

Development augmented reality assisted teaching modules human sensory system to improve student learning outcomes

I. Iwan ^{a,1,*}, Silvia Hanna Kusuma Sirait ^{a,2}, Nuryanti Rumalolas ^{a,3}

^a Department of Biology Education, Faculty of Teacher Training and Education, Universitas Papua, Jl. Gunung Salju Amban Manokwari, West Papua 98314, Indonesia

¹b.iwan@unipa.ac.id*; ²h.sirait@unipa.ac.id ³n.rumalolas@unipa.ac.id

*Corresponding author

Abstract: In the era of digital transformation, the use of technology to improve the quality of learning is very important. This research aimed to develop a teaching module for human sensory system material assisted by augmented reality media to improve students' biology learning outcomes. This research uses research and development methods. The subjects of this research were 22 Biology Education students at the University of Papua. Data collection instruments include validation sheets and questionnaires to determine the validity and responses of students to teaching modules as well as providing multiple choice questions to measure learning outcomes. The data analysis technique is descriptive by calculating validation results, analyzing student response questionnaires and student learning outcomes. The research results show that media and material expert validation test results obtained a percentage of 93.33% with a very valid category. The results of assessing student responses in the trial obtained an average percentage of 85.13% in the very good category. Student biology learning results show an average of 61.36 in the sufficient category. The conclusion of the research on Augmented Reality-assisted teaching modules meets the criteria of being valid, practical and effective and improving students' biology learning outcomes.

Keywords: augmented reality; human sensory system; learning outcomes; module

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1. Introduction

In the era of ongoing digital transformation, the education sector is faced with demands to utilize technology to improve the quality of learning. One technology that is attracting attention in this context is Augmented Reality. Augmented Reality combines real-world elements with virtual elements, creating an experience that combines digital information with physical reality (Wikanta et al., 2023). AR technology has been used in the world of education for approximately twenty-five years, and of course has many positive impacts and benefits for students (Qiao et al., 2019). The use of Augmented reality in the teaching and learning process, allows students to choose the content to work on, increasing their autonomy to learn and making proper self-evaluations based on this application and increasing their competency capacity when they achieve each goal in learning activities (Maraza-Quispe et al., 2023).

In the learning context, the use of Augmented Reality can open up new opportunities to increase students' understanding of three-dimensional concepts. The development of Augmented Reality in the education sector has changed the conventional classroom environment. This innovative approach provides in-depth visualization of learning content thereby increasing student interest. Digital literacy skills are a need for students in this modern era to filter information accurately as an educational medium. Supporting digital literacy is by using the right applications by applying augmented reality technology (Wikanta et al., 2023). AR technology can also increase motivation and enthusiasm for learning, and encourage students to be involved in learning (Ziden et al., 2022). The development of technology in education and teaching requires teachers to have

skills in creating and using technology as learning media, learning resources or learning supplements. Augmented Reality learning media helps teachers to visualize the structure of the organs that make up the sensory system with three-dimensional objects (Setyo et al., 2023). This development also plays a role in the development of learning media. Learning media is becoming more interesting and more concise, although this does not reduce the essence of the material (Pratama, 2022).

However, the problem so far is that students and teachers only rely on manual learning and still use printed books and worksheets without using learning media. So teachers only use simple tools in teaching and learning activities which makes students bored and less interested in studying the material that has been explained (Annisa et al., 2022). The problem is deficiencies in the visualization of abstract material, because teachers still use 2-dimensional media which is less effective (Sholikha et al., 2024). The operation of Augmented Reality certainly cannot be separated from the hardware and software that supports its components. The combination of AR hardware and software will produce virtual objects that are clearly visible to the user (Caboni & Hagberg, 2019; Popel & Shyshkina, 2018; Riskiono et al., 2020).

Learning media problems are still categorized as manual learning. This is less effective in its application because biology requires special media, such as real media, showing parts of the human body's organs that are easily visible inside and outside the classroom. Therefore, it is necessary to develop a biology teaching module based on augmented reality (Rahma Sari et al., 2023). The increasingly difficult educational challenges and needs in today's modern world require interactive learning (Lintangesukmanjaya et al., 2024). The limitations of teaching modules with learning media that utilize technology result in students' grades being less than optimal. It is necessary to develop teaching modules with learning media that can support learning by utilizing technology, one of which is audio-based learning media (Kumalasari & Fikroh, 2023).

Augmented Reality is a technology that combines virtual objects with real objects. One of the fields that uses AR technology is the education sector, used as a learning aid to make students better understand the material provided (Aprilinda et al., 2020). As supporters of biology learning which previously only used textbook guidelines, we designed an Android-based application to support learning. To attract students' interest, especially those related to human internal organs. Augmented Reality is a technology that inserts 3D images into a real environment in real-time using a camera as an intermediary (Anwar et al., 2023).

Several research results have been reported regarding the use of augmented reality media, including those carried out by Mustaqim et al., (2018) showing that the use of AR media can increase the value of student learning outcomes. In addition, research results (Thahir & Kamaruddin, 2021) show that Augmented Reality-based learning media has an effect on student learning outcomes. The augmented reality module increases students' ability to master concepts. The augmented reality module increases students' ability to master concepts (Permana et al., 2023). Other research by Fitriyaningsih et al., (2023) shows that there is an increase in student learning outcomes through the use of augmented reality media. Augmented Reality (AR) is the latest technology that can be a solution for educators to present learning that is innovative, informative, interesting, and can present virtual objects in virtual 3D in real form and presented in real time, so that it can present abstract concepts more realistically (Aripin & Suryaningsih, 2019).

Sensory Systems material often involves complex concepts that are difficult to explain using conventional teaching methods alone. Students often have difficulty imagining the three-dimensional structure of the organisms being studied. In this case, AR-based teaching materials can be an innovative solution by providing interactive three-dimensional models that allow students to observe and understand the structure of animal development in more depth. Learning sensory system material includes an

understanding of complex human organs. Students often face difficulties in visualizing and understanding the three-dimensional structure of the human sensory system. Lack of clear visual representation can hinder student understanding.

One of the teaching modules that will be developed in this research is a human sensory system teaching module that utilizes augmented reality media. Augmented Reality is an information technology that is used as a learning medium for the Sensory system. Augmented Reality is used in human sensory learning systems because it can display 3-dimensional objects that resemble their original form, so it is hoped that it will become an alternative media for human sensory learning. The aim of this research is to develop a teaching module for sensory system material assisted by augmented reality to improve student biology learning outcomes. Several previous studies related to the use of augmented reality in biology materials have been widely conducted, however for the material, especially the human sensory system in the animal development structure course, it has never been done in the biology education study program at the University of Papua, so this is a very important thing to be applied in lectures. Based on this, it is considered very important to develop a teaching module assisted by augmented reality to improve the biology learning outcomes of biology education students at the University of Papua

This research has contributed to improving the quality of learning, especially in the sub-material of the human sensory system by utilizing digital technology such as the use of augmented reality media which will make it easier for students to observe organs in 3 dimensions.

2. Research Methods

2.1 *Types of research*

This research is a type of research and development that refers to the ADDIE model which consists of five stages, namely Analyze, Design, Development, Implementation, and Evaluation (Branch, 2009). The research stages for developing the ADDIE model include; (1) Analyze. Through analysis of teaching module requirements, information was obtained that the teaching modules used so far are still limited to ordinary modules. The media used is still limited to visual media (images), audio visual (video) and simple 3D media. Never used innovative learning media. Meanwhile, the study of material on the sensory system is in the form of organ structure. This material requires a lot of detailed explanations through pictures to make it easier for students to understand concepts. The use of innovative learning media based on Augmented Reality in the Sensory Systems material is expected to improve students' ability to compare the structure of the sense organs in humans; (2) Design. One of the Goal in the Animal Development Structure is to compare the sense organs in vertebrates with the main material, namely the anatomical composition and structure of the sense organs and comparative anatomy of the sense organs of vertebrates. Face-to-face lectures are carried out with the help of AR-based learning media which presents 3D models of various sense organs in vertebrates which are projected onto the real world. Learning media is designed using the Assemblr application. Assessment of students' cognitive abilities uses formative tests in the form of posttests utilizing AI-based media (Quiziz); (3) Development. After becoming a prototype, the learning media will then be validated by validators, Learning Experts and Media Experts, as well as getting responses from students who have contracted MK, Structure of Animal Development, sub-material, human sensory systems; (4) Implementation. concrete steps to apply the learning media and instruments that have been created. At this stage everything that has been developed will be tested in actual conditions. In the trial stage, learning media was obtained from observing the implementation of the use of learning media; (5) Evaluation. Evaluation will be carried out at the end of each development stage. Furthermore, at the end of the stage a

summative evaluation will be carried out to see the success of developing learning media products.

2.2 Research Subjects and Objects

The subjects of this research were biology education students at the teaching and education faculty, semester 3, whose subject was the structure of animal development. The subjects of this research were biology education students at the teaching and education faculty, semester 3 of the animal development structure course, consisting of 22 students.

2.3 Data Types and Sources

The type of data used in this research is primary data sourced from lecturers and students. secondary data in the form of assessment results from implemented teaching modules.

2.4 Data collection technique

Data collection techniques are carried out using a validation instrument using a 5-point response format on a Likert scale. The answer to each item of the development instrument has a gradation from (1) very bad, (2) not good, (3) quite good (4) good (5) very good (Sugiyono, 2015). The questionnaire instrument was used to determine student responses to AR-based learning media. Instrument The final test (posttest) is used to determine the extent of students' understanding of the subject matter provided, and is carried out by students individually. The test questions used are multiple choice questions.

2.5 Data Analysis Techniques

Analysis of research data is grouped into two, namely validity and practicality. Calculate the validity of learning media using the following Formula 1:

$$\text{Eligibility percentage} = \frac{\text{obtained item score}}{\text{Maximum scorekor}} \times 100\% \tag{1}$$

The Table 1 shows the category of learning device validity based on the final score attained on a scale (0-100).

Table 1. Categories of Learning Media Validity

Interval (%)	Category
81-100	Completely
61-80	Valid
41-60	Less valid
21-40	Invalid
0 – 20	Completely Invalid

Products are tested to see student responses. The module will then be analyzed using student response data. Calculate responses to interactive e-modules using the Formula 2:

$$\% \text{ Eligibility percentage} = \frac{\text{obtained item score}}{\text{Maximum score}} \times 100\% \tag{2}$$

Student response criteria to see the practicality of modules can be seen in Table 2

Table 2. Response Questionnaire Criteria

Interval (%)	Category
81-100	Very Good
61-80	Good
41-60	Good enough
21-40	Not good
0- 20	Not very good

3. Results

3.1 Implementation of the Module teaching Augmented Reality

The results of research on the development of teaching modules assisted by augmented reality can be described as follows: Analyze Stages. For this analysis stage, an AR-based teaching module needs analysis was carried out to identify lecture problems regarding the structure of animal development and find solutions to the problems faced. In the survey, discussions and interviews were conducted with course lecturers. The teaching modules that lecturers use is still limited to ordinary textbooks without being developed by the lecturers themselves according to learning needs. In particular, sensory system material which emphasizes characteristics, properties and functions which require images in 3-dimensional form in learning has never been developed and applied by lecturers before. AR-assisted teaching modules have never been implemented, while currently students need to be prepared to face 21st century learning which emphasizes high-level thinking skills and the use of technology in learning in higher education.

Design Stages. In accordance with the CPMK in the Constitutional Court on the Structure of Animal Development, namely comparing the sense organs in vertebrates with the main material, namely the anatomical structure and structure of the sense organs and comparative anatomy of the sense organs of vertebrates. So, the teaching module was designed with the help of Augmented Reality-based learning media which presents 3D models of various sense organs in vertebrates which are projected into the real world. Learning media is designed using the Assemblr application. Assessment of students' cognitive abilities uses formative tests in the form of posttests utilizing AI-based media (Quiziz).

The Figure 1 and Figure 2 are an example of a design drawing that has been designed.



Figure 1. Augmented Reality Teaching Module



Figure 2. The 3D Ear Anatomy Shape with AR

Development stage. This stage contains activities to realize the product design in terms of AR-assisted Teaching Modules. After becoming a prototype, the AR-assisted Teaching Module on the human sensory system material will be validated by Learning Media experts and material experts on the AR-assisted Teaching Module that has been developed. Validation includes construct validation and content validation as well as readability validation. The following data from validation results by experts is presented in Table 3.

Table 3. Results of Material and Media Expert Assessment

No	Statement	Validator 1	Validator 2	Total
1	Cover, concept map, introduction and instructions for using modules based on Augmented Reality are available	4	4	8
2	Suitability of material in modules based on Augmented Reality with learning indicators	4	5	9
3	The general design of this modules based on Augmented Reality is quite interesting	5	5	10
4	modules based on Augmented Reality material is appropriate to students' level of thinking development	5	5	10
5	The flow and structure of modules based on Augmented Reality arouse students' motivation to read them	5	5	10
6	Visual elements (images, graphs, videos) support students' understanding of protist material	5	5	10
7	Make it easy for students to understand material concepts in modules based on Augmented Reality	5	5	10
8	The explanations in this module based on Augmented Reality are easy for students to understand	5	4	9
9	The language used is appropriate to the student's level of understanding	5	4	9
10	Interactive features (LKPD, QUIZ, assignments, etc. help improve student understanding	4	5	9
11	The modules based on Augmented Reality is an interactive learning resource to support students in learning	4	5	9
12	Practice questions/cases in this module based on Augmented Reality support the material and are in line with the learning objectives	4	5	9
Total				112
Percentage				93.33

Implementation Stage. At this stage, the AR-assisted Teaching Module is implemented on the Sensory System material and instruments that have been created. At this stage everything that has been developed will be tested in actual conditions. Real class trials were obtained through observing the implementation of the Teaching Module assisted by Augmented Reality. Evaluation will be carried out at the end of each Analyze, Design, Development and Implementation stage. Next, at the end of the stage, a summative evaluation will be carried out to see the success of developing AR-Assisted Teaching Module products on the Human Sensory System material. Below are presented the student Respondents' Assessment Results

Evaluation will be carried out at the end of each Analyze, Design, Development and Implementation stage. Next, at the end of the stage, a summative evaluation will be carried out to see the success of developing AR-Assisted Teaching Module products on the Human Sensory System material.

Table 4 and Table 5 are presented the student Respondents' Assessment Results. Based on Table 4, it shows that the student response to the augmented reality assisted teaching module was 85.13 in the very good category. Based on Table 5, it shows that the average student cognitive learning outcome is 61.36, which is in the sufficient category.

Table 4. Respondents' Assessment Results

No	Respondents	Score Percentage (%)	Category
1	ER	64.62	good
2	IMP	100.00	Very good
3	RIAAH	92.31	Very good
4	SR	80.00	Very good
5	Y	89.23	Very good
6	DL	80.00	Very good
7	NFKD	87.69	Very Good
8	MFBRR	70.77	good
9	KTN	93.85	Very good
10	CA	90.77	Very good
11	ST	96.92	Very good
12	AK	78.46	Good
13	DLI	83.08	Very good
14	FGW	89.23	Very good
15	HRS	67.69	good
16	RVR	86.15	Very good
17	WP	86.15	Very good
18	NTS	89.23	Very good
19	EM	69.23	good
20	JR	84.62	Very good
21	YSS	84.62	Very good
22	PK	87.69	Very good
Average Number Percentage		85.13	Very good

Table 5. Results of student learning outcomes

No	Respondents	Learning Outcomes	Category
1	ER	100	Very high
2	IMP	100	Very high
3	RIAAH	100	Very high
4	SR	100	Very high
5	Y	90	Very high
6	DL	100	Very high
7	NFKD	90	Very high
8	MFBRR	70	high
9	KTN	60	Medium
10	CA	60	Medium

No	Respondents	Learning Outcomes	Category
11	ST	50	low
12	AK	60	Medium
13	DLI	50	low
14	FGW	50	low
15	HRS	50	low
16	RVR	40	low
17	WP	40	low
18	NTS	40	low
19	EM	30	low
20	JR	30	low
21	YSS	30	low
22	PK	10	low
Average		61.36	Medium

4. Discussion

4.1 Validity of teaching modules assisted by augmented reality material on human sensory systems

Based on the validation results from media and material experts, the average validation result was 93.33%. This shows that the human sensory system teaching module assisted by augmented reality media is categorized as very feasible/very valid. This is in line with research conducted [Sholikha et al., \(2024\)](#) regarding the Development of Augmented Reality Learning Media showing that this AR product is very feasible with an average overall percentage of 92.73%.

This validity is very important before testing is carried out. Validity is a fundamental aspect that needs to be considered in operations research and development ([Clark & Watson, 2019](#)). The concept of validity is very important in ensuring that a product is capable of producing precise and reliable data ([Barry et al., 2014](#)).

[Widoyoko \(2014\)](#) believes that a product is said to be reliable if it is able to achieve a score in the "valid" category during the validation process. A high validity score indicates high consistency. This shows that the product has met the specified targets ([Souza et al., 2017](#)). The use of Augmented Reality media in this learning provides an innovative and effective solution to increase students' understanding of human sensory system material.

4.2 Practicality of teaching modules assisted by Augmented Reality material on human sensory systems

The practicality of this augmented reality assisted teaching module can be seen from the results of student responses to learning using this teaching module. The results of student responses show an average percentage score of 85.13% in the very practical category. This teaching module really makes it easier and helps students in the learning process. This is in line with what was stated by [Ilona-Elefertyja et al., \(2020\)](#) that the potential benefits surrounding the integration of AR in the learning process are very interesting and represent an opportunity in the future.

The learning process is an activity carried out at an educational institution to help students achieve learning goals. In the learning process, teachers as sources of information need to process various information so that students can receive information correctly and clearly, therefore there is a need for tools in the form of augmented reality learning media ([Fitrianingsih et al., 2023](#)). Research results shows that of the 714 articles, 42 of them explain the importance of applying AR technology in learning. Current developments have increased efforts to apply augmented reality technology in education ([Law & Heintz, 2021](#)). Currently, augmented reality technology is a new technology that is connected to information systems ([Aslan, 2021](#)).

4.3 Effectiveness of Augmented Reality-assisted Teaching Modules in improving student learning outcomes

Analysis of student learning outcomes data shows that the average value of student learning outcomes is 61.36, which is in the moderate or sufficient category. This can happen due to several reasons, including not being used to using augmented reality media, initial understanding of this media is still very limited, even though the average learning outcomes are quite adequate, some students get very high category scores. This shows that there is an increase in student learning outcomes with the use of augmented reality media. Augmented Reality is expected to increase students' understanding, especially of human sensory system material. Augmented Reality is a technology that involves overlaying computer graphics on the real world, where three-dimensional virtual worlds can be brought into the real world environment in real-time and is a technology that can be used as a learning medium (Areni et al., 2018).

Learning outcomes in this research have increased after implementing augmented reality-assisted teaching modules. This is supported by research by Purnamasari et al., (2016) showing that the application of augmented reality media has an effect on student learning achievement. Assemblr EDU media based on Augmented Reality can improve student learning outcomes (Lino Padang et al., 2022). In modern times like today, quite a few schools still have limitations or lack of learning media, so technology is needed to support the learning process to make it more interesting. one of them is augmented reality media. Augmented reality technology makes it possible to combine the virtual world and the real world in real time. By implementing this technology, it is hoped that it will attract students to study (Hadi et al., 2022).

The research results of Aripin and Suryaningsih (2019) show that Biology learning with the AR media developed is quite effective and can increase students' achievement of learning mastery. AR technology in education is a useful tool to make teaching and learning effective (Arulanand et al., 2020). The results of research Suharti et al., (2024) through educational games integrated with augmented reality have an effect on students' critical thinking abilities. Augmented Reality is increasingly popular in the educational process due to its recognized efficacy in the teaching and learning process (Garzón et al., 2020). The media developed can improve students' science learning outcomes in terms of cognitive aspects, affective aspects and psychomotor aspects (Fakhrudin et al., 2019). The application of AR-based media improves learning in Biology classes. AR has a significant influence on learning (Ciloglu & Ustun, 2023; Dehghani et al., 2023).

Based on the findings of this research, AR is useful for student learning outcomes and how this media can be applied in various educational contexts so that it has an impact on the modern learning cycle in education. AR has the ability to add new forms and methods and the ability of Augmented Reality technology will make classes more interactive (Garzón et al., 2020). It is necessary to update learning to be able to provide digital skills to students through the application of technology, one of which is the application of augmented reality (Tamam & Qomaria, 2023). The application of AR encourages students to be interactive, so that it can represent all student learning styles, whether dominant in visual or audio, because it can integrate all aspects of cognition that students need (Kharchenko et al., 2021). New technologies used in Augmented Reality (AR) and their role in the field of education are very important (Sharma et al., 2022).

Therefore, based on the findings in this study, the human sensory system material teaching module assisted by augmented reality was declared feasible for use in learning, and student responses stated that it was very practical to use in learning and could improve student learning outcomes. The implication of this research is that it can help improve the quality of learning and can utilize technology such as augmented reality to make it easier for students to understand learning material.

5. Conclusion

Based on the results of research on the development of teaching modules assisted by augmented reality material on the human sensory system, it can be concluded that this teaching module meets the criteria of being valid, practical and effective for improving learning outcomes for biology education students. This augmented reality assisted teaching module product is very practical to use in biology learning according to the very good response from students. Therefore, it is very important to develop teaching modules assisted by augmented reality in the future in accordance with the development of 21st century biology learning.

Author Contributions

Writing draft articles, analyzing data, : Iwan; collecting data: Silvia Hanna Kusuma Sirat; assisting with reference studies and helping to collect data: Nuryanti Rumarolas.

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Conflicts of Interest

The authors declare that there is no conflict of interest regarding the publication of this paper.

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