Literature Review: The Use of Augmented Reality Learning Media Oriented Towards Science Process Skills to Enhance Student Understanding and Scientific Attitudes Towards Genetics

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Biology Teaching and Learning

p-ISSN 2621 – 5527
e-ISSN 2621 – 5535

Abstract. *Integrating technology in education may vary in many forms. Augmented reality is an technology-oriented learning media that integrating real and virtual world to enhance the realness of an object. Genetics topic has main area in cellular and molecular object, so it is hard to learn because student can not directly observe the topics' object. Learning genetics need an indepth and comprehensive analysis. Learning method that integrating various scientific skills can guide student to learn by analyzing the concept. Scientific Process Skills (SPSs) method make learning become meaningful. This research is using literature review method to study the potential of using augmented reality as learning media to teach genetics topic. The results show that augmented reality as a learning media has a big potential to improve genetics topic teaching and learning while integrating SPSs based learning to improve students' knowledge and scientific attitudes to make the learning process as a whole.*
Keywords: *augmented reality, genetics, science process skills, scientific attitudes.*

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Introduction

The implementation of technology in the field of education can take various forms, and one of the most popular is technology-based learning media. The integration of technology in learning has been proven to have a positive impact on various aspects related to achieving learning outcomes. Various innovative solutions related to the use of technology in learning have been introduced to enhance students' knowledge of specific concepts and to make the learning process more interactive (Dreimane & Linda, 2020). One form of technology-based learning media that is currently being extensively studied for its effectiveness in education is augmented reality (AR). This is evidenced by the numerous studies on AR and its application as a learning medium over the past five years. Augmented reality is a technique that connects digital information with the real world by placing digital content such as images, sounds, and videos onto real-world imagery (Marin et al., 2023). Augmented reality enables an individual to magnify or shrink digital objects while observing them from various perspectives (Kose & Nevin, 2020). The examination of the use of AR in education can be considered from three main aspects: content structure, technological performance, and educational value (Dreimane & Linda, 2020). AR learning media can be applied to visualize concepts with abstract objects and can be integrated with various instructional models (Gnidoves et al., 2020; Marin et al., 2023; Salar et al., 2020; Ciloglu & Ahmet, 2023). One of the learning models that can be applied to the use of AR media is Science Process Skills (SPS) learning. Science process skills are a set of skills that can be used to gather and process information to acquire scientific knowledge (Diciki et al., 2018). Learning oriented towards SPS can support the achievement of learning outcomes, make learning more meaningful, and develop students' scientific skills and attitudes (Mumba et al., 2022; Rizal et al., 2022; Tanti et al., 2020). In addition to

p-ISSN 2621-5527
e-ISSN 2621-5535

helping students understand the material through scientific methods, SPS-based learning can also address other domains of learning achievement, such as psychomotor and affective.

The achievement of learning outcomes by students is not only limited to the aspect of knowledge but encompasses several other aspects. Widowati et al. (2018) state that a scientific attitude is an important aspect to be possessed and developed by students. According to Isnaeni et al. (2021), various models and learning strategies can be applied to develop the scientific attitude of students, especially models that involve scientific or inquiry-based activities. Therefore, scientific-based learning will be highly effective in enhancing the scientific attitude of students. The scientific attitude not only plays a role in assisting students in learning but also contributes to the development of students' personalities.

Subjects with abstract concepts are often considered challenging to learn due to the need for in-depth analysis to comprehend them. One such subject with these characteristics is genetics. The basic concepts of genetics are introduced at various grade levels, varying from country to country. In the United States, basic genetic concepts are introduced at the elementary school level, while in Indonesia, they are introduced at the secondary school level (Kemdikbudristek, 2022; Bapty, 2022). Several studies have examined various teaching strategies for genetics, such as developing teaching materials, using problem-based learning models, and incorporating animations (Mantilla et al., 2023; Peffer et al., 2019; Bapty, 2022). This article explores the potential use of AR media oriented towards Science Process Skills (KPS) to enhance students' understanding and scientific attitudes toward genetic concepts.

Research Method

This study employs a literature review method that analyzes a scientific study in the form of literature, including research articles, to ultimately derive conclusions that form new ideas or concepts. Various articles examined in this study were sourced from international journal publications using relevant keywords such as "augmented reality, science process skills, attitude toward science, and genetics for students." The primary articles analyzed in this study have several inclusion criteria, which can be seen in Table 1

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Table 1. Inclusion Criteria for Articles

No	Aspect	Inclusion
1	Article types	*Research article*
2	Publication year	2018-2023
3	Source of article	National/internasional
4	Journal status	*Scopus index*
5	Article samples	Middle School Students, Higher Education Students, and Educators
6	Including content focus	Biology/Science

Result and Discussion

Result

The articles examined in this study generally cover four main research focuses: the integration of augmented reality in the learning process, Science Process Skills (KPS) learning, scientific attitudes of students, and genetics learning. All the articles used as references in this study are from national and international research sources. The identities and research focuses of the examined articles can be seen in Table 2.

p-ISSN 2621-5527
e-ISSN 2621-5535

Table 2. Reference Articles

Literature Focus	Author/*Scoupus Index*	Country
Integration of Technology and the Use of Augmented Reality in Learning	Gnidoves *et al.* (2020)/Q1	Slovenia
	Salar *et al.* (2020)/Q1	Turki
	Marin *et al*. (2023)/Q1	Spanyol
	Erbas & Veysel (2019)/Q1	Turki
	Dreimane & Linda (2020)/Q1	Latvia
	Ciloglu & Ahmet (2023)/Q1	Turki
	Walan, S. (2020)/Q1	Swedia
	Rahmi *et al* (2019)/Q3	Indonesia
Learning Oriented towards Science Process Skills	Chakraborty & Gillian (2021)/Q1	Banglades
	Rizal *et al.* (2020)/Q3	Indonesia
	Tanti *et al.* (2020)/Q3	Indonesia
	Mumba *et al*. (2022)/Q1	Taiwan
	Dikici *et al.* (2018)/Q1	Turki
	Cakiroglu *et al*. (2020)/Q1	Turki
Scientific Attitude	Isnaeni *et al.* (2021)/Q3	Indonesia
	Toma & Greca (2018)/Q3	Spanyol
	Tai *et al*. (2022)/Q1	Korea
	Sundaravalli & Kokila (2022)/Q4	India
	Sahin & Yilmaz (2020)/Q1	Turki
Genetics Learning	Mantilla *et al*. (2023)/Q3	Filipina
	Peffer *et al.* (2019)/Q1	Amerika Serikat
	Zudaire & Maria (2020)/Q1	Spanyol
	Stromme & Sonja (2020)/Q1	Norwegia
	Bapty (2022)/Q1	Inggris

Discussion

The Use of Augmented Reality in Learning

The use of AR technology in education is commonly applied as a learning medium. AR media can be utilized in the form of applications or web-based platforms (Dreimane et al., 2020). Various research outcomes indicate that the use of augmented reality media can enhance learning outcomes, learning motivation, self-efficacy, and students' positive attitudes towards biology education (Erbas & Veysel, 2019; Ciloglu & Ahmet, 2023; Gnidovec et al., 2020). Furthermore, according to Salar et al. (2020), the use of augmented reality learning media can capture and focus students' attention and emotionally engage them in the learning process, thus making the teaching and learning process more interactive and meaningful. Based on these research findings, the use of AR media in education undoubtedly holds significant prospects with positive implications for achieving learning objectives.

Before an educator decides to use AR media, several considerations must be taken into account. In addition to research demonstrating the positive impact of AR-based learning media, there are also studies highlighting factors that need to be considered in the use of AR learning media. The utilization of AR media involves significant costs, as well as the need for adequate facilities and infrastructure. Furthermore, a teacher must possess technological skills to effectively incorporate AR into the classroom (Rahmi et al., 2019; Erbas & Veysel, 2019). Therefore, the choice of using AR media cannot be made arbitrarily. Additionally, as stated by Dreimane & Linda (2020), if the AR media used is not designed for educational purposes, its effectiveness may be compromised.

Furthermore, Dreimane & Linda (2020) state in their study that there are at least three main aspects that should be considered before choosing AR media. The first aspect is content structure, followed by technological performance, and finally, educational value. Meanwhile,

p-ISSN 2621-5527
e-ISSN 2621-5535

according to Erbas & Veysel (2019), augmented reality should be accessible on various types of devices. There are at least 12 items that can be used as indicators for selecting or developing augmented reality-based learning media. All of these items can be seen in Table 3.

Learning Based on Science Process Skills

Science Process Skills (KPS) are a set of skills that enable an individual to seek and process information through scientific methods. There are two types of KPS: basic KPS, which includes skills such as observation, inference, measurement, communication, classification, and prediction, and integrated KPS, which includes skills like identifying variables, formulating hypotheses, defining variables, designing experiments, and interpreting data (Cakiroglu et al., 2020). Both types of KPS generally consist of 11 different skills. Integrated Science Process Skills involve the combination of more than one basic KPS, forming a unity in their implementation. So far, KPS tends to be positioned as a dependent variable in research (Mumba et al., 2022). This indicates that KPS is crucial, and efforts are made to enhance it in students through various interventions.

Various skills within Science Process Skills (KPS) form the foundation of different learning models that involve scientific methods in their syntax. Learning models such as inquiry learning, problem-based learning, and project-based learning, which incorporate scientific methods in the learning process, essentially depict KPS (Tanti et al., 2020; Rizal et al., 2022). However, not all components of KPS can be facilitated by each learning model. Therefore, according to Mumba et al. (2019), it is necessary to apply a variety of learning models to accommodate all the skills expected to be mastered by students.

Table 3. Criteria for Good Augmented Reality Media

Aspect	Item
Content Structure	Interconnectedness of information
	Sequential presentation of material
	Clarity of instructions
	Content structure
	Additional information in written form
	Additional information in audio form
Technology Performance	Facilitating users with special needs
	Attractive display
	Accuracy of object dimensions
	Displaying objects as realistically as possible
	Quality of graphic display
	User-friendliness
	Application structure
	Application performance
	Availability for various types of devices
Education Value	Able to focus attention
	Challenging for discovering enrichment information
	Gamification elements
	Ability to facilitate group activities
	Knowledge tests

In addition to assisting learners in their studies, mastering science process skills (KPS) also contributes to one's integrity in daily life. For example, it instills traits such as responsibility and an appreciation for scientific values in learning (Cakiroglu et al., 2020). Various factors can influence an individual's KPS profile, such as age and gender (Dikici et al., 2018). Moreover, research conducted by Tanti et al. (2020) indicates that the location of residence also affects students' KPS profiles, with urban students demonstrating better mastery

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e-ISSN 2621-5535

of KPS. Based on these KPS profiles, when connected to the use of augmented reality media, students should at least possess skills in observing and interpreting data.

Scientific Attitude in Learning

Various aspects influence students' academic achievements. One aspect that plays a role in academic achievement is a scientific attitude. This is because a scientific attitude can assist students in learning through its three components: the cognitive component (one's beliefs about an object), the conative component (one's tendency to act), and finally, the affective component (one's feelings about an object) (Tai et al., 2022; Isnaeni et al., 2021). Therefore, a scientific attitude can indicate an individual's inclination to study a subject or topic, especially those of a scientific or scientific nature.

Measuring or assessing students' scientific attitudes is different from assessing their understanding of concepts. Assessing scientific attitudes has its own criteria and guidelines. Tai et al. (2022) conducted a longitudinal study to formulate a rubric for assessing scientific attitudes. In general, there are five main aspects mentioned: perceptions of the teacher, anxiety when learning science, the value of science in society, confidence in learning science, and interest in science. Meanwhile, Sahin & Yilmaz (2020) state that indicators of scientific attitudes can be developed according to the characteristics of the material taught, thus still encompassing the three aspects of cognitive, affective, and conative attitudes.

One of the most crucial learning outcomes is a scientific attitude, which is related to the affective aspect (Sundaravalli & Kokila, 2022). In line with this, Toma & Greca (2018) also state that a scientific attitude is important as it plays a role in the character development of learners. A scientific attitude involves one's inclination to think logically when responding to various situations. Equipping learners with a scientific attitude can contribute to their success in life because, beyond aiding learning, a scientific attitude also promotes personal development..

Genetics Material

Studying biology concepts and materials poses a unique challenge because some biological phenomena are difficult to observe directly. Biological concepts often involve micro-processes, making it challenging to present the objects directly (Peffer et al., 2019; Stromme & Sonja, 2020). One such biological concept with objects that are challenging to observe directly is genetics. According to the Ministry of Education and Culture (Mendikbudristek, 2020), the prevailing Independent Curriculum in Indonesia dictates that the basic genetic material is first introduced or taught at the secondary or junior high school level. Subsequently, the refinement of core genetic materials is taught again at the high school level. Genetics at the high school level is taught in a more structured manner in several stages. It begins with a review of basic materials, such as cell division as the basis for the inheritance of traits, followed by topics on mutations and inheritance patterns that encompass genes.

Genetic material involves objects of study that are challenging to observe directly because their scope extends to the cellular and even molecular levels. Zudaire & Maria (2020) state that, in general, genetics material includes the study of nucleic acids, genes, and chromosomes; replication; gene expression; Mendelian genetics; trait inheritance; and the basics of modern biotechnology related to gene modification. Bapty (2022) compares the sequence of teaching genetics according to experts, and in general, teaching can start by introducing the terms genetics and trait inheritance, then genes and chromosomes, followed by cell division, inheritance patterns, regulation of gene expression, and influencing factors, as well as population genetics and human genetics.

The use of instructional media that allows students to feel close to the subject of genetics will undoubtedly have a positive impact. This is especially relevant to students' perceptions of the subject matter they are studying. In response to the challenges of teaching genetics, Mantilla et al. (2023) suggest that teachers often use images as instructional media. Integrating

p-ISSN 2621-5527
e-ISSN 2621-5535

technology as an instructional medium for genetic material can undoubtedly enhance the quality of learning. Moreover, based on the characteristics of genetic material, learning such content will be more accessible through the use of instructional media that can depict the micro-bioprocesses that are the subject of genetic material.

Conclusion

Augmented reality-based instructional media has high potential and is suitable for implementation in learning with abstract and challenging-to-observe subjects such as genetics. The ability of AR media to display three-dimensional objects makes it easier for students to gain a deeper understanding of the subject. Learning genetics requires in-depth analysis and can be facilitated by incorporating scientific-themed learning activities. Teaching methods that integrate scientific steps or methods in the learning process fall under Science Process Skills (KPS) learning. KPS learning makes the learning process more meaningful as students actively construct their knowledge through scientific methods. Students who master KPS indicators are inclined to think and act while considering scientific values. Thus, the implementation of KPS learning can have a positive impact on students' scientific attitudes, which are part of the affective domain.

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p-ISSN 2621-5527
e-ISSN 2621-5535

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