# THE EFFECT OF USING AUGMENTED REALITY INTEGRATED INTERACTIVE DIGITAL MATERIALS ON STUDENTS' PERCEPTION

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## Abstract

Interaction between learners and learning content is a fundamental and essential component in every learning process, and this is especially true in online learning modes. Interactive digital learning materials have been provided to UT students since 2019. The Interactive Digital Learning Materials Application (ABADI) is one of the learning services. Students have not maximally utilized the ABADI application. With current technological advancements, the development of interactive learning materials with various learning activities is becoming increasingly popular in online learning environments. The use of multimedia in digital learning materials and Augmented Reality (AR) has a more significant impact and a very large effect on the learning process. This study aims to integrate Augmented Reality into the ABADI application to enrich multimedia and learning content interaction. The findings of this study illustrate a noticeable change in students' perceptions when augmented reality (AR) and integrated interactive digital materials are used in educational settings. Significant increases in engagement, motivation, and understanding were observed, indicating that these innovative tools not only enhance the learning experience but also foster a deeper understanding of complex concepts. As educators reflect on the future of pedagogical practices, it is important to consider the incorporation of AR and interactive elements into the curriculum. Such integration can accommodate diverse learning styles, promote collaborative learning environments, and better prepare students for the demands of a technology-driven world.

Keywords: Augmented Reality, Integrated Digital Materials, Perception.

## 1     INTRODUCTION

The Open University (UT), as an open and distance university (PTTJJ), has a great responsibility in providing educational services to its students. The student learning process is one of the important components that determines the success of a PTTJJ. This learning process cannot be separated from the readiness of the institution to provide good teaching materials. The process of developing a BA in a PTTJJ needs to consider whether, during the learning process using the BA, students are always motivated to continue learning, and whether communication between the material developer and students has been built through the Subject Matter Book or known as modules.

With today's technological advances, the development of interactive learning material with various learning activities is becoming more popular in the online learning's environment. UT's interactive digital teaching materials highlight the latest developments in modern learning approaches. As a leading educational institution in Indonesia, UT has introduced interactive digital teaching materials as an innovative solution to improve the quality of distance learning. This approach demonstrates UT's response to the demand for more engaging and participatory learning. Utilizing interactive technology, UT's digital teaching materials are designed to stimulate student engagement through various multimedia elements, simulations, and participatory activities. UT has tried to develop course materials designed to enhance learner interaction and content. One of the development projects carried out in this study is to convert print-based learning materials into interactive digital materials called the Interactive Teaching Materials Application (ABADI). The ABADI application is also designed for offline use, with a minimum of one audio and/or video media per module. In addition, the features of ABADI include taking notes, highlighting, watching videos, and searching for keywords on search engines such as Google and Wikipedia. Interactive Teaching Materials are designed by combining various media and learning activities such as images, illustrations, audio, videos, links, quotes, and in-text activities.

ABADI's learning design is a follow-up research from Dewi Padmo (2022), where the research uses Interactive Digital Materials (IDM), which is integrated into online tutorials, while ABADI now runs on its platform, such as a collection of digital books (e-library). Based on the study of Dewi Padmo (2022) her research explores the interaction between learners and learning content delivered through IDM, The interaction between learners and learning content is the main and fundamental component in every learning process, In terms of online learner content interaction, it not only supports passive interaction between learners and content, but also allows new opportunities to use interactive content that can respond to student behavior (Anderson, 2008). Kearsley, as cited in Zimmerman (2012), explained that learners develop understanding of instructional materials through direct interaction with the content, which occurs during activities such as reading, highlighting, and engaging in self-assessment.

The findings confirm that poor internet connections resulting in unsmooth access to content will prevent learners from having a pleasant experience in reading IDM and thus an overall less enjoyable learning experience (Padmo, 2022). The low use of interactive teaching

materials in ABADI found in this study confirms the importance of learner interface interaction stated by Mutalib et al. (2016). In addition, although the reading duration has increased, the provision of tablet-based ABADI that can be read offline has not significantly improved student interaction and content as optimally as expected at first. The duration of time spent reading material may have increased and potentially improved the quality of learner interaction and content; however, the fact is that not all learners can survive and complete the reading until the end of the material (Padmo, 2022).

The advent of augmented reality (AR) and integrated interactive digital materials has transformed educational landscapes, creating new avenues for engaging students in the learning process. This innovative technology offers immersive experiences that captivate students' attention, enabling them to interact with content in ways that traditional learning environments cannot match. By layering digital information over real-world contexts, AR can enhance understanding and retention, fostering a more profound connection between students and the material. Furthermore, the incorporation of interactive digital resources encourages collaboration and creativity, empowering students to take ownership of their learning. As educational institutions increasingly adopt these technologies, it becomes imperative to explore their effects on students' perceptions. This essay will delve into how AR and interactive materials reshape students' engagement, motivation, and learning outcomes, ultimately influencing their overall educational experience in the modern classroom.

Using Augmented Reality (AR) technology, many environments can be offered to the learner to experience a life-like experience. The AR-based learning environment not only provides students with a new learning environment but also gives students the opportunity to interact with the material (Cai et al., 2021). It can be an opportunity to increase the academic success of students who have difficulty in practice-based lessons. The fact that it is easy to access mobile technologies has brought more attention to AR applications today (Güngör and Kurt, 2014). There are many AR definitions in which the concepts of being interactive, synchronous, vivid, and unique to the environment are common (Barhorst et al., 2021). The influence of the use of augmented reality in teaching was found to attract students' interest and increase their interest in confidence and performance expectations. The applications used have proven to be easy to use and useful for effective learning (Al-Imamy S Y, 2020). Findings show that the use of augmented reality has been shown to be more beneficial in facilitating academic success and skill development in virtual classrooms, compared to virtual

classrooms that do not integrate augmented reality in the context of online distance learning (Eldokhny, 2021). Many researchers in the field of AR have emphasised its positive impact in the learning environment in terms of providing engagement and motivation for students towards learning and helping students gain experience by repeating situations that are difficult to repeat in reality (Eldokhny, 2021).

In accordance with this, UT has been trying to develop course materials that are designed to enhance learner-content interactions. One of the development projects was conducted for this study, which was initiated by integrating AR as one of the media learning into ABADI. This study concentrated on how does integrating AR into interactive digital materials and what are the effects of utilizing AR technologies on student engagement, motivation, and interest in the learning process. By addressing these questions, this research aims to provide a comprehensive understanding of the potential benefits and challenges associated with integrating AR in interactive digital materials, ultimately paving the way for more informed and effective integration of these transformative technologies in learning services in open and distance universities. The use of AR in Integrated Digital Materials can be an innovative solution to increase the attractiveness and effectiveness of learning in the technological era. This article will explain more about the exploration of AR in the ABADI application as a step towards technology-based education that is relevant to the times.

## 2    METHODOLOGY

The method used is R&D (*Research and Development*). The way to design and create new products or develop and test the effectiveness of these products uses R&D research methods (Sugiyono, 2016: 26). The development model used in the AR in ABADI research is ADDIE. ADDIE stands for *Analysis*, *Design*, *Development*, *Implementation*, and *Evaluation* (Astriani & Khairani, 2022).
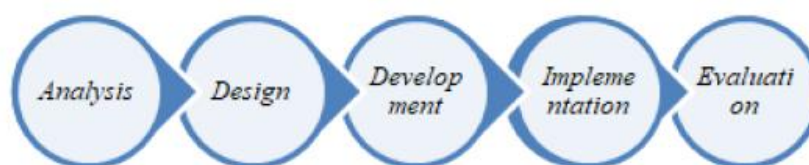


Gambar 2.1 Alur Penelitian Pengembangan ADDIE

The analysis stage is the first stage aimed at obtaining information related to the initial conditions and the needs. In this stage, potential analysis, curriculum analysis, and problem analysis are performed. This process is carried out through a literature review of interactive

teaching materials and augmented reality media. Interviews with subject matter experts (lecturers) are also conducted to get a clear picture of the needs and expectations of the product to be developed. The design stage is the stage of designing AR learning media products. Initial Product Design, once the user's needs are identified, the next process is the initial product design, which includes Special Instructional Objectives (ICT/TIU) analysis and instructional analysis. This initial product includes the development of a Media Instruction Outline (GBIM) as well as a media script that will be used in the development of AR applications. The development stage is the production stage of the design that has been made and then arranged into a ready-to-use product. The implementation stage is the stage of product application, meaning receiving input on the product that has been produced. The evaluation stage is the final stage of product development activities that aim to measure the achievement of the product development goals.

This AR learning media is validated by 2 experts, namely material experts and media experts. At this stage, the application that has been designed is validated by two groups of experts, namely media experts and material experts, according to their fields. Then the AR in ABADI learning media was carried out in product trial stages, such as: practicality trials with 2 lecturers, and large group practicality trials with 20 students. The expert validation test aims to determine the validity of AR products. The purpose of the practicality test is to find out the practicality of AR media.

The data collection technique used in the AR in ABADI research uses a questionnaire using a Likert scale by the validator, while qualitative data is obtained from the assessment and suggestions of the validator. The data obtained from questionnaires and interviews were analyzed using quantitative and qualitative descriptive techniques.

## 3　FINDINGS AND DISCUSSION

### 3.1　Analysis

At the problem analysis stage, a literature review is conducted. The results include the low enthusiasm of students in using the ABADI application, students have not massively used the ABADI application, the lack of interaction between learners and materials, the lack of learning media in the ABADI application, the development of interactive learning materials with various learning activities is becoming increasingly popular in the online learning environment, AR media which was developed as an initial prototype, namely the field of

science. From the description of the provisional data, the development of ABADI's integrated AR learning media is needed to enrich and increase learners' interests.

## 3.2    Design

The material contained in the ABADI integrated AR is taken from the BIOL4322 Vertebrate Taxonomy course, with the topic of Lamprey Fish and SPFI4302 Electromagnetics with the topic of Conductors and Inductors. The material contained in AR in ABADI is according to the learning outcomes in the module. Lamprey Fish material is used in the Biology study program, while conductor and inductor material are used in the physics education study program. The first stage in the design process is to develop. Media content outline (GBIM), material map and media script. GBIM includes the framework or structure of the material that will be delivered through learning media. This component is important as a guide in the preparation of content so that it is systematic, directed, and according to the needs of learners. A material map—or content map—serves as a visual guide that illustrates the relationship between a number of main materials or topics in the learning medium. Meanwhile, a media script is a written script that becomes a guideline for media production in the form of a sequence of text, visuals, and audio that will be recorded or displayed.

Figure 3.1 GBIM BIOL4322 Vertebrate Taxonomy – Lamprey Fish

| NO. | COMPETENCE | COMPETENCY INDICATORS | MATERIAL POINTS |
|---|---|---|---|
| (1) | (2) | (3) | (4) |
| 1 | Explaining the external structure and digestive system of lampreys | a) Students are able to mention the classification of lamprey fish vertebrates<br>b) Students are able to describe the outer structure of the lamprey fish<br>c) Students are able to describe the digestive system of lampreys | a) Position of the Lamprey Fish in the classification of vertebrates<br>b) Lamprey's Outer Structure<br>c) Lamprey's digestive system |

Figure 3.2 GBIM SPFI4302 - Conductors and Inductors

| NO. | COMPETENCE | COMPETENCY INDICATORS | MATERIAL POINTS |
|---|---|---|---|
| (1) | (2) | (3) | (4) |
| 1 | Capacitor Structure and Network | a) Mahasiswa is able to explain the definition, functions, working principles, and types of capacitors<br>b) Students are able to apply the basic properties and characteristics of capacitors to capacitive circuits | Definition, function, working principle and types of capacitors |

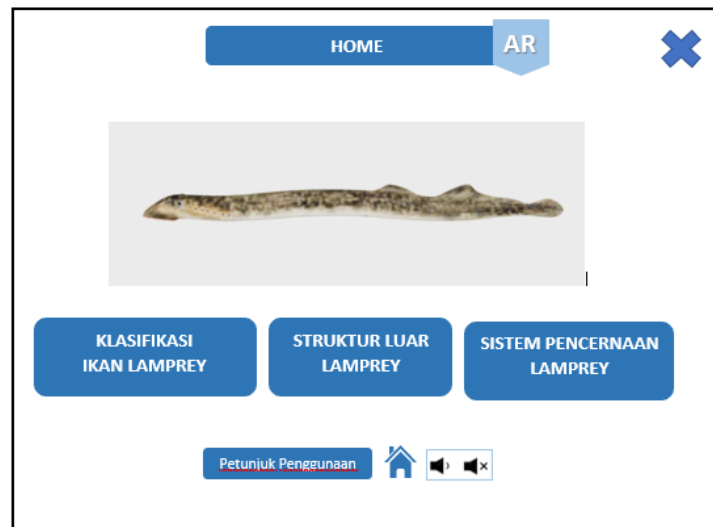| 2 | Inductor Structure and Network | a) Mahaisswa is able to explain the definition, functions, types and series of inductors<br>b) Students are able to apply the basic properties and characteristics of inductors to inductive series | Definition, functions, types and range of inductors |
|---|---|---|---|



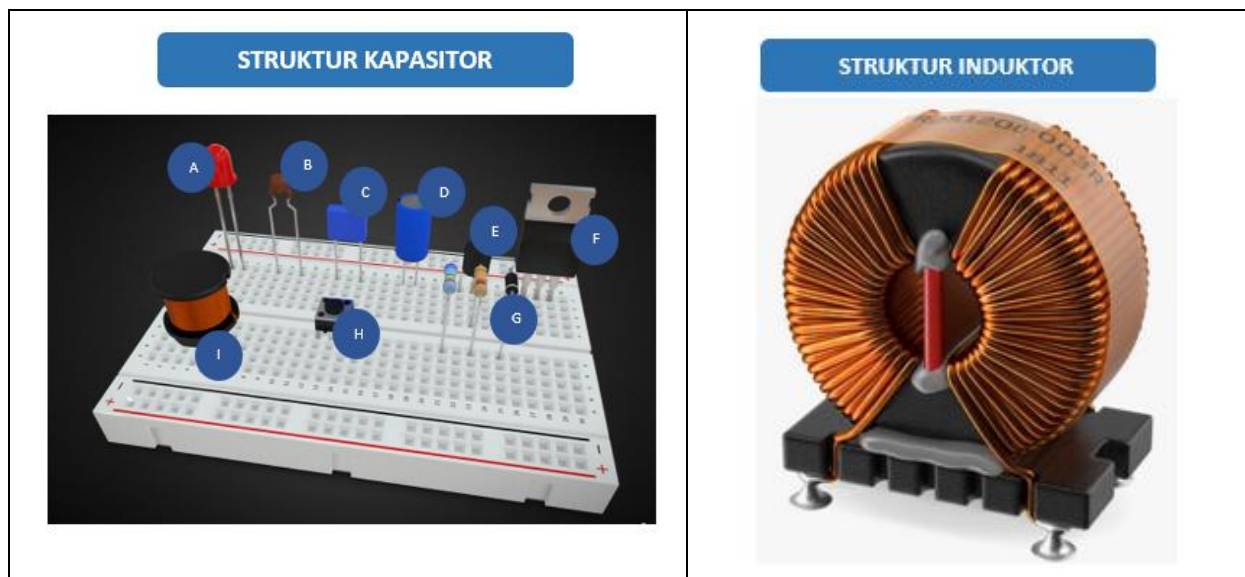Figure 3.1 Electromagnetic SPFI4302 Manuscript – Capacitor Structure



Figure 3.2 Electromagnetic SPFI4302 Manuscript – (a) Capacitor Structure, (b) Inductor Structure

### 3.3 Development

The stages that the researcher carried out in the creation of ABADI integrated AR learning media are as follows:

a) In the first stage, a 3D asset design of Lamprey Fish, Conductor and Inductor will be made in accordance with the media script.

b) Manually integrate 3D assets into the EON XR application.

c) Developing supporting media in the form of audio and video media.

d) Record audio narration using Prossa.ai App according to the script

e) Download the video material on the source link in the script and integrate it into EON XR

f) Download the PDF material at the source link in the manuscript and integrate it into EON XR

g) Develop annotations on 3D assets according to media scripts

h) Developing quizzes on EON XR

i) Compile and string annotations on each pop-up annotation.
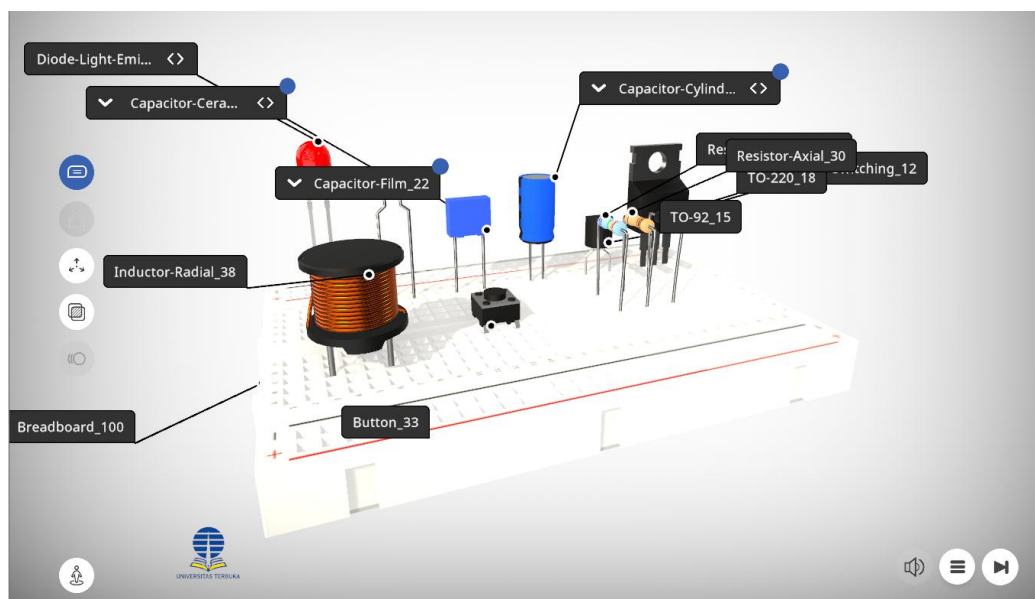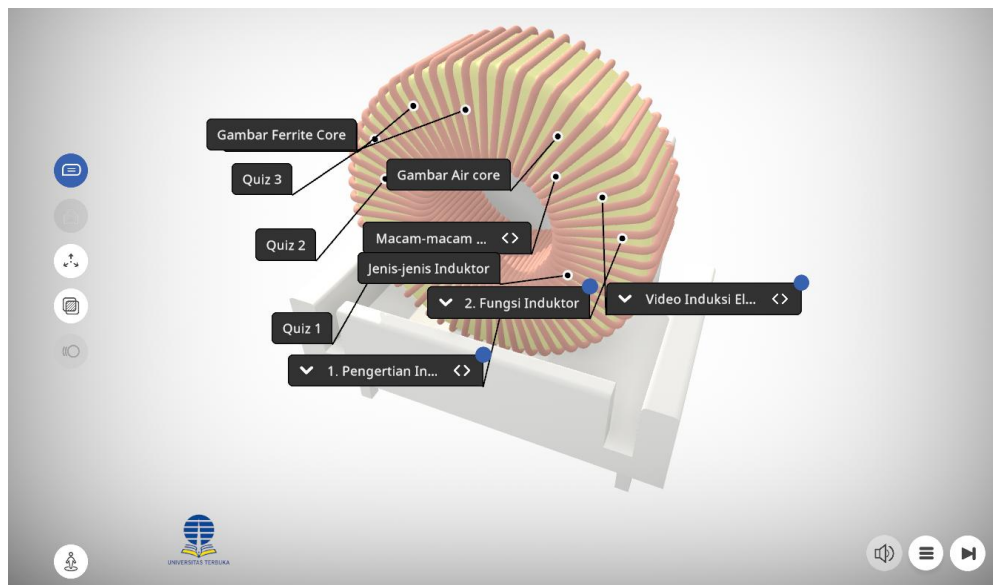


Gambar 3.4 Tampilan AR Konduktor

Figure 3.5 Inductor AR Display

Next, AR media that is ready to be integrated into the ABADI application. Each AR media uses a layout based on Figure 3.7, namely, an introduction to AR media and AR media capture. The image is clickable. If you click on it, it will go to AR and open it. The type of AR used is a non-Marker AR type.
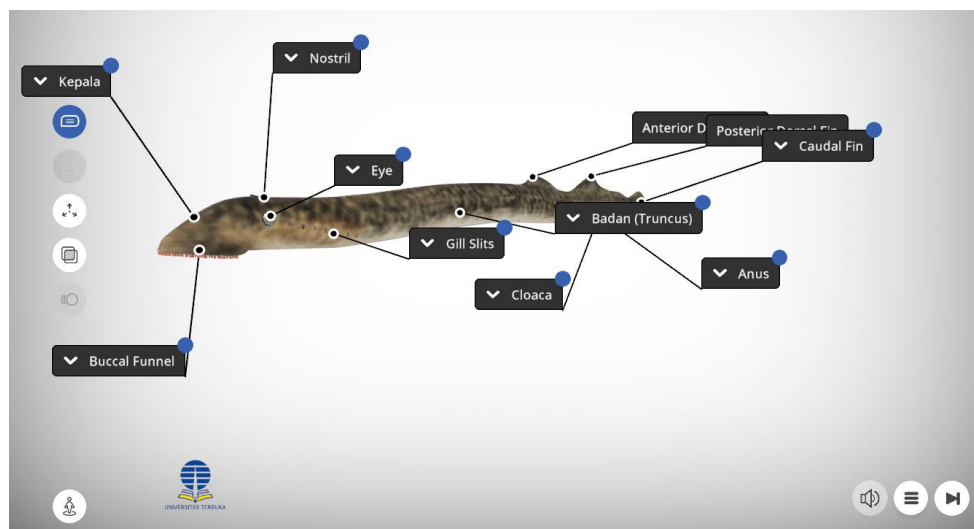


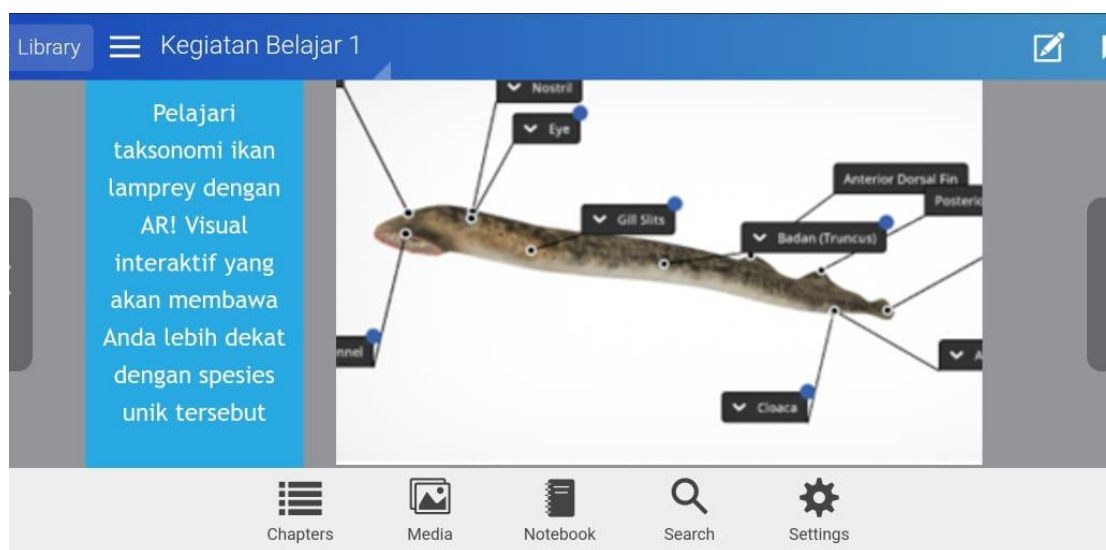Figure 3.6 AR Display of Lamprey Fish

Figure 3.7 AR Lamprey Fish Display on ABADI App

## 3.4     Implementation

After the researcher conducted a validation test by experts, it was followed by a practical test of the students. Five students carried out the small group practicality test, and 19 students carried out the large group. Small group and large group trials are carried out to obtain a practical assessment of the product. The following are the results of the percentage of assessments obtained from filling out the respondent questionnaire. Table 3.3 shows the results of a small group practicality test, which resulted in 91.17% in the very practical category.

Table 3.3 Small Group Practicality Test Results

| Aspect | Percentage (%) | Interpretation Level |
|---|---|---|
| 1)   User Convenience | | |
| 2)   Material Ease | 91.17% | Very Practical |
| 3)   Benefit | | |
| 4)   Satisfaction | | |

Table 3.4 shows the results of a large group of practicality tests that received a result of 90.37% in the very practical category. The assessment is based on the calculation of the average score of 19 students. The assessment is accompanied by criticism and suggestions given by practitioners for improvement to improve the quality of AR learning media. Here are some criticisms and suggestions that form the basis for evaluating AR media in ABADI. AR media is expected to be accessible to all courses, including chemistry, biology, and more. Added audio features that support language selection (Indonesian/English). Added subtitle or translation features for videos. Add a text feature to AR media to complete audio

explanations. The audio tempo needs to be adjusted to make it easier to understand. Provide quizzes with longer processing time and more detailed explanations.

Table 3.4 Results of Large Group Practicality Trials

| Aspek | Percentage (%) | Interpretation Level |
|---|---|---|
| 1) User Convenience<br>2) Material Ease<br>3) Benefit<br>4) Satisfaction | 90.37% | Very Practical |

The same data is also used to calculate the Alpha Cronbach for Likert scale items in your dataset, with a result of 0.975, which indicates the internal consistency and excellent reliability of the questionnaire. Here is the item-total correlation for each Likert scale item, which shows how well each item correlates to the sum of all the other items.

Table 3.5 Total item correlation

| No | Statement | Score |
|---|---|---|
| 1 | Augmented Reality (AR) material in audio form enhances understanding | 0.953 |
| 2 | Augmented Reality (AR) material in image form enhances understanding | 0.799 |
| 3 | Augmented Reality (AR) material in video form enhances understanding | 0.908 |
| 4 | I am satisfied with the Augmented Reality media presented | 0.864 |
| 5 | I will recommend it to friends or others | 0.859 |
| 6 | I give a positive reaction to the Augmented Reality (AR) innovation in Biology–Lamprey Fish and Physics–Conductors and Inductors | 0.955 |
| 7 | I feel happy using this Augmented Reality media | 0.887 |
| 8 | I feel the desire to repeatedly use and access AR media | 0.802 |
| 9 | I try to use the AR application to improve skills | 0.915 |
| 10 | I use the AR application to gain greater benefits | 0.935 |
| 11 | I plan to use the AR application in the future | 0.912 |
| 12 | I intend to continue using the AR application | 0.838 |
| 13 | I hope the use of AR will continue in the future | 0.909 |

Based on the data of Table 3.5, these values show a strong relationship between individual items and the overall scale, with most correlations above 0.8, which further supports the validity of the questionnaire. Figure 4.2 visualizes the item-total correlation for each Likert

scale item. The chart shows the strength of the correlation between each item and the total score, helping to identify the items (Nos. 24-36) that best fit the overall scale.
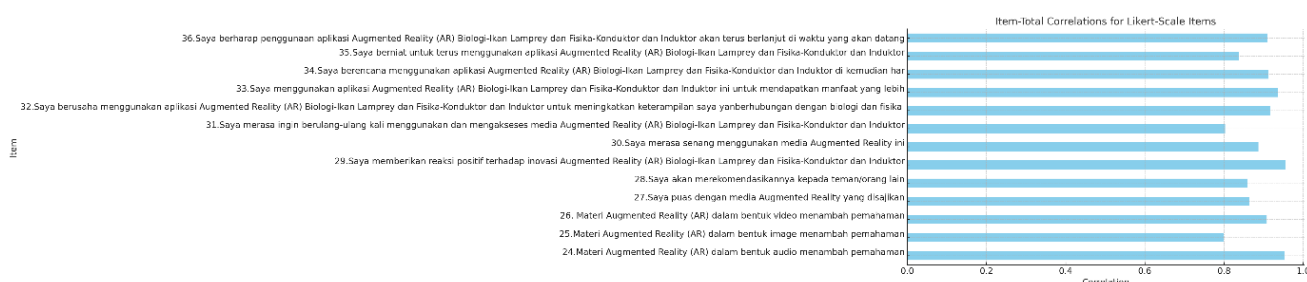


Figure 4.2 Total Item Correlation

The item with the lowest average score was "I can instantly figure out how to undergo Augmented Reality (AR) without reading the written instructions", getting an average score of 3.04 (out of 4). It suggests that some participants may find it difficult to understand how to use the AR app in ABADI without reading the instructions, which indicates potential areas for improvement in user interface design or onboarding instructions. The item with the highest average score was the item "Augmented Reality (AR) Biology-Lamprey's Fish and Physics-Conductors and Inductors can be used at any time" with an average score of 3.79 (out of 4). It shows that participants find AR apps very accessible and easy to use at any time, which reflects a strong positive perception in terms of usability and convenience.

## 3.5    Evaluation

The evaluation stage is carried out after the validation stage and the implementation stage. This evaluation stage is based on the results of revisions according to suggestions and input from validators and practitioners for the improvement of AR learning media in ABADI. Final evaluation of the developed product will be done by paying attention to detail and improving some enrichment material on AR media. Some of the enrichment measures used include the selection of image quality, the use of audio introductions accompanied by text, the use of video with subtitles, and all inputs according to the suggestions given by validators and practitioners.
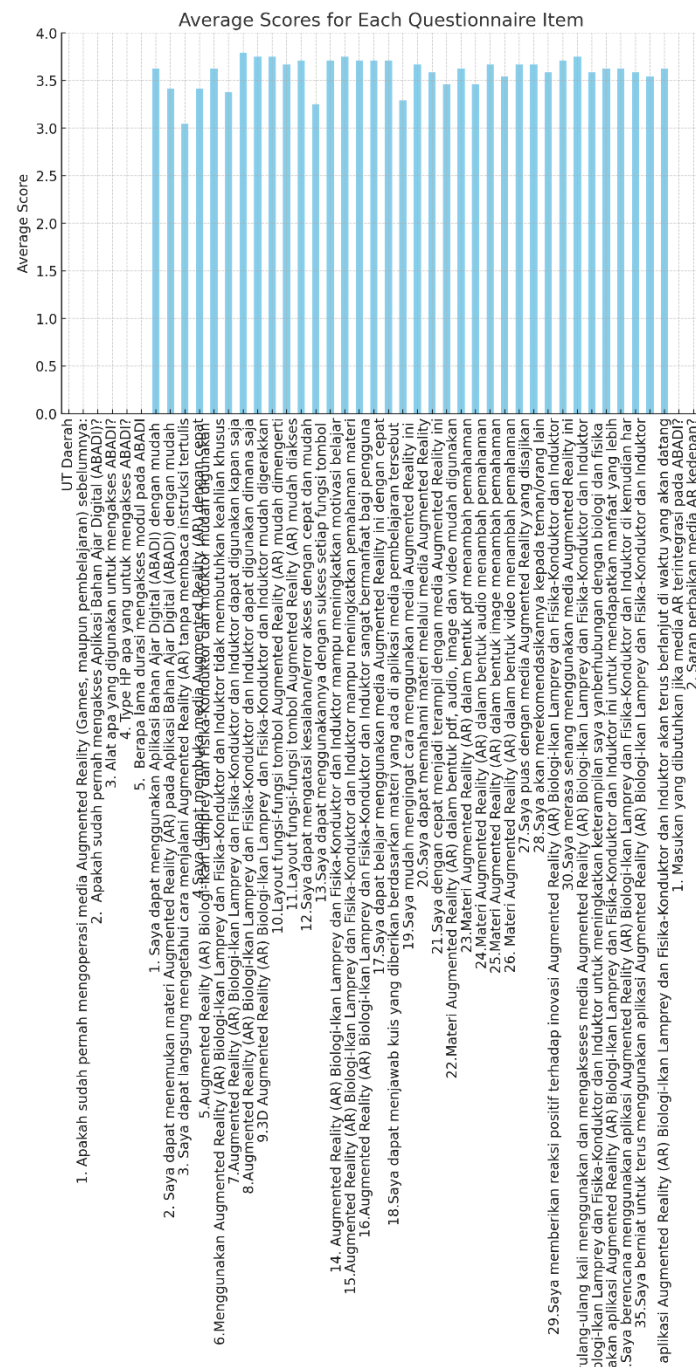
Figure 4.1 Average Respondent Score

To maximize the potential of AR and increase its interaction, here are some research recommendations that can be carried out among others (a) A/B experiment on AR Features: Comparing a group of users who use certain interactive features (such as audio, gamification, or collaboration) with a control group that does not use these features, (b) Qualitative User Experience Studies: Conducting in-depth interviews or discussion groups with users to understand more about their challenges and desires regarding AR interactions, and (c)

Longitudinal Test: Observed the impact of AR use over a longer period to understand whether users experienced improvements in understanding, motivation, and learning skills over time. This ongoing research will provide deeper insights that can be applied to improve the quality of AR experiences in learning.

## 4    CONCLUSION

In conclusion, the impact of AR and integrated interactive digital materials on students perceptions is profound and multifaceted. The evidence suggests that incorporating AR into educational frameworks not only enhances student motivation but also significantly improves academic performance. The findings indicate a strong relationship between the use of AR-enriched materials and heightened student engagement, as noted in studies that utilized Keller's Instructional Material Motivational Survey to gauge student interest and motivation levels. Specifically, the motivation derived from using AR within classroom settings translated into improved performance across various subjects. It aligns with the assertion that AR, in tandem with mobile technology, forms a powerful basis for facilitating significant learning experiences. These insights underscore the necessity for educators to consider the integration of innovative technologies like AR to foster a more motivating and effective learning environment, thereby transforming traditional educational approaches (Osuna B et al.), (Almenara C et al.).

The findings of this study illustrate a pronounced shift in students' perceptions when AR and integrated interactive digital materials are employed in the educational setting. Significant improvements in engagement, motivation, and comprehension were observed, suggesting that these innovative tools not only enhance learning experiences but also foster a deeper understanding of complex concepts. As educators contemplate the future of pedagogical practices, it is crucial to consider the incorporation of AR and interactive elements into curricula. Such integration can cater to diverse learning styles, promote collaborative learning environments, and better prepare students for the demands of a technology-driven world. However, it is equally important to address potential challenges, such as access to technology and the need for adequate training for educators. By prioritizing these areas, educational institutions can harness the full potential of AR, thereby enriching the learning experience and shaping a generation of technologically adept learners.

The results of trials and longitudinal studies can show and provide deeper insights into their impact on users' understanding and learning skills. By following these recommendations, it is

hoped that AR applications can provide a more fun, effective, and immersive learning experience for future users.

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