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# The effects of augmented reality on students' perceptions, awareness, and attitudes toward sustainability of endangered animals

**Yunus Abidin** [1], Universitas Pendidikan Indonesia, Program Studi Pendidikan Guru Sekolah Dasar Kampus Cibiru, Kota Bandung, Jawa Barat 40154, Indonesia.

**Yusuf Tri Herlambang**, Universitas Pendidikan Indonesia, Program Studi Pendidikan Guru Sekolah Dasar Kampus Cibiru, Kota Bandung, Jawa Barat 40154, Indonesia.

**Dudu Suhandi Saputra**, Universitas Majalengka, Program Studi Pendidikan Guru Sekolah Dasar, Java, Indonesia.

**Sigit Vebrianto Susilo**, Universitas Majalengka, Program Studi Pendidikan Guru Sekolah Dasar, Java, Indonesia.

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**Abstract**

Preserving endangered animals is one effort whose importance should be instilled early. To realize that the education sector is regarded as a crucial sector. This effort can be realized by building and developing elementary students' perceptions, awareness, and attitudes toward endangered animals. This study aimed to enhance the perceptions, awareness, and attitudes of elementary students toward endangered animals in Indonesia by leveraging augmented reality. This study was conducted using a quasi-experimental method with five treatments. This research involved 352 elementary school students in West Java, Indonesia. Three types of questionnaires were used to collect data. The research findings are that the perceptions, awareness, and attitudes of elementary students toward the preservation of endangered species have improved. The most significant improvement is seen in students' perceptions. Therefore, this study concludes that augmented reality is effective in enhancing the perceptions, awareness, and attitudes of elementary students toward the preservation of endangered animals in Indonesia.

***Keywords*:** Attitude; augmented reality; awareness; endangered animal; perception, sustainability.

* ADDRESS FOR CORRESPONDENCE: Yunus Abidin, Universitas Pendidikan Indonesia, Jl. Dr. Setiabudi No.229, Isola, Kec. Sukasari, Kota Bandung, Jawa Barat 40154, Indonesia.
*E-mail address*: yunusabidin@upi.edu

## 1. Introduction

One of the central issues of the 21st century's education sector is environmental degradation (Landler, Burgstaller & Schweiger, 2023). The environment as the most important part of human life is now starting to get polluted and contaminated. Climate change has also exacerbated environmental conditions. Green economy, green value, and green education movements are considered as several alternatives to preserve environmental sustainability. Environmental degradation also has an impact on the extinction of animals and plants on Earth (Mammola, Frigo & Cardoso, 2022). Certain animal species are currently threatened.

The extinction of certain animals happens in Indonesia. Various conservation and preservation efforts are undertaken for these animals, one of which is through education. Education is considered an important domain in the conservation of various endangered animals (Feilen et al., 2018; Liu et al., 2016). Efforts to preserve endangered animals through education are indeed reasonable (Portelli, 2020). In education, various strategies can be implemented to instill understanding in students that endangered animals need to be preserved. One of the measures to take advantage of the education sector to conserve endangered animals is by instilling a love for animals in students from an early age (Bullock, 1994).

Instilling awareness of the preservation of endangered animals through education can be done through various strategies, one of which is developing biologically-charged fairy tales (Ruckert, 2016). Another creative measure is leveraging multimedia technology to foster children's love for fauna (Sembiring et al., 2018; Pearson et al., 2011). Educative and interactive games are also developed as a means to introduce children to animals while they were in school (Damayanti et al., 2020). Through edutainment games, children feel the joy of learning and experience activities of love for flora and fauna (Carmen Juan et al., 2008). In addition to common games, a creative measure for teachers is the development of an animal love campaign game with special naming that appeals to children ( Wulandari & Lenny, 2017).

The introduction of animal conservation through education is also realized in an integrated way through the learning process. This introduction through integration is carried out by implementing STEM learning in a learning process whose content is still oriented toward the preservation of endangered species (Norlizawaty & Nurzatulshima, 2018). The use of endangered animal dolls in children's art performances as a medium for learning science is also an example of integrating endangered animal conservation into the learning process (Hannigan et al., 2022). In high school students, integration is more deeply implemented by tasking students to present various ideas to preserve endangered animals (Dikmenli & Cardak, 2018).

It has been agreed that the conservation of endangered animals is of great importance so that future generations can still witness certain animal species. Efforts to prevent extinction continue to be carried out through the development of perceptions and attitudes toward endangered animals (Sigit, 2019). Developing perceptions and attitudes towards the preservation of endangered animals in the world of education is carried out not only by using simple media but also with various media that utilize technological breakthroughs. One of the technological breakthroughs used to build perceptions and attitudes toward endangered animal conservation is augmented reality (Artdias et al., 2018; Kim et al., 2020). Augmented reality in the context of endangered animal preservation is not only developed in a simple form. It has also been integrated with games to appeal to children (Hidayat et al., 2020; Juan et al., 2011).

The use of such media has been accepted in education processes (Darmawel, 2020). Instilling awareness of conservation through education is considered cheaper in terms of cost (Liu et al., 2016) In addition, this effort is considered a way to divert biotechnology-based conservation efforts towards digital-based conservation (Pizzi et al., 2013). In line with the above description, the researchers adopted

augmented reality in the learning process to enhance students' perceptions, awareness, and attitudes toward the preservation of endangered animals.

### *1.1. Literature Review*

#### *1.1.1.* Augmented Reality

The term augmented reality (AR) is used to describe a combination of technologies that enable the real-time mixing of computer-generated content with live video displays. Traditionally, it is distinguished from virtual reality (VR) in that VR involves creating complete, immersive 3D environments, and AR uses various hardware technologies to create an annotated, or "augmented," composite based on the real world (Mullen, 2011). Augmented Reality (AR) offers us a new way to interact with the physical (or real) world. It creates a modified version of our reality, enriched with digital (or virtual) information, on the screen of your desktop computer or mobile device. Merging and combining the virtual and the real can leverage a new range of user experiences, going beyond what common apps are capable of (Grubert & Grasset, 2013). To put it simply, "augmented reality" is all about using digital content to improve our real world to add better information, understanding, and value to our experiences (Linowes, 2021).

Augmented reality in the world of education, many experts have researched it. Its general acceptance in the learning process has been studied also (Wei et al., 2021). In language learning, augmented reality has been accepted by school teachers (Jamrus & Razali, 2021; Jamrus & Razali, 2019). The use of technology has been proven to improve the foreign language competence of students who use it (Sergeeva et al., 2021). This technology can also be used to improve language skills in young/elementary school-age learners (Tulgar, 2019), and in early childhood education programs (Redondo et al., 2020). In line with that, other studies have shown that technology has been accepted by elementary students and teachers (Abidin et al., 2021) or junior high school students and teachers (Moreno-Guerrero et al., 2021; Pellas et al., 2019; Freitas & Campos, 2008).

In the field of mathematics, augmented reality has been used for teaching polyhedra in the third course of compulsory secondary education in Spain (Fernández-Enríquez & Delgado-Martín, 2020). In geometry, it has been used to improve the mathematical abilities of junior high school students (Mailizar et al., 2020). In general, the advent of augmented reality is well-received in learning mathematics at school whether combined with other platforms (Schutera et al., 2021) or on its own.

In the field of science, augmented reality has also been utilized in various subjects and materials (Moreno-Guerrero et al., 2021). In biology, it has a big impact on improving student learning abilities (Yapici & Karakoyun, 2021; Nuanmeesri, 2018). In physics, it was found that teaching materials based on augmented reality on the topic of electromagnetism physics can be used for teaching and learning at the highest level (Techakosit & Nilsook, 2015).

Augmented reality is proven to be used in other fields of learning such as geography (Rellia, 2022), agronomy (Parras-Burgos et al., 2020), engineering education (dos Anjos et al., 2022), and even for learning students with special needs (Bridges et al., 2020). To put it concisely, as a medium or teaching material augmented reality has been able to improve the quality of learning in the world of education (Anuar Salwa, 2021; Szymczyk & Skulimowski, 2017; Klimova et al., 2018).

#### *1.1.2. Perception, Awareness, and Attitude*

Perception is a field of psychology studies that is very important in the field of education. This is in line with the concept of self-perception which is construed as a complex process involving high-level mechanisms such as interpretation and memory that are involved in brain activity. Perception involves higher functions of the brain in construing an object or event (Goldstein & Cacciamani, 2022). Perception is a sensory, objective representation — paradigmatically by the individual — resulting from the current

stimulus representing the environmental entity in which the person exists (Burge, 2022). Perception is further viewed as a basis for the emergence of one's awareness of an object based on the knowledge one has (Fish, 2021).

Awareness is conceptualized as a relationship between a subject and an object. If the subject is aware of itself, it must regard itself as an object. If the subject is aware of an object, it is not aware of itself as a subject (Zahavi, 2020). In education, consciousness is viewed as a state in which students understand their position on something and will interpret and act on that thing (Borner et al., 2019). Students' awareness of endangered animals can be seen as the condition of students to react to the animals, for example intending to protect, maintain, and so on.

In forming awareness, there are three necessary stages. They are mental readiness, mental conditioning, and mental awareness. In mental readiness, one's awareness is formed from their ability to verify the reality that is happening, determining attitudes towards that reality, forming self-approval, and readiness to take responsibility (Lovette & Spaulding, 2005). Based on this conception, one's awareness is inseparable from their attitude. The existence of endangered animals, people will have awareness of endangered animals if they have an attitude toward these animals.

As one very important element in the formation of awareness, the study of attitudes is an important thing to undertake. Attitude is simply seen as a person's perspective on an object, content and discontent, like and dislike, and whether to act on the object or not (Ajzen, 2005). Attitude is often viewed as the basis for someone to act and behave (Baumeister & Busman, 2014); even though some experts argue that not all behaviors depend on attitudes (Myers, 2013).

Based on the description of the concept, the existence of perceptions, awareness, and attitudes is very intriguing to study. Studies on the three points, individually or collectively, have been undertaken by many researchers. In the field of health, these studies were conducted to determine awareness, attitudes, and perceptions before and after health education for dental nurses because these three are considered important domains for a health worker (Han et al., 2023; Haresaku et al., 2021; Khan et al., 2020; Low & Zailan, 2018). Perceptions, attitudes, and awareness are also important factors in the establishment of green schools (Dasrita et al., 2015). In fact, in education, the researchers felt the need to conduct a dedicated study to compare the three students who are learning activities and students who are learning traditionally (Paños et al., 2020).

During the Covid-19 pandemic, perceptions, awareness, and attitudes are interesting research topics. Researchers believe that online and offline learning affect students' conditions. So that teachers can correctly choose and carry out learning according to the conditions of students, efforts to study the perceptions, attitudes, and awareness of students are carried out by researchers (Al-Dossary et al., 2020) (Maison et al., 2021). Studies on the three are not limited to the education domain but are also carried out in agriculture (Akhtar et al., 2018), economics (Ayob et al., 2016), and social media use (Bhatnagar & Pry, 2020). In line with those studies, this study examined elementary students' perceptions, awareness, and attitudes toward endangered animals.

### *1.2. Purpose of study*

This study aimed to identify the effect of the use of augmented reality on the perceptions, awareness, and attitudes of elementary students toward endangered animals.

## 2. Methods and Materials

### *2.1. Research Design*

In line with the objective, this study was conducted using a quasi-experimental method, The Matching-Only Pretest-Posttest Control Group Design as seen in Figure 1 (Fraenkel et al., 2012).

**Figure 1**

*The Matching-Only Pretest-Posttest Control Group Design*

**The Matching-Only Pretest-Posttest Control Group Design**

| | | | | |
|---|---|---|---|---|
| Treatment group | *M* | *O* | *X* | *O* |
| Control group | *M* | *O* | *C* | *O* |

### *2.2. Participants*

The researchers collaborated with elementary school teacher organizations and education offices to determine the research sample. As a result, 14 elementary schools were selected in the East Priangan area, Bandung City, and Bandung Regency, West Jawa, Indonesia. The number of research subjects was 352 people, consisting of 134 boys and 218 girls. Their average age was estimated to be between 9-12 years. Due to the limitations of the authors, the sampling technique used was random sampling based on the area (cluster random sampling). In this technique, the research subjects were visited according to their place of residence. Working closely with teachers, the researchers designed and conducted the study taking into account the diversity of school locations.

### *2.3. Data collection instrument*

The research data was generated from the pre-test and post-test on students. Before the measurement, the researchers carried out a Focus Group Discussion (FGD) with various parties, such as homeroom teachers and the schools concerned. Initial measurements were carried out under the supervision of the researchers and teachers so that any questions by the students can be addressed. Initial measurements were carried out for three days by the researchers' access to the location of the research subject.

The learning process was completely delegated to the teachers. The teachers before carrying out learning took part in learning workshops organized by the researchers so that they understand the research objectives and master the learning process that has been designed by the researchers. In the final stage, a posttest was carried out by the teachers without the presence of the researchers.

There were three parts to the test for measuring the students. The instrument used in this research has been developed in several stages. In the first stage, the researchers compiled the instrument based on the indicators of the three aspects to be measured. The test drafts and their outlines were then weighed by experts and elementary school teachers to obtain content validity, constructs, and criteria. After that, the instrument was field-tested to measure its empirical validity and reliability. The instrument used in this study has an item validity value of 0.70 and a reliability value of 0.74, thus considered valid and reliable.

### *2.4. Procedure*

This study began with conducting initial measurements using a questionnaire for the students. In the next stage, four learning sessions were provided to the students. For the experiment class students, learning was carried out using the problem-based learning model using augmented reality media of endangered animals. For the control students, learning was conducted using the problem-based learning model without using augmented reality media of endangered animals. In the last stage, measurements

were made using a questionnaire consisting of three research variables namely a) perception; b) awareness; and c) attitudes of the students towards the augmented reality of endangered animals. The respondents were assisted by the researchers and their homeroom teachers to help their understanding in filling out the questionnaire.

Learning in the experimental class and control class was carried out 4 times. In the first session, the teachers presented several cases regarding endangered animals in Indonesia. Students were asked in groups to find several endangered animals in Indonesia. At the end of the session, students compiled a report on endangered animals in Indonesia. During the second session, students were presented with cases about the importance of preserving endangered animals. Students in groups were asked to present their perceptions of endangered animal conservation. At the end of the session, students were tasked with writing essays on the preservation of endangered animals.

The third session began with presenting cases regarding the awareness of citizens of the world of endangered animals. The students watched a video on poaching, endangered species trafficking, and the effect of animal extinction on environmental balance. At the end of the session, students were tasked with writing essays on what should be done regarding endangered animals in Indonesia. During the fourth session, the students were again presented with cases regarding the conservation efforts of endangered animals in Indonesia. They presented in groups their attitudes toward the various types of efforts. At the end of the session, students were tasked with writing simple essays on efforts they can make to preserve endangered animals.

### *2.5. Analyzing Data*

Quantitative data obtained from students' initial and final test results were then analyzed using the SPSS series 20. The data were tested for normality to determine data distribution in a group of data or variables and whether the data were normally distributed. The final step was to test the hypothesis using a two-way ANOVA test. This test aimed to find out whether there was an average difference between the initial test and the final test both in terms of the gender of the students and the use of augmented reality endangered animals. With this analysis, the researchers were able to proceed to the data interpretation process and discussion (Coladarci & Cobb, 2013).

### *2.6. Ethics*

The participants had to respond in the affirmative for a written participation form before they were allowed to proceed with the study. This was to ensure that all participants participated voluntarily. The studies involving human participants were reviewed and approved by Universitas Pendidikan Indonesia. The participants provided their written informed consent to participate in this.

## 3. Results

The study was conducted through several stages. In the first stage, a pretest was conducted on the perceptions, awareness, and attitudes of students toward endangered animals. Afterward, both the experimental and control classes received 4 learning sessions with the main differentiating factor being the use of augmented reality endangered animals. Then, the second posttest was conducted for both groups.

In line with the objective of the study to determine the effect of augmented reality on perceptions, awareness, and attitudes of students towards endangered animals, the data analysis process commenced. Based on the research design used, it was necessary to first believe that the student's initial abilities in both classes are equal. The research data are presented in Table 1 as follows.

**Table 1**

*Descriptive Data of Research Results*

| | N | | | | | |
|---|---|---|---|---|---|---|
| | Valid | Missing | Mean | Median | Mode | Std. Deviation |
| PSPREEKS | 176 | 0 | 27,8580 | 28,0000 | 31,00 | 3,86741 |
| AWPREEKS | 176 | 0 | 28,3182 | 29,0000 | 30,00 | 3,30902 |
| ATPREEKS | 176 | 0 | 28,4034 | 30,0000 | 31,00 | 3,63032 |
| PSPOSEKS | 176 | 0 | 42,2102 | 42,0000 | 41,00 | 3,34598 |
| AWPOSEKS | 176 | 0 | 42,9830 | 43,0000 | 45,00 | 3,17935 |
| ATPOSEKS | 176 | 0 | 43,0341 | 43,0000 | 46,00 | 3,39226 |
| PSPREKON | 176 | 0 | 27,4545 | 28,0000 | 31,00 | 3,93638 |
| AWPREKON | 176 | 0 | 28,1705 | 29,0000 | 31,00 | 3,43502 |
| ATPREKON | 176 | 0 | 28,0057 | 29,0000 | 31,00 | 3,88035 |
| PSPOSKON | 176 | 0 | 39,9602 | 40,0000 | 41,00 | 1,95481 |
| AWPOSKON | 176 | 0 | 38,6648 | 39,0000 | 39,00 | 1,81300 |
| ATPOSKON | 176 | 0 | 39,8409 | 40,0000 | 41,00 | 1,92361 |

Therefore, the results of the pretest from these classes were compared using the t-test with the results as shown in Table 2 below.

**Table 2**

*Pretest Difference Test Results of the Experiment Class and Control Class*

| | | t-test for Equality of Means | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | t | df | Sig. (2-tailed) | Mean Difference | Std. Error Difference | 95% Confidence Interval of the Difference Lower | Upper |
| PSPREAB | Equal variances assumed | ,970 | 350 | ,333 | ,40341 | ,41596 | -,41469 | 1,22150 |
| AWPREAB | Equal variances assumed | ,411 | 350 | ,681 | ,14773 | ,35952 | -,55937 | ,85482 |
| ATPREAB | Equal variances assumed | ,993 | 350 | ,321 | ,39773 | ,40054 | -,39004 | 1,18550 |

The results of the different tests on students' initial competence in the three research variables between the experimental class and the control class resulted in a significance level greater than 0.05. This shows that the perceptions, awareness, and attitudes of the students towards endangered animals are similar (no difference in competence). Testing continued to determine the effect of learning carried out on the final competence of students. Therefore, a paired sample t-test was used with the results as shown in Table 3 as follows.

**Table 3**

*Results of Paired Sample T-Test of Experiment and Control Pretest and Posttest*

| | | Paired Differences | | | | | t | df | Sig. (2-tailed) |
|---|---|---|---|---|---|---|---|---|---|
| | | Mean | Std. Deviation | Std. Error Mean | 95% Confidence Interval of the Difference Lower | Upper | | | |
| Pair 1 | PSPOSEKS - PSPREEKS | 14,68 | 5,54 | ,42 | 13,86 | 15,51 | 35,148 | 175 | ,000 |
| Pair 2 | AWPOSEKS - AWPREEKS | 14,34 | 4,39 | ,33 | 13,69 | 14,99 | 43,386 | 175 | ,000 |
| Pair 3 | ATPOSEKS - ATPREEKS | 14,63 | 5,08 | ,38 | 13,87 | 15,39 | 38,205 | 175 | ,000 |
| Pair 4 | PSPOSKON - PSPREKON | 12,51 | 4,37 | ,33 | 11,86 | 13,16 | 37,965 | 175 | ,000 |
| Pair 5 | AWPOSKON - AWPREKON | 10,49 | 3,83 | ,29 | 9,92 | 11,06 | 36,372 | 175 | ,000 |
| Pair 6 | ATPOSKON - ATPREKON | 11,84 | 4,17 | ,31 | 11,21 | 12,46 | 37,633 | 175 | ,000 |

From Table 3, it can be said that among the three variables tested, there is a difference between the pretest and posttest results in both the experimental and control classes. This means that the learning conducted is shown to be able to significantly enhance students' perceptions, awareness, and attitudes toward endangered animals. The learning affected both the experimental class that applied augmented reality of endangered animals and the control class that did not utilize augmented reality of endangered animals. Based on these results, testing needed to be followed up by comparing the posttests of the two classes accompanied by the moderator variable, gender. The test used was a two-way ANOVA test with the results being presented in Tables 4, 5, and 6 below.

**Table 4**

*Two-Way ANOVA Test Results of Student's Perceptions*

| Source | Type III Sum of Squares | df | Mean Square | F | Sig. |
|---|---|---|---|---|---|
| Corrected Model | 2340,663[a] | 3 | 780,221 | 273,890 | ,000 |
| Intercept | 550930,317 | 1 | 550930,317 | 193399,224 | ,000 |
| Augmented | 394,517 | 1 | 394,517 | 138,492 | ,000 |
| Gender | 1522,862 | 1 | 1522,862 | 534,587 | ,000 |
| Augmented * Gender | 232,244 | 1 | 232,244 | 81,527 | ,000 |
| Error | 991,337 | 348 | 2,849 | | |
| Total | 602282,000 | 352 | | | |
| Corrected Total | 3332,000 | 351 | | | |
| a. R Squared = ,702 (Adjusted R Squared = ,700) | | | | | |

By the test results as shown in Table 4, it can be said that the use of augmented reality of endangered animals affects elementary students' perceptions. Gender also affects students' perceptions. The interaction of the use of augmented reality of endangered animals and gender also has a significant effect on the perceptions of elementary school students. This shows that the use of augmented reality of endangered animals can enhance students' perceptions of endangered animals.

**Table 5**

*Two-Way ANOVA Test Results of Student's Awareness*

| Source | Type III Sum of Squares | df | Mean Square | F | Sig. |
|---|---|---|---|---|---|
| Corrected Model | 2441,995[a] | 3 | 813,998 | 227,628 | ,000 |
| Intercept | 538033,213 | 1 | 538033,213 | 150456,744 | ,000 |
| Augmented | 1181,283 | 1 | 1181,283 | 330,336 | ,000 |
| Gender | 958,792 | 1 | 958,792 | 268,119 | ,000 |
| Augmented * Gender | 75,203 | 1 | 75,203 | 21,030 | ,000 |
| Error | 1244,448 | 348 | 3,576 | | |
| Total | 585762,000 | 352 | | | |
| Corrected Total | 3686,443 | 351 | | | |
| a. R Squared = ,662 (Adjusted R Squared = ,660) | | | | | |

By the test results as shown in Table 5, it can be said that the use of augmented reality of endangered animals affects elementary students' awareness. Gender also affects students' awareness. The interaction of the use of augmented reality of endangered animals and gender also has a significant effect on the awareness of elementary school students. This shows that the use of augmented reality of endangered animals can enhance students' awareness of endangered animals.

**Table 6**

*Two-Way ANOVA Test Results of Student's Awareness*

| Source | Type III Sum of Squares | df | Mean Square | F | Sig. |
|---|---|---|---|---|---|
| Corrected Model | 2586,721[a] | 3 | 862,240 | 308,734 | ,000 |
| Intercept | 555930,270 | 1 | 555930,270 | 199056,337 | ,000 |
| Augmented | 685,553 | 1 | 685,553 | 245,469 | ,000 |
| Gender | 1541,122 | 1 | 1541,122 | 551,814 | ,000 |
| Augmented * Gender | 148,314 | 1 | 148,314 | 53,105 | ,000 |
| Error | 971,904 | 348 | 2,793 | | |
| Total | 607966,000 | 352 | | | |
| Corrected Total | 3558,625 | 351 | | | |

a. R Squared = ,727 (Adjusted R Squared = ,725)

By the test results as shown in Table 6, it can be said that the use of augmented reality of endangered animals affects elementary students' attitudes. Gender also affects students' attitudes. The interaction of the use of augmented reality of endangered animals and gender also has a significant effect on the attitude of elementary school students. This shows that the use of augmented reality of endangered animals can improve students' attitudes toward endangered animals.

## 4. Discussion

This study was motivated by the need to enhance students' perceptions, awareness, and attitudes toward endangered animals. The reason is the fact that animals are more and more endangered. Conservation efforts are of great importance. One way to achieve that is through the field of education by cultivating perceptions, awareness, and attitudes in students toward endangered animals. It is expected that through this effort, the preservation of endangered animals can be achieved.

Efforts to cultivate students' perceptions, awareness and attitudes toward endangered animals are carried out through learning. Attractive learning should also use attractive media. Therefore, this study used augmented reality as the learning medium. Augmented reality coupled with a good learning process is expected to enhance students' perceptions, awareness, and attitudes toward endangered animals.

This study shows that good learning can improve students' perceptions, awareness, and attitudes toward endangered animals. The use of problem-based learning models has been able to improve students' perceptions, awareness, and attitudes toward endangered animals both in the experimental class and the control class. The results of this study, this study corroborates the results of previous studies demonstrating that problem-based learning models can improve student learning outcomes (Dupri et al., 2020; Amalya et al., 2021; Munfaridah et al., 2021).

The effectiveness of the use of augmented reality to improve students' perceptions, awareness, and attitudes toward endangered animals has been demonstrated through the comparison of the post-test competence between the experiment class and the control class. Based on the results of the two-way ANOVA test, there is a significant difference in post-test competence between students of the experiment class and the control class. This shows that augmented reality can improve students' perceptions, awareness, and attitudes toward endangered animals. In line with this, this study corroborates the results of previous studies demonstrating that augmented reality can be utilized to introduce various types of rare animals both land animals and aquatic animals, to other animals with more specific characteristics (Syahputra et al., 2020; Yeztiani et al., 2022; Wulandari et al., 2019).

The success of the use of augmented reality to enhance students' perceptions, awareness, and attitudes toward endangered animals is evident during the learning process, where students become more active. This is possible because incorporating augmented reality during learning boosts students' learning motivation. This condition is in line with previous research which showed that student's motivation to learn mathematics has been shown to increase through the application of augmented reality (Hsieh & Chen, 2019).

Using augmented reality in this study was shown to drive students to better express their thoughts. The ability to think of these students is proof that students are better able to understand the concept of endangered animal conservation compared to other students who do not use augmented reality. Students were enthusiastic to explore the augmented reality used during learning; thus, their understanding is well-developed, consciously or unconsciously. This condition is in line with the results of other studies which prove augmented reality has a positive impact on chemistry learning, where the interactive chemistry augmented reality app can help students understand complex chemical concepts in entertaining and exciting ways (Alam et al., 2020; De Prada Pérez De Azpeitia, 2016).

From a gender point of view, female students, in this case, were more enthusiastic about exploring so naturally, their abilities are better than male students (Erdiana et al., 2019). With more dominant ownership of learning styles and seriousness of learning, female students were able to be more assertive in expressing their opinions and attitudes toward efforts to conserve endangered animals (Hofheinz, 2021). Their awareness also developed quicker to come up with creative efforts to preserve endangered animals. This is driven by the psychological traits of women which are considered to have more transformational qualities to overcome various barriers to gender bias (Silva & Mendis, 2017).

Seeing the improvement between perceptions, awareness, and attitudes, the most significant improvement was observed in attitudes. This more significant improvement in attitudes is reasonable and expected. Enhanced perceptions and awareness experienced by students will contribute simultaneously to students' attitudes (Aronson et al., 2013; Lovette & Spaulding, 2005).

In learning through augmented reality, students do not only use one mode of learning. They learn multimodally so that their competence improves (Shariman et al., 2014). During learning students' attitudes develop, especially when students explore the augmented reality provided, which not only displays virtual images but is also equipped with an audio mode. Therefore, augmented reality is proven to be able to improve learning outcomes in the field of study being studied and can improve students' attitudes (Lham et al., 2020), the ability to collaborate (Khambari, 2018), visualization, and minimize their cognitive burden.

Efforts to further foster perceptions, awareness, and attitudes of students toward endangered animals must continue (Weldemariam, 2020; Underkoffler & Adams, 2021). Technology that can present a stronger virtual image would provide greater benefits. In this case, virtual reality can be used to introduce various rare animal animations and zoos to incite interest and support for the preservation of endangered animals (Fukano et al., 2020). The use of virtual reality is hoped to help familiarization with various endangered animals ( Kim & Bednarz, 2017). This should be taken into account by future researchers who wish to study the preservation of endangered animals.

## 5. Conclusions

Based on the research results and discussion, it can be concluded that using augmented reality in learning that implements problem-based learning models is shown to improve students' perceptions, awareness, and attitudes toward endangered animals. Augmented reality can concretely evoke a pleasant impression and foster high curiosity about learning technology considered relatively new for elementary

school students in Indonesia. Augmented reality also provides opportunities for female students to explore so that their perceptions, awareness, and attitudes toward endangered animals are better developed than their male counterparts.

Based on the research conclusions, it can be recommended that augmented reality can be used in shaping perceptions, cultivating attitudes, and forming behavior for students at school. The application of augmented reality and other forms of reality to improve students' cognitive thinking skills needs further investigation. For future studies, researchers are implored to use better media in generating virtual imagery, such as virtual reality.

**Conflict of Interest**

The authors declare no conflict of interest. The funders had no role in the design of the study; in the collection, analysis, or interpretation of data; in the writing of the manuscript; or in the decision to publish the results.

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