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Analysis of the Needs for the Development of Interactive Multimedia Based on Augmented Reality in Physics Learning

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ABSTRACT

Purpose of the Study: This study investigates the initial needs of teachers for the development of interactive multimedia based on Augmented Reality (AR) for physics education, specifically in the context of kinetic gas theory. As part of development research at the preliminary study stage, the goal is to design innovative teaching tools that simplify complex physics concepts and enhance student engagement.

Methodology: A survey-based research design was adopted, with data collected via questionnaires distributed to middle and high school physics teachers using the Google Form platform. The study examined teacher perspectives on AR-based learning media's necessity, usability, and potential impact in their classrooms.

Main Findings: The results revealed a strong demand among physics teachers for AR-based interactive multimedia, highlighting its potential to address the challenges of teaching physics concepts often perceived as abstract and complex by students. Teachers emphasized the need for tools that make the learning process more engaging, interactive, and relatable. The findings also indicated that AR-based multimedia offers a promising solution, aligning with the growing integration of digital technology in education. Teachers noted that AR tools could increase efficiency, foster active learning, and cater to diverse learning styles, making physics more accessible and enjoyable.

Novelty/Originality of the Study: This study contributes to the growing field of digital education by emphasizing the application of AR technology in physics learning. It provides a novel perspective on how AR can bridge the gap between theoretical physics and practical understanding, fostering curiosity and deeper comprehension.

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1. INTRODUCTION

Education is a lifelong process that empowers individuals to enhance their quality of life, enabling them to adapt, compete, and thrive in a rapidly changing world [1]. In Indonesia, education continues to evolve, as evidenced by the ongoing development and refinement of the national curriculum to meet the demands of the times. One significant milestone in this progression is the introduction of the Independent Curriculum, which prioritizes the independence of students as learners [2]. This curriculum aims to equip students with essential 21st-century skills, such as critical reasoning, which is prominently featured in the Pancasila Student Profile [3].

Critical reasoning skills are fundamental for navigating the complexities of modern life [4]–[6]. Students equipped with strong critical reasoning abilities can analyze problems logically, evaluate situations

effectively, and draw sound conclusions [6], [7]. These skills are essential not only for academic success but also for personal and professional development. However, evidence indicates that students' critical reasoning skills, particularly in physics, remain inadequate [5], [8]–[10]. One primary reason for this deficiency is the persistent use of teacher-centered instructional methods in physics classrooms. These methods often fail to engage students actively, limiting their ability to explore concepts independently and fostering a dependency on rote learning [5]. Consequently, students struggle to develop critical reasoning skills and exhibit low levels of learning independence.

Physics, as a branch of science, is often perceived as one of the most challenging subjects for students [9]. Its abstract concepts and mathematical rigor can deter student interest, especially when taught in a monotonous, teacher-centered manner [10]. Such an approach emphasizes short-term memorization over deep, long-term understanding, which is critical for developing critical reasoning skills [12]. Despite numerous innovations in education, their implementation in classroom practice remains limited. Many teachers continue to rely on traditional lecture methods and underutilize teaching materials and media, further exacerbating students' disengagement from physics [11]. To address these challenges, physics instruction needs to incorporate innovative, engaging, and interactive learning media that facilitate a deeper understanding of concepts. Augmented Reality (AR) is emerging as a promising tool in this regard [14], [15]. AR can create immersive learning experiences by presenting three-dimensional visuals and interactive simulations that make abstract physics concepts more tangible and relatable [16].

Several studies have demonstrated the effectiveness of AR in enhancing physics learning. For example, AR-based modules have been developed for topics such as basic physics [17], electricity [18], and circular motion [19], [20]. These studies report significant improvements in students' motivation, conceptual understanding, learning outcomes, practical skills, and critical reasoning abilities. AR's ability to combine interactivity with realistic simulations makes it particularly suitable for physics education, where students often struggle to visualize and comprehend abstract phenomena.

Despite the promising potential of AR, gaps remain in its widespread application and evaluation within the Indonesian educational context. Previous studies have largely focused on specific topics or limited classroom settings, leaving questions about its scalability, integration with the Independent Curriculum, and long-term impact on critical reasoning skills unanswered. Moreover, while AR has shown promise in enhancing learning motivation and outcomes, its direct influence on fostering critical reasoning skills requires further exploration.

This study aims to fill these gaps by investigating the effectiveness of AR in improving critical reasoning skills in physics education. Specifically, it will examine how AR-based media can address the limitations of traditional teaching methods, enhance students' engagement with abstract concepts, and align with the goals of the Independent Curriculum.

2. RESEARCH METHOD

This study employed a survey research design to identify the needs of physics teachers for interactive multimedia utilizing augmented reality (AR) in physics education. The research represents the preliminary stage of a broader development study aimed at creating AR-based interactive multimedia specifically for teaching the kinetic theory of gases. The ultimate goal of this development is to enhance students' understanding of physics concepts and provide an engaging, enjoyable, and effective learning resource. The participants in this study were junior high and high school physics teachers from various provinces across the country, including both state and private school teachers. A total of 59 physics teachers participated in this study. These participants were selected to represent diverse educational settings and provide comprehensive input on the needs and preferences for AR-based interactive multimedia in physics education.

The primary data collection instrument used in this study was a structured questionnaire. The questionnaire was designed to gather detailed information about the specific needs and expectations of physics teachers for interactive multimedia. It explored aspects such as the challenges faced in teaching physics, the perceived benefits of AR-based tools, and the desired features and functionalities of the proposed multimedia. The questionnaire was distributed digitally via the Google Forms platform, ensuring accessibility for teachers across different regions. The use of an online platform facilitated efficient data collection and enabled the participation of teachers from geographically diverse areas.

The data collection process focused on identifying the needs of physics teachers for interactive AR-based multimedia. Teachers provided their input on how such tools could address common learning challenges, enhance conceptual understanding, and increase student engagement in physics lessons. The responses were analyzed to gain insights into the key requirements for the development of effective AR-based educational tools. The data obtained from the questionnaire were analyzed quantitatively and qualitatively. Quantitative analysis involved summarizing teachers' responses using descriptive statistics to identify common trends and priorities. Qualitative analysis focused on open-ended responses to capture nuanced insights and specific suggestions from

teachers. The results of this analysis provided a foundational understanding of the requirements for developing AR-based interactive multimedia tailored to physics education.

The needs analysis conducted in this preliminary study highlights the demand for AR-based interactive multimedia in teaching the kinetic theory of gases. The findings emphasize the importance of developing tools that are user-friendly, visually engaging, and capable of simplifying complex physics concepts. By addressing the identified needs, the subsequent stages of the development process aim to create an innovative learning resource that enhances both teaching and learning experiences in physics education.

3. RESULTS AND DICUSSION

Analysis of the need for developing interactive multimedia based on augmented reality aims to collect as much information as possible regarding the problems in the physics learning process and their causes[21]. The results of the needs analysis that have been obtained will be used as a basis for determining alternative solutions in developing interactive multimedia based on augmented reality in physics learning. The results of the needs analysis questionnaire conducted on teachers.

3.1. Use of interactive multimedia in the learning process

The results of the study related to the use of interactive multimedia in the learning process that has been carried out. Table 1 shows that of the 59 teachers involved, 72.9% of teachers have used interactive multimedia in the physics learning process at school, and the remaining 27.1% of teachers have not used interactive multimedia in class. These results indicate that there are still many teachers who have not used interactive multimedia in the physics learning process. The demands of today's era require teachers to be literate in technology and information [22].

Table 1. Use of interactive multimedia

Information	Frequency	%
Yes	43	72.9
No	16	27.1

The existence of interactive multimedia is very helpful in the physics learning process [23]. The role of interactive multimedia in the learning process can connect the knowledge possessed by the teacher with the concepts to be learned by the students, thus making it possible to facilitate the learning of abstract physics material.[24]. Several types of interactive multimedia are often used by the educational community. Table 2 shows the results of multimedia data that are often used by teachers in the physics learning process at school.

Table 2. Multimedia used by students

Interactive Multimedia	Frequency	N	%
Quizizz	10	59	16.95
Gform	45		76.27
Live Sheet	5		8.47
Animated video	15		25.42
Virtual lab	10		16.95
PPT	40		67.80
e-modul	20		33.90
Canva	20		33.90

The results in the table show that the interactive multimedia most widely used by teachers in the physics learning process are gform, e-module, and PPT, more than 20 teachers choose these interactive multimedia with PPT and Google Form as the media most used by teachers. This is because many teachers do not know other types of interactive multimedia and are not yet able to use them. This information is supported by the opinion of 93.9% of physics teachers who need ready-to-use interactive multimedia. So that it helps them in the physics learning process. The results of the analysis of the needs of the teachers showed that the majority of teachers think that the types of multimedia that must and are appropriate to be used in physics learning include multimedia that can be accessed using laptops or smartphones, there are audiovisuals, interactive videos, in 3D such as using augmented reality, and can be accessed anywhere and anytime. In addition, physics teachers also think that interactive multimedia that can give a real impression to students is easy to understand and interesting to increase student motivation in physics learning. Representative comments include:

A1 "interactive multimedia that can be accessed by laptops and Android, because nowadays there are many digital practicals/virtual labs"

A2 "There are audiovisuals, interactive videos, or media that can give a real impression"

A6 "Yes, it can also be like interactive multimedia based on Augmented Reality"

A22 "multimedia that displays real examples can be in 2D or 3D so that students can imagine what they are learning"

A29 "In the physics learning process, the appropriate media is audiovisual & technology that combines real-time with digital content created by computers such as Augmented Reality is also appropriate"

However, the skills, abilities, and experience of teachers in developing interactive multimedia independently are still very lacking. The results of the needs analysis in Table 3 show that more than 50% of teachers have never created interactive multimedia in physics learning. This is supported by the results of observations which show that the majority of teachers only use interactive multimedia that is available on the Internet without adjusting it to the development stage of students. This phenomenon is a major reflection in Indonesian education, especially related to the skills of teachers in developing interactive multimedia that can be used in the learning process to help students understand physics material. The existence of interactive multimedia is very large in the learning process, such as being able to arouse students' interest in learning to stimulate their desire to learn, encourage students' curiosity, and be able to improve time and place limitations [25].

3.2. The need for interactive multimedia based on augmented reality

Proper citation of other works should be made to avoid plagiarism. When referring to a reference item, please use the reference number as in [3] or [4] for multiple references. The use of "Ref [5]..." should be employed for any reference citation at the beginning of sentence. For any reference with more than 3 or more authors, only the first author is to be written followed by et al. (e.g. in [6]). Examples of reference items of different categories shown in the References section. Each item in the references section should be typed using 8 pt font size [7]–[8].

The use of interactive multimedia is very necessary in the learning process. Augmented reality is one of the interactive multimedia that can be applied. Augmented Reality (AR) is a technology that can facilitate student interaction with the material being studied. Through the application of augmented reality, the learning process will be more fun, interactive, and easy to use [26]. However, even with the advantages offered, the facts in the field show that the majority of teachers do not know about AR. The data is presented in Table 3.

Table 3. Physics teachers' responses to interactive multimedia based on Augmented Reality in physics learning

Statement	Response	%
Getting to Know Augmented Reality	Yes	84.8
	No	15.2
Experience using Augmented Reality	Yes	21.2
	No	78.8
Knowing the Role of Using Augmented Reality in Physics Learning	Yes	60.6
	No	39.4

The data in the table above shows that more than 80% of physics teachers are aware of the existence of augmented reality as a learning medium, and also know its role in the physics learning process. However, as many as 78.8% of physics teachers have never had experience in implementing augmented reality in the learning process. Then the results of the study in Table 4 below show that as many as 97% of physics teachers agree that they need learning media in the form of interactive multimedia based on augmented reality in the physics learning process in schools. This means that the development of interactive multimedia based on augmented reality is a priority to be developed immediately so that it can help teachers in delivering physics material to students.

Table 4. Teacher responses regarding the importance of AR interactive multimedia in physics learning

Category	%
Important	97%
Very important	3 %

The results of the needs analysis are also supported by teacher responses regarding the reasons why interactive multimedia must be developed in problem-based learning. augmented reality. The majority of teachers believe that the application of interactive multimedia can provide a more meaningful understanding for students, hopefully, it can attract students' interest in learning so that students' learning outcomes will be much

better than before. In addition, teachers also believe that the application of augmented reality is very supportive in the physics learning process, especially in abstract materials that are difficult for students to imagine directly. This is supported by the results of research that has been conducted [27]. Here are the relevant teacher responses:

A1 "I agree, this is a learning innovation given by teachers to students, the better and newer the media used, the more it attracts students' interest in learning using the media, so that the final results of the student learning process will be achieved."

A3 "Very supportive in helping to explain abstract and micro-content"

A14 "So that students can understand the learning material with real-world application examples directly, where the images of how it works can be displayed directly via computer media."

A19 "Because much of the physics material is abstract, AR will help teachers explain the material and also make it easier for students to understand the material."

The development of augmented reality in the learning process in schools certainly requires adequate technological and information support. Based on the results of the needs analysis that has been carried out, it was obtained that the majority of students in high school are allowed to bring smartphones when they are in the school environment. The application of Augmented Reality technology is used as a stepping stone. This is because this technology can function as a good message delivery related to teaching materials to students. Augmented Reality in the learning process can help students to actively find physics concepts so that an independent learning environment can be formed [28]. This is supported by research that has been conducted by Herliandry et al; Ismail; Rahmawati et al; and Vari, by applying augmented reality in physics learning, especially in the material of heat transfer, harmonic vibrations, circular motion, and magnetism [28]-[31].

The application of AR in the learning process can also increase student motivation. Socrates et al, Students who are motivated to learn will follow the learning process well. This will certainly have an impact on the smoothness and achievement of learning objectives [32]. Rahmawati et al, in his article stated that students' learning motivation increased through the use of AR-based learning applications as learning media that greatly support the learning process [30]. In addition, the application of AR-based multimedia can optimize student learning outcomes. This is in line with the results of research conducted by Dewi & Kuswanto, in the form of developing an AR-based pocketbook in the material of circular motion [20]. The results show that the teaching materials developed can improve the learning outcomes of students with a high category. The book can visualize the shapes of the planets in 3D visuals that can be seen by students. So that students understand the material better by seeing the details of the shape of the planet so that the material can enter their long-term memory.

Apart from that, the application of AR can also improve students' skills, especially critical thinking skills [31], [33]. The use of media using AR can stimulate critical thinking patterns towards problems and events in everyday life. From the media used, it is expected that students will try to criticize existing problems and have imaginative power and activeness in participating in learning. Based on the results of the study, it was obtained that AR media can train critical thinking skills effectively in cognitive skills in the form of interpretation, analysis, evaluation, conclusion, and explaining. In addition, AR media can also increase students' imaginative power [32]. The results of this study indicate the need to develop interactive multimedia based on augmented reality to improve students' critical thinking skills in the material of gas kinetic theory.

4. CONCLUSION

The findings of this study highlight the critical need for interactive multimedia based on Augmented Reality (AR) as a tool to enhance the learning process, particularly in physics education. AR-based multimedia provides an engaging and immersive experience, helping students better understand complex physics concepts while increasing their interest and enthusiasm for the subject. This innovative approach transforms physics into an enjoyable and interactive subject, countering perceptions of boredom and difficulty. Furthermore, AR's dynamic and technologically advanced features align with the demands of the digital age, making it a highly relevant resource for modern classrooms.

The implications of this study emphasize the potential of AR-based interactive multimedia to revolutionize physics education by improving students' critical reasoning skills and deepening their conceptual understanding. Teachers can leverage AR as an effective medium to create a more stimulating and student-centered learning environment. Beyond physics, this approach can be adapted to other STEM subjects, expanding its impact on education. Future research should focus on the development and testing of AR-based multimedia tailored to different educational levels and topics in physics. Additionally, studies could explore the long-term effects of AR on student learning outcomes, engagement, and retention. Integrating AR-based tools into teacher training programs can further ensure successful implementation and maximize their potential. By fostering critical reasoning and technological literacy, AR-based interactive multimedia can play a pivotal role in preparing students for the challenges of the 21st century.

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