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FEASIBILITY AND PRACTICALITY ANALYSIS OF AUGMENTED REALITY (AR) AS A SCIENCE LEARNING MEDIA IN ELEMENTARY SCHOOLS**Muttakin^a, Ucia Mahya Dewi^{a*}, Arlin Maya Sari^b**^a Chemistry Education Department, Malikussaleh University, Aceh Utara, Indonesia, 24355^b Physics Education Department, Malikussaleh University, Aceh Utara, Indonesia, 24355**Abstract**

Information and communication technology should be integrated into the learning process to enhance the quality of education. One of the technologies that can be utilized is Augmented Reality (AR). AR media can help students learn complex concepts through interactive 3D visualizations of science topics. In the study, a science learning media based on mobile Augmented Reality (AR) technology was developed using the 4-D model (Define, Design, Develop, Disseminate). This study aimed to validate the feasibility and practicality of mobile augmented reality (AR) based science learning media. Lecturers, teachers, and students tested the feasibility and practicality of the media. The media validation test conducted by two lecturers resulted in a score of 92.26%, while the subject matter validation test by lecturers and students yielded a score of 97.84%. The developed AR media was also classified as highly practical, with the teacher and student questionnaires scoring 91.07% and 88.33%, respectively. The validity assessments of this AR media indicate that both the media and the subject matter fall into the "Highly Feasible" and "Highly Practical" categories for use as science learning media in elementary schools. The student's response to using this media in learning is very good. Students are enthusiastic about participating in learning and enhancing their curiosity.

Keywords: Meta-analysis, Guided Inquiry Learning, Learning Outcomes, Chemistry

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(CC BY-NC-SA 4.0)**INTRODUCTION**

The development of educational technology has brought convenience, particularly in the learning process. Educational technology facilitates a shift in the orientation of learning from one party's mere presentation of knowledge to a more interactive process of guiding students in exploring knowledge [1]. The learning process integrated with information and communication technology should be implemented to enhance the quality of education, both in terms of students' learning outcomes and educators' ability to conduct the learning process, to prepare the 21st-century generation [2]. However, in reality, the learning process often underutilizes technology, especially in using technology in learning resources [3].

Natural Science, or science education, is a branch of knowledge that studies the natural world's potential based on experiments and observations conducted by humans, systematically organized [4]. In science education, it is essential to master knowledge in the form of facts, concepts, principles, and aspects of discovery. Therefore, in the learning process, students are expected to study and understand themselves and their environment so that they can apply this knowledge in their lives.

One thing that needs to be prepared in the learning process is instructional media [5]. Instructional media can facilitate the delivery of materials by visualizing abstract concepts into more concrete forms, thus enhancing students' understanding [6]. Furthermore, engaging, interactive, and innovative

instructional media can boost students' learning enthusiasm [7] and simplify science learning for teachers and students [8].

Currently, teachers face the challenge of preparing instructional media that can visualize abstract subject matter in the science learning process. Augmented reality (AR) is a technology that can address this issue. AR-based instructional media is a digital-based instructional media that integrates virtual objects in two or three dimensions into the real environment, which is then projected in real-time [9]. AR-based instructional media can display images, text, audio, video, and 3D visuals [10]. It can increase students' level of understanding and provide an exciting learning experience regarding the material being studied using technology-based learning media [11].

Augmented Reality is an application that merges the real world with the virtual world in the form of two-dimensional or three-dimensional images projected into a real environment simultaneously [12]. This relatively new technology has limited use in Indonesia, particularly in the North Aceh district. One of the reasons for this is the limited knowledge among teachers about this technology. Utilizing mobile Augmented Reality (AR) as an alternative learning medium can enhance students' enthusiasm in learning [13].

The use of Augmented Reality (AR) mobile media can help teachers in the learning process [14] because almost everyone uses Android-based smartphones,

which are considered easy to operate and also provide new experiences for students in learning using mobile AR [15].

Learning media using mobile Augmented Reality is considered practical and interesting because it is able to realize the virtual world into the real world. This technology can change abstract objects in 3D form so that students get a clear and more realistic visualization of the subject matter presented [16].

Based on the problems above, researchers developed new innovations in science learning by utilizing sophisticated technology, namely the Augmented Reality (AR) system that can be accessed via Android. This learning media is validated in terms of the feasibility of the subject matter and media as well as the practicality of using the media that has been developed.

METHOD

This research is a Research and Development (R&D) study that aims to develop a product. The resulting product is a science learning media using Augmented Reality (AR) mobile technology. This learning media was developed using a 4-D model (Define, Design, Develop, Disseminate).

- Define stage: A literature study analysis is carried out to collect information related to product development and needs analysis by formulating a general description of learning media that is adjusted to student characteristics and to determine the right subject matter for AR media as Android-based science learning.
- Design stage: The design is carried out, and the selected subject matter is then arranged to become the application content that will be developed.
- In the Development stage, the media that has been created is validated by subject matter experts and media experts to determine its feasibility, and a practicality test is carried out to determine its practicality.
- In the dissemination stage, augmented reality (AR) mobile technology learning media will be distributed to teachers at elementary schools in North Aceh District.

The media expert validation stage includes media, technical, and display quality. Validation by learning design experts includes aspects of media content quality and display quality. Meanwhile, material experts validate the elements of material, learning, and language use.

Media feasibility is assessed by using AR media design, image and illustration layout, presentation and language, ease of use, and user benefits. The feasibility of the subject matter is assessed from the aspects of content, presentation and communication aspects, and aspects for learning strategies. Each aspect consists of

several points assessed by the validator with the lowest score of 1 meaning "Very Unsuitable" and the highest score of 4 meaning "Very Suitable".

The percentage of validity and practicality can be calculated using the formula:

$$\text{Results} = \frac{\text{total score obtained}}{\text{maximum score}} \times 100\%$$

Feasibility categories are based on the following criteria :

Table 1. Media feasibility Criteria

Score range (%)	Feasibility Criteria
81 - 100	Highly feasible
61 - 80	Feasible
41 - 60	Quite Feasible
21 - 40	Not feasible
< 21	Very not feasible

Practicality categories are based on the following criteria:

Table 2. Media Practicality Criteria

Score range (%)	Practicality criteria
81 - 100	Highly practical
61 - 80	Practical
41 - 60	Quite practical
21 - 40	Impractical
< 21%	Extremely impractical

RESULTS AND DISCUSSION

The results obtained from the research conducted by the researcher produced Augmented Reality-Based Science Learning Media on Photosynthesis subject matter. A learning media that is created will be said to be valid and practical if used as a learning resource for students. The researcher tested the development of learning media that experts created. The testing of learning media that was carried out involved subject matter test experts and media expert tests, which teachers and students also carried out.

In the results of the define stage, the subject matter that meets the needs of students and teachers is the photosynthesis subject. The AR media that was developed can describe the abstract concept of photosynthesis so that it is easy for students to understand. In the design stage, the researcher mapped the subject matter to be developed by determining core competencies, basic competencies, and learning indicators to be developed in augmented reality-based learning media.

At the development stage, Augmented Reality-based learning media on photosynthesis subject matter began to be developed in accordance with the design that had been determined at the previous design stage.

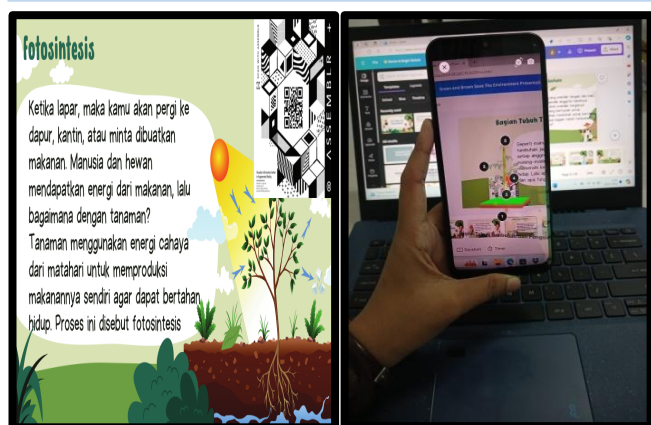


Figure 1. Visual representation of mobile AR interface used for science media

Subsequently, the media and subject matters that have been developed are tested for validity through a validation questionnaire filled out by two validators, media experts and subject matter experts. In addition, teachers and students carry out practical tests. The validation results by media and subject matter experts are described below.

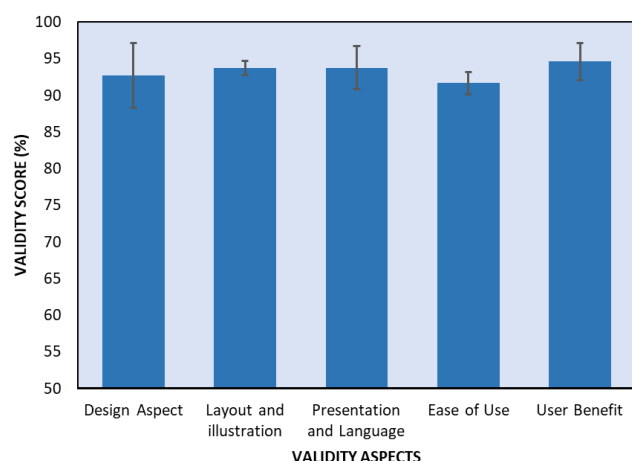


Figure 2. Validity Score of The Developed Media

The graph showcases the validity scores for five key aspects of a material or tool: *Design Aspect*, *Layout and Illustration*, *Presentation and Language*, *Ease of Use*, and *User Benefit*. All aspects received high scores exceeding 90%, indicating that the material is well-developed and effective across multiple dimensions. The *Design Aspect* scored slightly above 90%, reflecting its visual appeal and functional structure, with a small error bar indicating consistent agreement among evaluators. *Layout and Illustration* performed marginally better, highlighting the clarity and attractiveness of the content arrangement and visual elements, which users strongly appreciated. *Presentation and Language* matched the score of *Layout and Illustration*, suggesting that the material's linguistic clarity and presentation style were deemed highly appropriate, with minimal variability in responses, showcasing consensus on its quality. The

Ease of Use aspect, though slightly lower than the others, still scored above 90%, demonstrating that the material is largely user-friendly, though the somewhat wider error bar suggests some variation in experiences, possibly hinting at minor usability challenges for certain users. Finally, *User Benefit* achieved the highest score, nearing 95%, emphasizing the material's perceived effectiveness and value in fulfilling its intended purpose. The narrow error bar here reinforces strong agreement among evaluators regarding the material's ability to deliver substantial benefits to its users. The graph indicates that the material excels across all assessed aspects, with particularly strong perceptions of its value and quality. The consistently narrow error bars underscore the reliability of these findings, though the slight variability in *Ease of Use* suggests potential areas for further improvement. This analysis underscores the material's strengths in design, clarity, usability, and impact, confirming its readiness for effective implementation and highlighting opportunities to refine user accessibility. The calculations of subject matter experts by lecturers and teachers can be seen in Figure 3.

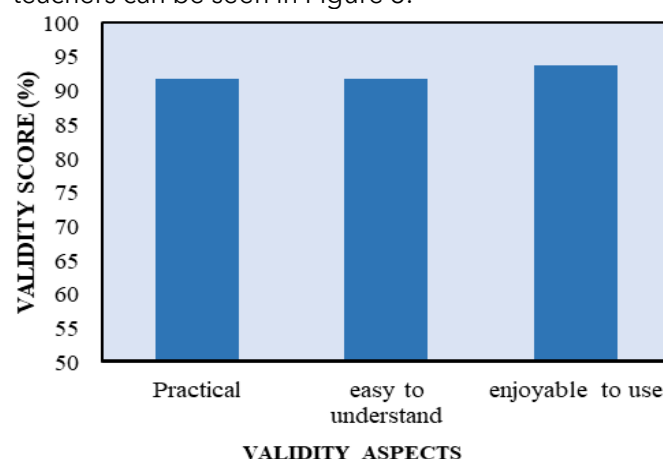


Figure 3. Subject matter validity score

The subject matter validity test results showed that every aspect assessed from the subject matter validation was included in the "Very Feasible" category, as was the overall validity, valued at 97.84%. The subject matter validity test results, with an overall validity of 97.84% and a classification in the "Very Feasible" category, are crucial for ensuring the effectiveness and reliability of instructional materials. This exceptionally high validity indicates that the content aligns well with the intended learning objectives, ensuring it covers the necessary concepts, skills, and knowledge to meet educational goals. Such alignment is vital because it guarantees that students engage with relevant material that directly supports their learning progress.

Additionally, a high validity score reflects rigorous evaluation by subject matter experts and bolsters the material's credibility and trustworthiness among educators, students, and stakeholders. When

educators are confident in the quality and accuracy of the subject matter, they are more likely to adopt it in their teaching practices, knowing it reduces the risk of errors or the need for supplementary explanations. This trust is particularly important in fields like science or chemistry, where precise and clear communication of complex concepts is necessary to avoid misconceptions. Furthermore, validated materials ensure that learners are exposed to content that is not only accurate but also pedagogically sound, enhancing their engagement, understanding, and retention of information. High validity also implies that the material is structured to effectively address diverse learner needs and promote meaningful learning experiences, maximizing outcomes and helping students build a strong conceptual foundation. In the case of innovative educational tools, such as those incorporating Augmented Reality (AR), the high validity of the subject matter is even more critical, as the success of these tools depends on the accuracy and pedagogical soundness of the content they deliver. Thus, a near-perfect validity score signifies that the instructional material is ready for implementation and capable of fostering an effective and engaging learning environment.

Practicality Test

The questionnaire/response questionnaire sheet given to educators and students of SDN 16 Dewantara after using learning media in the teaching and learning process aims to determine the practicality of Augmented Reality (AR) learning media.

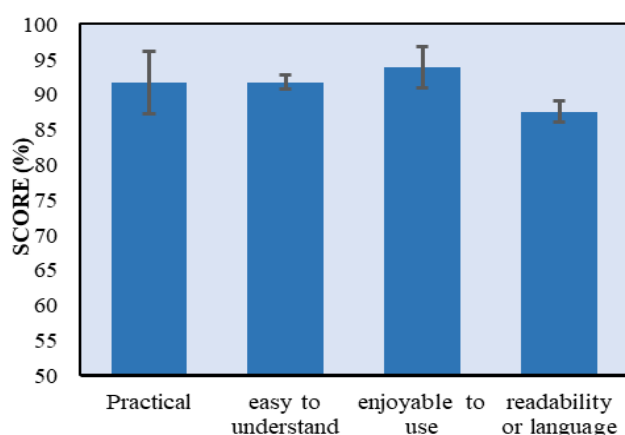


Figure 4. Practicality Questionnaire Data Results by Teachers

The graph shows high evaluation scores across four aspects: *Practicality*, *Ease of Understanding*, *Enjoyability to Use*, and *Readability or Language*. *Practicality* scored the highest, slightly over 90%, with minimal variability, indicating strong agreement on its usefulness. *Ease of Understanding* and *Enjoyability to Use* followed closely, highlighting the material's clarity and engaging nature, though *Enjoyability* showed slightly more variation in responses. *Readability or*

Language had the lowest score, just below 90%, with the largest error bar, suggesting some variability in opinions, possibly due to differing user expectations or language proficiencies. Overall, the material performed exceptionally well in all aspects, with room for minor improvements in language accessibility.

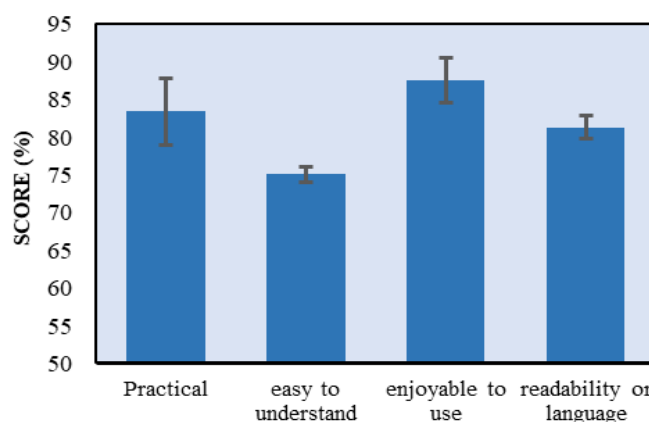


Figure 5. Practicality Questionnaire Data Results by Students

The results of the practicality questionnaire by students regarding the learning media developed by the researcher obtained a percentage result of 81.77%. The percentage result is included in the criteria for the level of practicality of learning media, namely very practical. From the results of the feasibility and practicality tests carried out, the main material presented in the Augmented Reality (AR) media has content, presentation, and use of learning strategies that are categorized as "Very Feasible" and "Very Practical" for use in science learning in Elementary Schools. Students can well receive this learning media application, and it is suitable for use as a learning medium to support the learning process, both in class and independent learning.



Figure 6. Field test of AR app practicality

In addition to being an application, the product developed is accompanied by a material book. This application is easy to install on smartphones and use by teachers and students because a practical guidebook accompanies it. This is in line with Musliadi's research [17], Augmented Reality (AR)-based media on the primary material of the circulatory system has met the criteria of valid, practical, and effective; in addition, Khan's research [18], the learning process using AR media can increase learning motivation. Previous research indicates that the application of Augmented Reality technology in learning can help improve students' understanding of the material and increase their motivation to learn, thus improving students' learning achievement [19]. Other research also states that using Augmented Reality learning media can visualize abstract concepts for students [20].

One of the main challenges in implementing AR media in the classroom is the limited technology and costs incurred. AR technology requires special devices that are sometimes expensive, and not all educational institutions can afford them. In addition, to run AR smoothly, a stable and fast internet connection is also needed, which is only sometimes available in all areas. AR media does not depict the environment as a whole. The overall environmental design is less supportive in the implementation of AR-based systems. Users do not see any combination of virtual objects with the real world. Users will certainly feel that the entire environment generated virtually feels more real than just objects positioned in the real world.

CONCLUSION

The guided inquiry learning model uses a syntax that engages students directly in concept discovery, so it can improve student learning outcomes, especially in chemistry, where most of the material is abstract. The results of a review of six articles that meet the specified criteria show an average effect size value of 1.40, which is classified as high. Thus, it can be concluded that applying the guided inquiry learning model can improve students' chemistry learning outcomes. Therefore, this learning model can be used as an effective learning model in chemistry learning. Further research is expected to analyze the effect of the guided inquiry learning model on students' science process skills (KPS), critical thinking, and learning motivation. Thus, the effectiveness of using the guided inquiry learning model on the overall learning process can be known.

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