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The urgency of developing augmented reality-based biology learning media on genetic substance material

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ABSTRACT

The implementation of biology learning in the field encounters numerous challenges. Specifically on genetic substance material, students experience learning difficulties due to abstract, interdisciplinary concepts and difficulties in understanding textbooks. This problem can be overcome one way by using learning media. Under current learning demands, technology-based media is appropriate to use. Augmented Reality (AR) based media is one option. The accessibility of augmented reality-based media remains limited, especially for genetic substance material, despite the necessity for media capable of visualizing its complex and abstract characteristics. The results of the needs analysis for teachers and students also show that AR-based media is needed in genetic substance learning. The use of AR media is very possible because of the support of adequate infrastructure. Teachers and students also expressed their willingness to use AR media in learning. Based on the research results, it can be concluded that AR-based biology learning media on Genetic Substance material is urgent to be developed. This media will be able to enrich the variety of biology learning media and become one of the solutions to overcome problems in biology learning, especially genetic substance material.

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INTRODUCTION

The practical application of biology learning still experiences numerous challenges. Students often perceive biology as a challenging subject due to its extensive scope and numerous complex concepts that need to be understood (Awidi & Paynter, 2018; Erbas & Demirer, 2019; Mulyanto et al., 2018), concepts are abstract and interrelated (Chrzanowski et al., 2018). One of the

materials discussed in Biology learning is Genetic Substance. In this material, students also experience learning difficulties.

The reasons given by students regarding the difficulties in learning genetic substance material were due to abstract, interdisciplinary concepts and difficulties in understanding textbooks (Çimer, 2012). Concepts that are considered difficult by students in genetic substance material are the differences between DNA and RNA, transcription and translation stages, and the genetic code (Suhermiati, 2015; Wulandari et al., 2020). Research (Hala et al., 2018) shows that as many as 47.62% of students do not understand the concept and 26.67% of students experience misconceptions about genetic substance material.

Problems in biology learning, especially in genetic material, certainly need to be resolved. One solution that can be implemented is the use of learning media. Learning media is a means or message channel that contains sources of information in learning material that can be conveyed to data recipients (Munasti & Suryadi, 2022). Utilizing educational media can help maintain students' engagement during learning activities, catering to diverse learning styles (Ritakumari, 2019)

In response to modern learning requirements, technology integration has become essential, leading to the adoption of technology-based educational media. Augmented reality (AR) stands out as a promising medium for learning applications. AR technology seamlessly merges virtual 3D objects into real-world environments in real time (Azuma, 1997). Utilizing AR technology offers students the opportunity to visualize intricate scientific phenomena typically imperceptible to the naked eye, such as chemical reactions and biological processes within the human body (Klopfer & Squire, 2008). AR-based learning media also holds the advantage of enhancing students' cognitive, affective, and psychomotor skills, facilitating deeper comprehension of abstract and complex concepts. (Mantasia & Jaya, 2016), provides more realistic interactions, and can increase student interest and motivation (Irfansyah, 2017; Kamelia, 2015). Learning enriched with innovative technology can explain abstract and complex genetic substance concepts, such as the structure of genetic material and the process of gene expression (Rini et al., 2022). In order, to explain this abstractness and complexity, teachers can use AR as a technology-based learning medium.

Based on the description above, it is necessary to examine the urgency of developing AR-based biology learning media on Genetic Substance Material. This media will later become one of the solutions to overcome problems in biology learning, especially genetic substance material.

RESEARCH METHODS

Research Design

This research is a qualitative descriptive research using literature review and survey techniques. Qualitative research data is collected through interviews to collect visual, virtual, or digital data. Data were analyzed by coding and interpreting conversations, narratives, and discourse analysis (Flick, 2022). Qualitative descriptive research aims to objectively elucidate the subjects and objects under study, systematically describing typical occurrences and factual observations (Zellatifanny & Mudjiyanto, 2018). Qualitative research has two main objectives, the first is to describe and explore and the second objective is to describe and explain (Siyoto & Sodik, 2015).

Population and Samples

The subjects involved in this research were biology teachers and students of Al-Azhar Islamic High School 22 Cikarang. The number of respondents involved was 37 people. Determination of samples using sampling techniques based on objectives. In qualitative research, sampling is very appropriate if it is based on the research objectives or problems, and uses the researchers' considerations, in order, to obtain the accuracy and adequacy of the information needed by the objectives or problems being studied (Patton, 1990) Samples based on this concept can range from n = 1 to n = 40 or more (MacMillan & Schumacher, 2001).

Instruments

The instrument used to collect data was a biology teacher interview guide. The aspects asked during the interview are outlined in the instrument grid in Table 1.

Table 1. Teacher needs analysis interview guide framework

No.	Indicator	Question	Item	Amount
1.	Curriculum	Curriculum used	1	1
		Biology KKM value	2	1
2.	Biology learning characteristics	Student's difficulties in understanding genetic substance material	3, 4	2
		Indicators of competency achievement that students must achieve in the material	5	1
3.	Learning Activities	Learning methods used	6, 7	2
		Learning obstacles	8	1
4.	Learning media needs	Learning media used	9, 10	2
		Required learning media	11	1
5.	Views on augmented reality-based learning media on genetic substance material	Use of technology in learning	12	1
		Teachers' opinions on augmented reality-based learning media on genetic substance material	13, 14	2
		Willingness to use augmented reality-based learning media on genetic substance material	15	1
Total				15

The next instrument is a student needs analysis questionnaire distributed via Google Forms. The aspects responded to by students are contained in the instrument grid in Table 2.

Table 2. Student needs analysis instrument grid

No.	Indicator	Question	Item	Amount
1.	Views on genetic substance material	Difficulty in understanding genetic substance material	1, 2	2
		Alternatives overcome the difficulty of understanding genetic substance material	3	1
2.	Views on learning media	Learning media used	4, 5, 6	3
		Required learning media	7	1
3.	Views on augmented reality-based learning media on genetic substance material	Students' opinions regarding augmented reality-based learning media on genetic substance material	8, 9, 10, 11, 12	5
		Willingness to use augmented reality-based learning media on genetic substance material	13	1
Total				13

Procedures

The research began with a literature review related to the development of AR-based media in biology learning. AR media is also studied in learning genetic material. To explore more specifically the importance of developing and utilizing AR-based media on genetic substance material, interviews were conducted with biology teachers. To find out students' responses and needs, a needs analysis of students was also conducted by distributing a needs analysis questionnaire.

Data Analysis

The data obtained during the research was analyzed using descriptive statistics. The data analysis steps follow data analysis techniques (Miles & Huberman, 1994). Data from the research literature is presented in descriptive form. The results of interviews with teachers are described based on the aspects asked. Student needs analysis data is also presented in narrative form. The presentation of analysis data is equipped with graphs and charts.

RESULTS

Literature Review Results

The results of a review of articles conducted (Saputra et al., 2023) found that the research topics that were least conducted were learning media in the form of applications, artificial intelligence, Augmented Reality, and virtual environments. Based on searches using Publish or Perish (Google Scholar and Scopus) spanning the years 2017-2023, only a few articles were found that discussed AR-based learning media on genetic substance material. The first article is about research into the development of AR application marker methods using DNA transcription material. When the object is displayed, the DNA transcription process and the components involved in this process are visible, such as DNA helicase and gyrase (Diki et al., 2022). Next, researchers (Nuraini et al., 2019) developed an AR application for the marker method using DNA structure material.

Research on the use of AR-based media in teaching biology and other material includes research (Haryanto et al., 2017) on the application of augmented reality as a learning medium for cell division material. The implementation of augmented reality in Biology Subjects for the introduction of human sensory organs using the marker method was researched by (Lestari et al., 2018).

The impact of using AR-based media in biology learning has also been stated in several studies. The effect of applying AR in biology learning on academic achievement and motivation was researched by (Demircioglu et al., 2022; Kul & Berber, 2022; Omurtak et al., 2022).

There are quite a lot of articles related to the development and use of augmented reality-based media in other subjects. For example, in learning physics, chemistry, and mathematics. In chemistry learning (Abdinejad et al., 2021) developed a simple and cost-effective markerless AR tool for teaching chemistry. Research conducted (Qingtang et al., 2022) in chemistry learning regarding the effects of using AR on increasing knowledge, learning motivation, and students' perceptions of technology. The effectiveness of using the Augmented Reality Module in Geometry Learning on mathematics achievement among elementary school students was researched by (Yusra et al., 2023)

In social learning, several articles were also found that discussed the use of AR. The impact of using AR in microeconomics courses was researched by (Ali et al., 2023). Development of Augmented Reality-Based Educational Media for Interior and Exterior Design (Wahyudi et al., 2017).

Needs Analysis Results

. Based on an interview with one of the high school biology teachers, it was revealed that students found the genetic substance material challenging due to the extensive memorization required for numerous terms. Additionally, factors such as a tendency to guess answers, lack of thoroughness, and reluctance to seek clarification even when concepts were not fully understood were identified among the students. The teaching methods employed by teachers include lectures and group presentations, supplemented with PowerPoint presentations, learning videos, and direct explanations on the blackboard. While teachers believe these methods and media should enhance learning effectiveness, they find the current media less engaging, and there are persistent factors among students hindering effective learning. The teacher advocates for innovative, engaging

learning media with superior visualization compared to current teaching materials. Additionally, the teacher expresses enthusiasm for the adoption of AR-based learning media, especially for genetic substance material, believing it would greatly enhance the learning experience.

The results of the needs analysis for students revealed that 78.38% of students considered genetic substance material to be difficult material. Concepts that are considered difficult by students are the concept of the protein synthesis process (62.16%), the concept of RNA (40.54%), and genetic material (43.24%). An illustration of the percentage of students who experience difficulties with each concept can be seen in Figure 1.

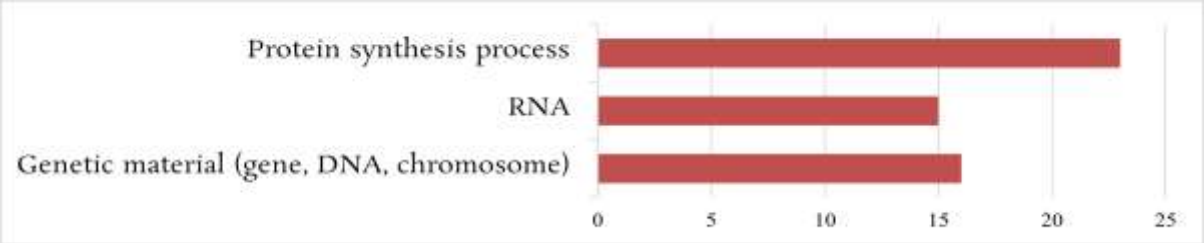

Figure 1. Difficult concepts in genetic substance material

Throughout their learning experience, students have utilized various media, including smartphones, tablets, laptops, posters, teaching aids, and PPT. A comparative description of the use of these media can be seen in Figure 2.

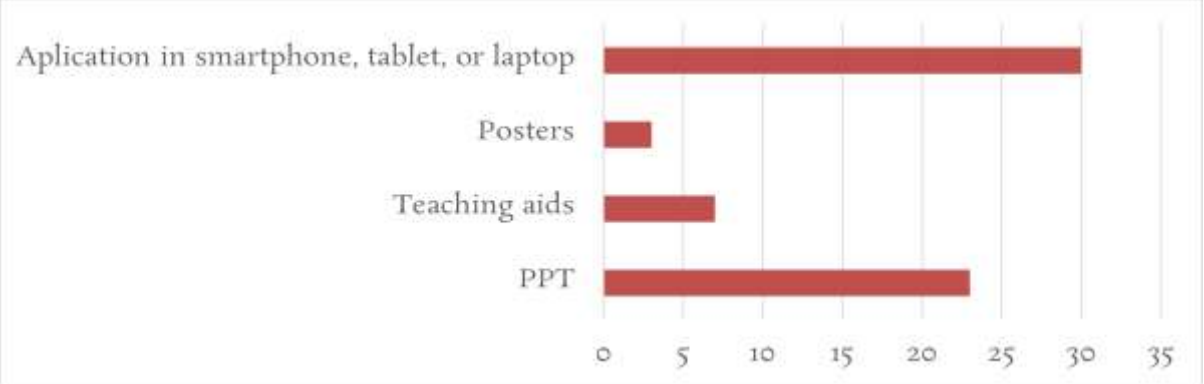

Figure 2. Media commonly used in biology learning

Based on Figure 2, it can be seen that the use of smartphones is quite high, followed by the use of PPT media. When queried about their preferred learning media, the responses from students can be seen in Figure 3.

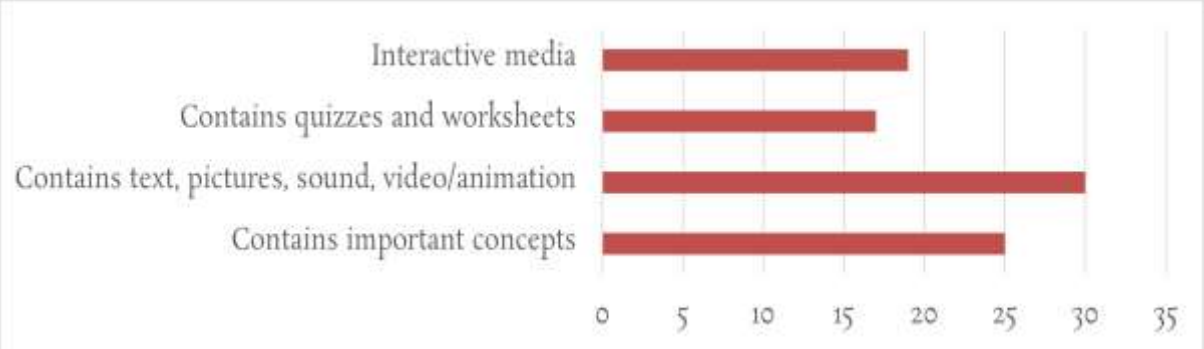

Figure 3. Media needed by students

Based on Figure 3, it can be seen that the media most needed by students is media that contains text, images, audio, and video/animation. Regarding AR technology, 53% of surveyed students demonstrated prior awareness, with 52.63% of those respondents having utilized it. Additionally, when questioned about their receptiveness to augmented reality-based learning media for genetic substance material, 59.46% expressed willingness to incorporate this technology into their learning.

DISCUSSION

Based on the results of the article search, it turns out that there is a limited number of augmented reality-based media currently in development focusing on genetic substance material. While numerous studies exist on the development and impact of augmented reality (AR) media in physics, chemistry, and mathematics learning, comparatively fewer studies are available in biology learning, particularly regarding genetic substance material. This gap presents an opportunity for the development of AR-based media tailored to genetic substance material. Given the abstract nature of genetic substance concepts, visual support becomes imperative. The inherent characteristics of AR, facilitating the visualization of abstract concepts, can significantly aid students in understanding genetic substance material. AR applications transform abstract concepts into tangible entities, thereby fostering deeper comprehension and enhancing the overall learning experience (Omurtak et al., 2022). The use of AR is very informative and interesting (Rizki & Riau, 2019)

The development of augmented reality-based media holds immense potential in meeting the current demands of learning. Learning and technology must complement each other (Leshchenko et al., 2021). Employing AR technology can facilitate students in constructing concept maps and support their conceptual understanding (Çakıroğlu et al., 2022). AR technology can improve students' cognitive and affective skills and increase their ability to understand abstract and complex things (Mantasia & Jaya, 2016). AR technology can improve students' cognitive and affective skills and increase their ability to understand abstract and complex things (Schmidthaler et al., 2021)

The importance of developing this media is also supported by the results of the needs analysis that has been conducted. Needs analysis reveals problems, needs, and development potential (Qamariah & Nurhadi, 2021). The need for this media was expressed by the teacher. According to the teacher, interesting media is needed. Learning media designed and created by teachers will inspire students, fostering enthusiasm and encouraging attentive engagement with the lesson material (Akrim, 2018). Media also makes learning more effective and increases student motivation (Sabbah et al., 2023; Simanjuntak et al., 2021). The use of AR media can improve learning outcomes and student learning completeness (Rejekiningsih et al., 2023)

During the interview, the teacher expressed a desire for innovative and engaging learning media with enhanced visualization, which could be achieved through AR-based technology. The unique capabilities of AR media enable the visualization of structures in three dimensions, fulfilling this expectation (Abdinejad et al., 2021). The use of AR-based media in science learning has a positive impact on understanding concepts (Ropawandi et al., 2022) and achieving learning outcomes(Jdaitawi et al., 2022). AR-based technology enables open access to materials and improves the organization of modern library media spaces (Horban et al., 2023).

Specifically for learning genetic substance material, the results of the needs analysis show that students think genetic substance material is difficult material. This difficulty is due to the abstract and interdisciplinary characteristics of genetic material (Çimer, 2012). Concepts that students consider difficult are the concept of the protein synthesis process (62.16%), the concept of RNA (40.54%), and genetic material (43.24%). These results are in line with research (Fitriana et al., 2022) which concluded that students had difficulty learning genetic material (chromosomes, genes,

DNA, and RNA) as well as foreign concepts and terms contained in the process of cell division and inheritance.

The development of AR-based media certainly requires supporting facilities for its application in the field. The results of the needs analysis show that the facilities available at school support the application of this media in learning. Facility support determines the smoothness of the learning process. Apart from supporting facilities, the willingness and readiness of teachers and students to use AR-based media are also needed (Arthur-nyarko, 2020; Bernacki et al., 2019). The results of the needs analysis found that teachers expressed their willingness to use AR-based media and expressed a great need for this media.

The device support that students have is also very adequate for using technology-based media. The devices that most students own, such as smartphones, have great potential for developing innovative technology-based learning media (Rejekiningsih et al., 2023).

Integrating technology in current learning conditions is a necessity. Teachers need to integrate technology into their learning design. The integration of this technology is aimed at improving the quality of the learning process and achieving learning outcomes. AR technology is a form of technology that teachers can integrate into learning.

CONCLUSION

Augmented Reality-based biology learning media on Genetic Substance Material is very urgent to be developed based on the trend of using AR-based media in the world of education and the positive benefits of this media on learning processes and outcomes. In biology learning, especially genetic substance material, the availability of AR-based media remains limited, highlighting the significance of addressing this gap. Teachers and students also expressed their need for technology-based media, especially AR-based media. Explanation of abstract and complicated material can be facilitated through the utilization of AR-based media. Based on these reasons, AR-based media on genetic substance material is urgent to be developed. The development of AR-based media will be able to enrich the learning media used for biology learning, especially genetic substance material.

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