who acted as a media expert validator was (V1). The media expert did not provide comments on technical aspects so that the product was declared 'valid'.

*Product validity by material experts*

Product validation by material experts is done face-to-face or in person. Material expert validation is carried out to see the suitability of the media and materials developed from curriculum and learning aspects. Experts who act as material expert validators, namely (V2).

The results of product validation by material experts were carried out three times. The following are criticisms and suggestions from material experts:

1. First validation results
   a. Learning Objectives (TP) are not in accordance with the Learning Outcomes (CP).
   b. Adjust to the learning outcomes (CP).

The criticisms and suggestions are used for product improvement. The revision results on the suitability of Learning Objectives (TP) with Learning Outcomes (CP) of AR IPAS learning media can be seen in Table 1.

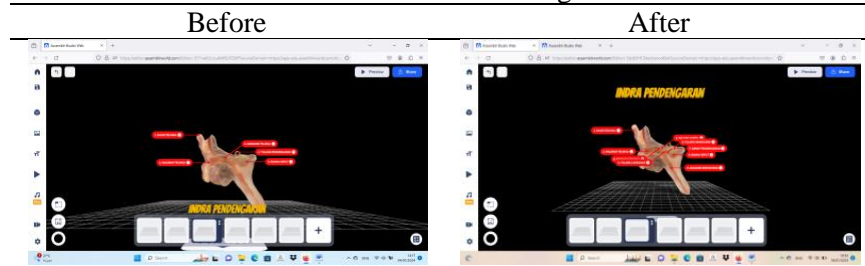Table 1. Media revision in accordance with learning outcomes (CP)

| Before | After |
| --- | --- |
|  |  |

2. Second validation results
   a. Add explanation of auditory bones (hammerhead, anvil, stirrup). The revised addition of the auditory bones can be seen in Table 2.

Table 2. Revision of hearing bones

| Before | After |
|--------|-------|
|  |  |

   b. The explanation of the nasal bone is omitted, replacing it with the mucous membrane. The revision of the nasal bone can be seen in Table 3.

Table 3. Revision of the nose bone

| Before | After |
|--------|-------|
|  |  |
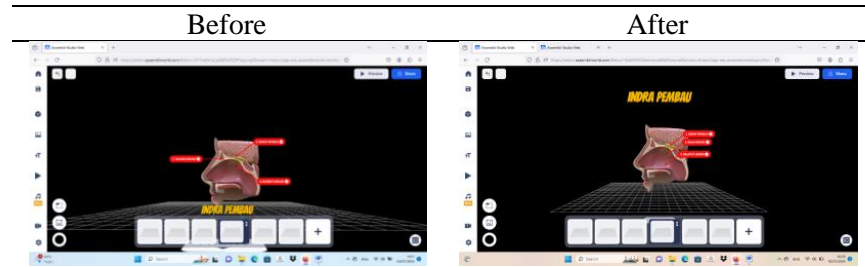
   c. Add an explanation of the various forms of papillae on the tongue. Revised types of papillae can be seen in Table 4.

Table 4. Revision of papillae forms

| Before | After |
|--------|-------|
|  |  |
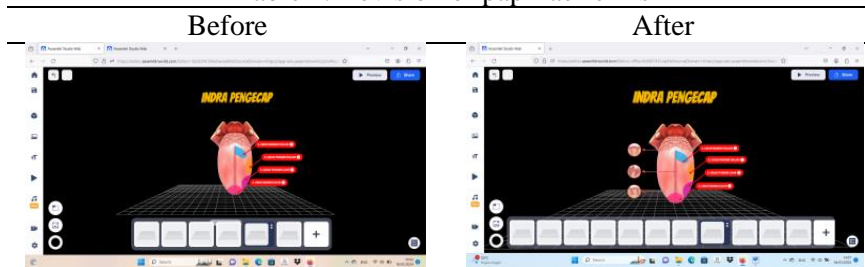
*Product assessment by teacher*

The revised product based on the input of media and material experts was then assessed by teachers. Ten teachers were involved in this assessment and the results are in Table 5. The results of the teacher assessment show that the Augmented Reality (AR) learning media product is declared to have very good quality. In addition to assessing, teachers also provide input, criticism and suggestions, including:
1. P5 on technical aspects 'the colour of the writing is varied to make it more interesting and can improve children's motor skills'.
2. P6 on technical aspects 'needs to be tes ted with various networks'.

Table 5. Results of product assessment by teachers

| No | Class teacher | Agency | Total | Criteria |
|----|---------------|--------|-------|----------|
| 1. | P1 | SDN kalongan | 47 | Very good |
| 2. | P2 | SDN 01 Sorogenen | 45 | Very good |
| 3. | P3 | SDN Maguwoharjo 1 | 42 | Very good |
| 4. | P4 | SDN Ringinsari | 45 | Very good |
| 6. | P5 | SDN Depok 1 | 48 | Very good |
| 7. | P6 | SDN Depok 1 | 48 | Very good |
| 5. | P7 | SDN Depok 2 | 44 | Very good |
| 8. | P8 | MI Ma'arif Bego | 46 | Very good |
| 9. | P9 | MI Ma'arif Bego | 46 | Very good |
| 10. | P10 | MI Ma'arif Bego | 50 | Very good |

*Final product outcome*

Product revisions based on teacher input resulted in IPAS Augmented Reality (AR) learning media that has several components. The components include: the first slide displays the types and functions of the five senses in humans, the second slide displays the parts and functions of the sense of sight in humans, the third slide displays the parts and functions of the sense of hearing in humans, the fourth slide the parts and functions of the sense of smell in humans, the fifth slide displays the parts and functions of the sense of taste in humans, the sixth slide displays the parts and functions of the sense of touch in humans. The structure of the media can be seen in the following figures:


Figure 11.
First slideshow
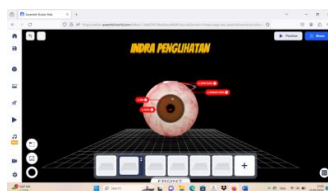

Figure 12.
Second slide show


Figure 13.
Third slide show
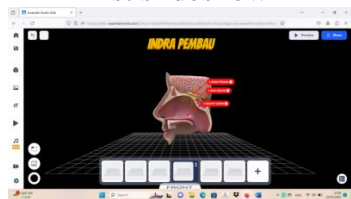

Figure 14.
Fourth slide show
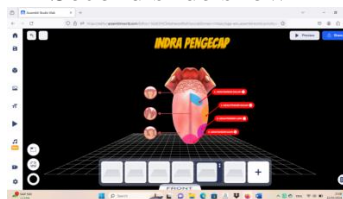

Figure 15.
Fifth slide show
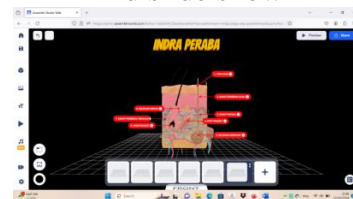

Figure 16.
Sixth slide show

*Implementation*

This implementation stage involves class IV A students of SD Negeri Nanggulan and class IV B students of MI Al-Huda Sleman as the subject of product implementation. After the IPAS Augmented Reality (AR) learning media development product has been implemented, students are asked to do questions as a form of student response. Product implementation can be seen in (Figure 17. and Figure 18.). The student response data will be explained in the next sub chapter.

Figure 17.
Implementation at SDN Nanggulan


Figure 18.
Implementation at MI Al-Huda

*Evaluation*

At the evaluation stage, the quality of IPAS Augmented Reality (AR) learning media products can be determined through three aspects, namely 1) Perception, 2) Learning (results), 3) Performance (attitude) as follows.

1. Students' perceptions or responses to AR learning media include ease of operation, better understanding of the material, attractiveness of images and illustrations, and clear presentation with easy-to-understand language.

2. Students' attitude or behaviour when using AR learning media includes actively listening to the teacher's explanation, connecting the material with real-life situations, exploring concepts directly, participating in questions and answers, completing tasks on time, cooperating in groups, and being able to conclude the material that has been learned..

3. Learning outcomes using AR learning media at SD Negeri Nanggulan and MI Al-Huda Sleman are considered successful if they reach or exceed the set KKM standard, which is 75. The pretest and posttest results showed a significant increase in critical thinking skills. Pretest results of critical thinking skills at SD Negeri Nanggulan got a score of 59.6 and posttest got a score of 83.7. Pretest results of critical thinking skills at MI Al-Huda Sleman got a score of 49.6 and posttest got a score of 81.6.

Theodoropoulos' research supports that AR media gets positive responses from students and teachers, enhances a fun and interesting learning atmosphere, and increases the effectiveness and efficiency of the learning process (Theodoropoulos & Lepouras, 2021). In addition, Thees' research shows that the use of AR media affects students' higher-order thinking skills and supports the continuity of learning processes that are oriented towards learning outcomes (Thees et al., 2020). This finding is reinforced by Baabdullah's research which states that AR media provides space for students to imagine, which positively affects cognitive learning outcomes, including the ability to remember, understand, apply, and analyse (Baabdullah et al., 2022).

## A. Product trial results
### Series of product trial implementation

This product was tested on students of class IV A SD Negeri Nanggulan and class IV B MI Al-Huda Sleman. Before using the AR IPAS learning media, researchers provided conventional learning using picture media for the material of

Living Things and Life Processes (five senses). Students were given pretest questions to evaluate their understanding. Furthermore, students receive learning with AR IPAS learning media that has been developed according to the designed teaching module. This trial aims to enable students to analyse the relationship between the form and function of human body parts (five senses) with the help of learning resources from the environment and the internet as well as AR learning media, and achieve higher order thinking skills (HOTS). Table 6 shows the three topics covered in this trial.

Table 6. Topics/materials

| Meeting | Topic | Material |
|---|---|---|
| 1 | Topic A | Parts and functions of the human sense of sight and sense of hearing. |
| 2 | Topic B | Parts and functions of the sense of smell and taste. |
| 3 | Topic C | Parts and functions of the sense of touch. |

After the AR IPAS media was trialled according to the topic and schedule set, its effectiveness was tested by giving a posttest to measure students' critical thinking skills and retention power. This posttest was not conducted at one time, but in accordance with the retention test procedure which requires an interval of a week.

### Pretest and posttest data analysis results

The implementation of pretests and posttests was carried out directly or face-to-face to fourth grade students of SD Negeri Nanggulan and fourth grade students of MI Al-Huda Sleman. The test was given in the form of questions to 27 fourth grade students of SD Negeri Nanggulan and 25 fourth grade students of MI Al-Huda Sleman. Pretest and Posttest scores are described in Table 7.

Table 7. Analysis of pretest and posttest score of SD Negeri Nanggulan

| No | Statistics | Critical Thinking | |
|---|---|---|---|
| | | *Pretest* | *Posttest* |
| 1. | Amount of data | 27 | 27 |
| 2. | Lowest score | 30 | 60 |
| 3. | Centre score | 60 | 80 |
| 4. | Highest score | 90 | 100 |
| | Average | 59,6 | 83,7 |

Table 7. shows the results of the pretest and posttest scores of SD Negeri Nanggulan. The critical thinking pretest score obtained the lowest score of 30, the middle score of 60, the highest score of 90, and the average score of 59.6. The critical thinking posttest score obtained the lowest score of 60, the middle score of 80, the highest score of 100, and the average score of 83.7.

Table 8. Analysis of pretest and posttest scores MI Al-Huda

| No | Statistics | Critical Thinking | |
|----|-----------|---------|---------|
| | | *Pretest* | *Posttest* |
| 1. | Amount of data | 25 | 25 |
| 2. | Lowest score | 30 | 50 |
| 3. | Centre score | 50 | 80 |
| 4. | Highest score | 70 | 100 |
| Average | | 49,6 | 81,6 |

Table 8 illustrates the results of MI Al-Huda pretest and posttest scores. The critical thinking pretest score obtained the lowest score of 30, the middle score of 50, the highest score of 70 and the average score of 49.6. The critical thinking posttest score obtained the lowest score of 50, the middle score of 80, the highest score of 100 and the average score of 81.6.

The results of data analysis of pretest and posttest critical thinking skills have increased before and after using Augmented Reality (AR) IPAS media at SD Negeri Nanggulan and MI Al-Huda Sleman. The results of this study support the results of Viona's research, which states that AR can improve student learning outcomes. (Sapulette 2023). and supported by the results of Andriani AR's research can improve critical thinking skills (Andriani dan Ramadani 2022).

### *Product effectiveness test analysis*

Augmented Reality (AR) IPAS learning media products are tested for effectiveness by analysing data from pretest and posttest results of critical thinking skills and retention power:

1. Normality Test

The normality test was carried out on critical thinking and retention data using SPSS 16.0 and the results can be seen in Table 9. The normality test was carried out using Shapiro-Wilk because the sample < 50.

Table 9. Normality test results for critical thinking skills score data

| Critical thinking | Shapiro-Wilk | | |
|-------------------|-----------|-----|------|
| | Statistic | df | Sig. |
| Critical Thinking Pretest MI | .899 | 25 | .017 |
| Critical Thinking Posttest MI | .893 | 25 | .013 |
| Critical Thinking Pretest SD | .903 | 27 | .015 |
| Critical Thinking Posttest SD | .914 | 27 | .029 |

The normality test results show that the MI Al-Huda critical thinking pretest score with a p-value of .017> 0.05 and the MI Al-Huda critical thinking Posttest score with a p-value of .013> 0.05. Furthermore, the normality test results show that the pretest score of critical thinking of SD Negeri Nanggulan with a p-value of .015> 0.05 and the Posttest score of critical thinking of SD Negeri Nanggulan with a p-value of .029> 0.05. These results indicate that the pretest and posttest critical thinking scores are normally distributed.

2. Homogeneity Test

The results of the homogeneity test of the pretest and posttest critical thinking score data can be seen in Table 10.

Table 10. Homogeneity test results of critical thinking skills score data

| Critical Thinking | Levene Statistic | df1 | df2 | Sig. |
|---|---|---|---|---|
| Based On Mean | .000 | 1 | 50 | .993 |

Table 10. shows the significance value on the pretest and posttest critical thinking scores of .993, so it can be concluded that the pretest and posttest critical thinking skills score data is homogeneous because the p-value is greater than 0.05.

*Hypothesis test*

The hypothesis of this study was tested using a paired sample t-test, which aims to determine the average difference between two groups paired together and includes a parametric t-test. Before conducting the paired sample t-test, a correlation test was carried out, and the results can be seen in Table 11.

Table 11. Correlation test results of critical thinking skills

| Critical Thinking | N | Correlation | Sig. |
|---|---|---|---|
| MI Critical Thinking Pretest & MI Critical Thinking Posttest | 25 | .133 | .525 |
| SD Critical Thinking Pretest & SD Critical Thinking Posttest | 27 | -.241 | .227 |

Table 11. shows the correlation results of MI Al-Huda critical thinking data on pretest and posttest scores of .133 and a significance value of .525 (greater than 0.05). Then the correlation results of critical thinking data of SD Negeri Nanggulan on pretest and posttest scores are known to have a correlation value of -.241 and a significance value of .227 (greater than 0.05). Therefore, it can be concluded that the critical thinking data of MI Al-Huda and SD Negeri Nanggulan on pretest and posttest scores do not have a significant relationship.

The next hypothesis test is the paired samples t-test test to determine the difference in the means of two paired samples. The results of the paired samples t-test of pretest and posttest data on critical thinking of MI Al-Huda and SD Negeri Nanggulan using SPSS 16.0 can be seen in Table 12.

Table 12. Paired samples T-Test results from critical thinking

| Critical Thinking | Paired Differences | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | Std. Deviation | Std. Error Mean | 95% Confidence Interval of the Difference | | t | df | Sig. (2-tailed) |
| | Mean | | | Lower | Upper | | | |
| Critical Thinking Pretest and Posttest MI | -32.000 | 16.833 | 3.367 | -38.948 | -25.052 | -9.505 | 24 | 000 |
| Critical Thinking Pretest and Posttest SD | -24.074 | 21.350 | .109 | -32.520 | -15.628 | 5.859 | 26 | 000 |

Table 12. shows the results of the paired sample t-test of pretest and posttest data on critical thinking in the MI Al-Huda experimental class have a significant value of 0.000 <0.05, meaning that there is a difference in the critical thinking ability of MI Al-Huda students before and after media use. The results of the paired sample t-test test of pretest and posttest data on critical thinking at SD Negeri Nanggulan show that the significant value is 0.000 <0.05, meaning that there is a real difference before and after being given the media.

Based on Table 12, the t value in the paired sample t-test for critical thinking skills at MI Al-Huda is -9.505, which basically shows that the average posttest score is higher than the average pretest score. However, the negative t value is converted to positive, i.e. 9.505, indicating that there is a significant increase. This result shows that the calculated t value (9.505) is greater than the critical t table value (2.063 with df=24). Similarly, the calculated t value in the paired sample t-test for SD Negeri Nanggulan is -5.859, which after being converted to positive to 5.859, shows a significant increase between the pretest and posttest. The calculated t value (5.859) also exceeds the critical t table value (2.055 with df=26). Overall, these results indicate a significant difference between the average critical thinking before and after the use of IPAS Augmented Reality (AR) learning media on the material of the five senses.

## B. Final product result analysis

The development of IPAS Augmented Reality (AR) learning media for class IV A students of SD Negeri Nanggulan and class IV B teachers of MI Al-Huda Sleman is a progressive step in education, utilising the internet as the main source. This media is designed to be accessible through various devices such as smartphones, laptops, and computers, making it practical and flexible. The use of Augmented Reality (AR) in learning is gaining popularity as it allows students to access materials online as well as offline. With AR, students can utilise technology to learn dynamically, not just limited to printed books. This gives students the flexibility to choose a learning style that suits their individual preferences. Online access to AR learning media can be done through scanning the barcode in Figure 19.



Gambar 18. *Scan barcode* media AR

By scanning the barcode above, students can access learning materials flexibly, anytime and anywhere. The use of Augmented Reality (AR) learning

media allows students to learn independently and explore the material more deeply, whether at home, on the go, or in other environments that are convenient for them. The development of Augmented Reality (AR) learning media can be done easily and updated continuously. This makes education more dynamic and in accordance with the needs of today's digital age. The integration of Augmented Reality (AR) technology in education is a step forward that supports wider access to knowledge and expands students' skills.

IPAS Augmented Reality (AR) learning media has a significant positive impact on students and teachers. Among them, increasing students' critical thinking, saving time and costs in the learning process, and providing easy access through devices such as mobile phones and laptops. Other advantages are interactivity, effectiveness of use, and ease of widespread implementation. However, this media development also has some disadvantages such as sensitivity to changes in viewpoints and requires sufficient memory capacity on the device used

## Conclusion

The results of the research on the development of Science S Augmented Reality (AR) Learning Media to improve critical thinking skills of elementary school students on the material of Living Things and Life Processes show several main findings: First, IPAS Augmented Reality (AR) learning media combines the real and virtual worlds, providing real-time interactive information in 2D and 3D formats. This media is known to be effective, affordable in manufacturing, and easy to operate through barcode scanning for zoom and rotation. However, this media is sensitive to changes in viewing angle and requires sufficient memory capacity on the device used. Second, the implementation of IPAS Augmented Reality (AR) media at SD Negeri Nanggulan and MI Al-Huda Sleman was conducted in five meetings. Students showed high enthusiasm and active involvement in learning, allowing them to explore the concepts directly. Third, testing using paired sample t-test in the two schools showed strong statistical significance with p value <0.05. This indicated a significant difference in students' critical thinking skills before and after using AR IPAS media.

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