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Development of a Microbiology Practical Guide Based on Augmented Reality Technology on Virus Material

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ABSTRACT

This study aims to develop an Augmented Reality (AR)-based Microbiology practicum guide to enhance learning quality and student engagement. AR technology facilitates understanding by presenting interactive 3D images and videos, making complex concepts like viruses more accessible and engaging for students. The research follows a Research and Development (R&D) methodology comprising three stages: define, design, and develop. The practicum guide was created using vuforia, Blender 3D, Unity, and Photoshop software. A marker was designed to connect the AR components with 3D models for Android devices and incorporated into a printable guide. Validation results classify the AR-based practicum guide as highly valid, with overall validity reaching 85.8%. Specific aspects scored as follows: content (87.5%), presentation (85.7%), practicality (83.3%), language (85%), and media (87.5%). Student and lecturer responses also rated the guide as good, emphasizing its effectiveness in facilitating concept visualization and independent learning. The AR-based practicum guide significantly improves learning quality by motivating students, enabling real-life object visualization, and simplifying abstract concepts. This approach demonstrates the potential of AR technology to transform microbiology education and beyond. The developed AR-based Microbiology practicum guide is valid, effective, and tested, offering a modern, interactive approach to education. Its applications extend beyond microbiology, with potential use in disciplines like agriculture, architecture, and health sciences.

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1. INTRODUCTION

Technology has a profound impact on the quality of education in Indonesia, enriching the learning process by making it more diverse and enabling detailed communication and understanding of complex concepts. This technological integration empowers students to interpret and grasp theories more effectively. Practicum activities play a crucial role in this process, as they help develop concepts and provide students with hands-on experience (Hamidah, 2014). However, effective practicum activities require thorough preparation and well-designed guidelines to support their implementation (Prasetyo, 2016). Practicum guides are essential tools that assist students in conducting these activities systematically.

Current practicum guides, however, often fail to effectively motivate students in learning. Students frequently demonstrate a lack of responsibility in completing practicum tasks, which can be attributed to unengaging content, unclear procedures, and guides that merely present instructional text, images, objectives, benefits, and lists of tools and materials. This inadequacy makes it difficult for students to understand abstract concepts, especially in Microbiology, where many objects are not visible in real life. Consequently, lecturers or laboratory assistants must provide extensive explanations, directions, and support before, during, and after the practicum.

To address these challenges, integrating technology into practicum guides, particularly AR, becomes essential. AR technology can present interactive 3D visualizations, enhancing student understanding and engagement. This research aims to develop an AR-based Microbiology practicum guide to improve the quality of practicum activities and provide students with an innovative and effective learning resource. Augmented Reality (AR) technology allows the projection of two-dimensional or three-dimensional virtual objects into real-world environments, enhancing the presentation and comprehension of information (Ozdemir et al., 2018). AR provides users with practical convenience by integrating virtual objects into real-life contexts, making it an effective tool for improving understanding and visualization (Wardani, 2015). As Mustaqim (2016) suggests, AR is particularly valuable for visualizing abstract concepts, such as the structure of object models, which are often challenging to grasp through traditional methods.

AR-based practicum guides offer students the ability to conduct practical activities independently, without requiring extensive assistance from lecturers or laboratory assistants. According to Siahaan (2019), AR-enabled practicum tools empower students to learn autonomously through interactive videos that are accessible via mobile devices without the need for an internet connection. This technology provides a dynamic and memorable learning experience, simplifies the understanding of complex materials, and equips students with skills aligned with the demands of the digital era.

Despite its potential, research addressing the integration of AR technology in practicum guides, particularly for Microbiology courses, remains limited. Existing guides often fail to engage students effectively or support independent learning. This study addresses this gap by developing an AR-based practicum guide focused on virus material, offering a novel approach to enhance learning outcomes. The research aims to create a practical, engaging, and effective guide that leverages AR technology to support independent learning. Its significance lies in improving educational resources, fostering student autonomy, and preparing learners with essential skills for the digital age.

2. METHODS

This study employs a research and development (R&D) methodology using a procedural development approach. The development model applied is a modified version of the 4-D model by Thiagarajan (1974). The research procedure consists of four stages: define, design, develop, and disseminate. However, the development of the AR-based Microbiology practicum guide was limited to the third stage, namely the development stage. The stages of the 4-D model are illustrated in Figure 1 below.

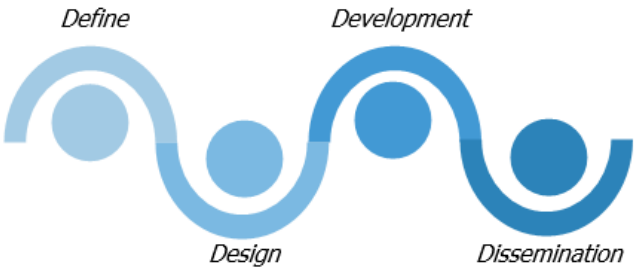


Figure 1. Stages of development of ar technology-based microbiology practicum guide

2.1 Research Subject

The limited trial respondents were 30 students who had participated in the Microbiology course and two lecturers in the Microbiology course. The trial of AR technology-based practicum guide development products goes through 3 stages, namely the validation and revision stages from content, language and media experts. Data was collected through the dissemination of a needs analysis questionnaire containing questions and a response questionnaire used to test the product design internally. The instruments used have been validated by the expert judgement team (Lecturers) from the University of Muhammadiyah Bengkulu, namely the content validator by Drs. Rusdi Hasan, M.Si., Ph.D, the linguist validator by Dr. Ira Yuniati, M.Pd., M.Hum and the media expert validator, namely Agung Kharisma, M.Kom. Feedback provided by the validator team is presented in the form of a separate table from the instrument used.

2.2 Development Stages

According to Thiagarajan (1974), it is known as a 4D model which consists of definition, design, development and deployment.

2.2.1 Define Stage

This stage aims to analyze development needs. The need to develop learning tools or components is based on student characteristics, problems that arise in the teaching and learning process, and learning needs. At this stage, lecturers collect data from students related to the practicum guides that are currently used. After that, the collected data is analyzed for consideration in product development. Quoting Thiagarajan (in Surani, 2018) that the stages of defining include several stages, namely:

a. Front-end analysis. The front-end analysis process is related to the identification of problems in teaching and learning activities as well as problems in the field related to the need for the development of learning components. This aims to identify the problems that are being faced, especially the difficulties students face in achieving learning goals.
b. Student analysis (learner analysis). One of the key factors in developing products that are suitable for learning is student analysis. The characteristics analyzed are the level of cognitive, affective, and psychomotor abilities, which are influenced by the learning environment and climate. This analysis will strengthen the proper identification of problems in the research product development process.
c. Task analysis. Researchers need to analyze the assignment first by detailing the content of the main assignment for students in order to achieve the competencies that have been determined. The development of learning products, whether worksheets or media, must be based on the instructions and content to be compiled.
d. Concept analysis. First, analyze and identify the concepts that will be contained in the product, then formulate a systematic process to achieve the expected learning outcomes so that it can be measured through the use of the product.
e. Specifying instructional objectives. The specification of learning objectives is compiled as the overall result of the task and concept analysis steps. The breakdown and identification of tasks

and concepts in the product are narrowed down to the learning objectives. This goal is the basis for determining tests and evaluations for the products developed.

2.2.2 Design Stage

The products to be developed and tested are designed to get product results that suit the needs. The design of the practicum guide begins by containing the content to be loaded as well as the format and reference for evaluation. The development of AR technology-based practicum guides refers to the characteristics of students in terms of both cognitive, affective, and psychomotor aspects. At the end of practicum activities, there needs to be an evaluation test that correlates with student characteristics with certain learning outcomes. The assessment is carried out in the form of repeated tests of worksheets. The integration of technology into practicum guides is adjusted to the material and competencies that must be achieved at a certain level. The technology used needs to consider practicality and measurability so that the practicum guides can overcome previous problems. The format of the product contains the title, introduction, materials and how it works, results, discussion, conclusion, and bibliography.

2.2.3 Development Stage

The results of the AR technology-based practicum guide design then enter the development stage which includes the submission of input, suggestions, or recommendations to verify and assess a product. Product validation and evaluation are carried out by experts, known as expert appraisal, while development testing is a test of product design on the research subject. The results of this test were then used as the basis for further improvements. The stages of development are carried out as follows.

a. Validation by experts. Product validation is carried out by a team of experts relevant to their scientific field. This validator consists of lecturers or academics who are experts in language, materials, and media. At the validation stage, improvements are made based on input, suggestions, or recommendations from the validator team. This aims to produce a product that is worthy of being tested.
b. Development Test. This process aims to implement a product that has been developed. At this stage, students are involved in gaining learning experience through the use of the practicum guide. Students are then asked to provide responses to AR technology-based practicum instructors based on assessment indicators. Teaching and learning activities using worksheets need to be measured by testing the implementation of activities on worksheets and assessing work performance related to the competencies to be achieved.

2.2.4 Deployment Stage

According to Thiagarajan (as cited in Surani, 2018), the development stage involves validation testing and the implementation of improved products. At this stage, researchers assess and analyze the effectiveness of the product in achieving its intended goals. The dissemination stage involves preparing the product for broader use, including packaging and navigating the diffusion and adoption processes to ensure it is ready for implementation by other users.

Data analysis in this study utilized the percentage technique and descriptive processing. The percentage technique was employed to calculate and display data proportions in percentage form. For instance, the percentage of respondents agreeing with a particular statement was determined by dividing the number of agreeing respondents by the total number of respondents, and then multiplying the result by 100. Descriptive analysis was used to interpret the data by describing and explaining its fundamental characteristics, offering a clear understanding of the results. The grid of expert validation instruments can be seen in Table 1.

Table 1. Validator questionnaire grid

Variable	Aspect	Item Number	Number of Items
Practical Guide Validity Components	Contents	1-24	24
	Presentation	8-22	15
	Practicality	1-44	44
	Language	1-10	10
	Media	1-26	26
	Total		119

Table 1 provides a detailed breakdown of the aspects assessed by the validator team, including content, presentation, practicality, language, and media. The number of assessment items was tailored to align with the development objectives, ensuring a comprehensive evaluation of all relevant aspects.

The collected data were analyzed qualitatively to determine the feasibility of the development. To convert the questionnaire responses into qualitative data, a Likert scale was utilized. The interpretation of the Likert scale for evaluating content, language, and media is detailed in Table 2.

Table 2. Likert scale aspects of content, language and media

Interpretation	Score
Very suitable	4
In accordance	3
Not Appropriate	2
It is not in accordance with	1

The interpretation of the Likert scale in terms of presentation and practicality can be seen in the following Table 3.

Table 3. Likert scale aspects of presentation and practicality

Interpretation	Score
Strongly agree	4
Agree	3
Don't agree	2
Strongly Disagree	1

Tables 2 and 3 show the scores that can be selected by the validator team based on the statements that have been presented. The total score on the aspects of content, language, media, presentation, and practicality is used to determine the categories in each aspect by using the formula of the total score obtained divided by the maximum score and multiplied by 100. Furthermore, if you get a final score, it will be adjusted to the appropriate category. The categories used in the content and presentation aspects can be seen in Table 4, the practicality aspect in Table 5, the language aspect in Table 6 and the media aspect in Table 7. Practicum guides are categorized as not good, not good, good or very good according to the scale obtained. This scale aims to measure the level of validation of a product.

Table 4. Table of assessment of content and presentation aspects

Score Range	Category
49-96	Very good
25-48	Good
13-24	Not good
0-12	Not good

Table 5. Practical aspect assessment table

Score Range	Category
164-176	Very good
151-163	Good
138-150	Not good
0-137	Not good

Table 6. Language aspect assessment table

Score Range	Category
39-52	Very good
26-38	Good
13-25	Not good
0-12	Not good

Table 7. Media aspect assessment table

Score Range	Category
92-104	Very good
81-93	Good
68-80	Not good
0-67	Not good

(Adapted from Mardapi, 2008)

3. FINDINGS AND DISCUSSION

3.3.1 Define Stage

Before carrying out development research, it is necessary to carry out the definition stage first. This aims to find out and analyze the needs of lecturers and students in the field. The first step is observation of the use of learning media in the Biology Education Study Program Laboratory. This analysis uses a questionnaire for lecturers and students to find out the characteristics and level of use needs for the media to be developed. Based on the data obtained, 70% of students stated that practicum activities were very important to be carried out. Then, 100% of students answered that they had never done a practicum on virus material. In addition, no practicum guide based on 3D images and videos has been developed so far, so 99% of students answered that they agreed to develop a special practicum guide for virus material. Based on the analysis of lecturers' needs, lecturers do not know or know the AR application. The needs analysis data is presented in the figure below.

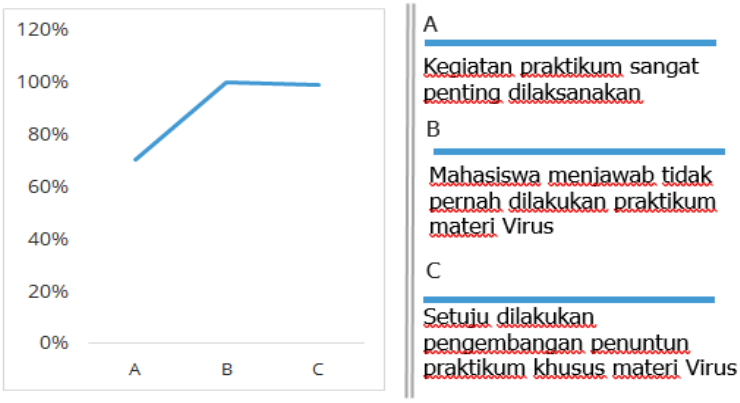


Figure 2. Identification of needs analysis of AR technology-based practicum guides

3.3.2 Design Stage

The researcher prepares all the necessary materials for the development of practicum guides. To produce development products, it is necessary to make a guide design so as to produce an appropriate system (Hanafi, 2017). The stages of the practicum guide design consist of:

a). Instructions for the use of the Guide

The instructions for the use of practicum guides are formulated clearly and systematically because they will be used as guidelines (guidlines) in carrying out practicum activities. Instructions for using practicum guides make it easier for students to understand step by step so that practicum activities can run effectively and efficiently.

b). Practicum Report Format

The format of the practicum report provides an overview of the details of the development of the content of practicum activities. The report format is used as the boundaries of content development so that the concepts created do not go out of discussion. If the report format is prepared in a directional and uniform manner, the results of practicum activities run optimally. Therefore, the report format must be compiled in a valid, measurable, objective, and comprehensive manner. The format of the practicum report using AR technology includes the title, background, materials and how it works, results, discussion, conclusion, and bibliography.

c). Material

Preparation of material based on the existing syllabus in the Microbiology course. The syllabus used is about the structure, forms of viruses, life cycles, and viral pathogens in living things. The material provided to students must be relevant and contextual. Then after the device and content are designed, the product is created based on the results of the needs analysis and design.

d). Tools, Materials and How They Work

The provision of detailed tools, materials, and how to work in the practicum guide makes it easier for students to complete activities. The tools, materials, and ways of working are presented in full using the standard language. In addition, the understanding of the function of tools, materials and how to work must be understood and mastered by students before conducting practicum. This is because the results of student observations have high validity.

e). Making Evaluation Questions

At the end of the practicum activity, the lecturer gave the students an instrument in the form of a description test sheet. The data and information obtained are very necessary in determining the extent of student competency absorption of the material. Then the lecturer prepares a follow-up plan for the assessment results that may need improvement.

After creating a practicum guide design, the practicum guide will be designed with AR using software, namely Vuforia, Blender 3D, Unity, and Photoshop. The next stage is to create markers that

will connect AR with the 3D model to the android, and then the markers that have been designed are input into the practicum guide to be printed. The system design process involves merging pre-made assets with the AR system (Ein, 2021). The integration process can be seen in Figure 3 below.

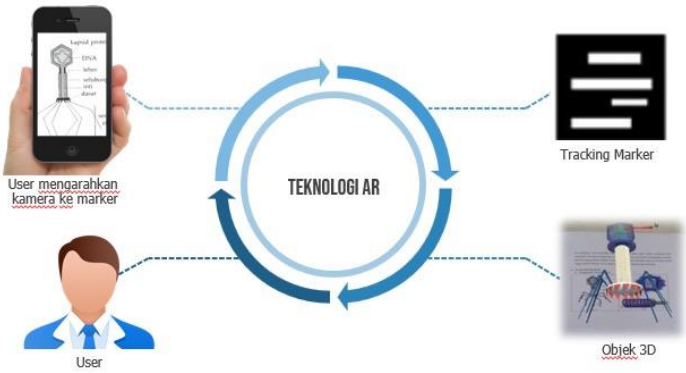


Figure 3. Use of ar technology in practicum guidance

3.3.3 Development Stage

Three expert reviewers—Expert I (linguist), Expert II (material specialist), and Expert III (media specialist)—conducted a product validity test to evaluate the developed product. This stage aimed to assess the validity and feasibility of the AR-based practicum guide. Based on the average results across key aspects, including content, presentation, practicality, language, and the alignment between material and media, the product was categorized as "very good" with an overall validity percentage of 85.8%. This indicates that the AR-based practicum guide meets the required standards in all assessed areas. The total results of the validity test are illustrated in Figure 4.

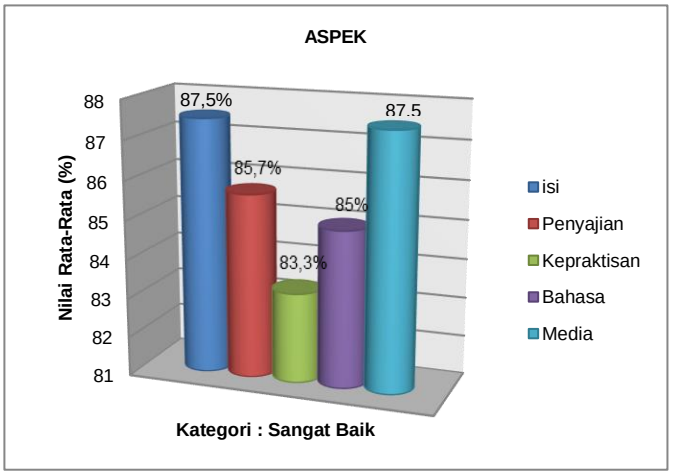


Figure 4. Test the validity of the practicum guide

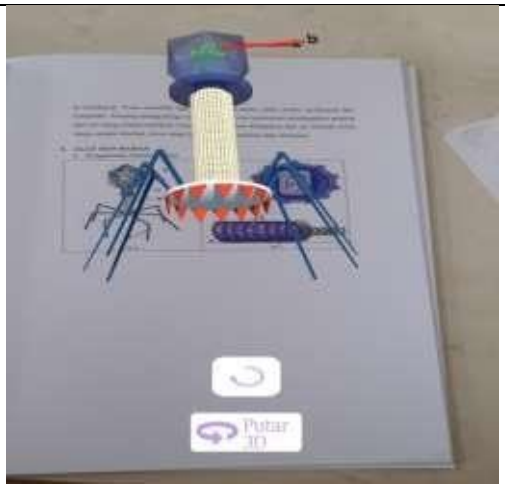
Based on the results of the image above, the aspects assessed in the practicum guide using AR technology in the form of content, presentation, practicality, language, and media are categorized as very good with a score obtained above 80%. So that the practicum guides that have been developed are worthy of implementation. Furthermore, the validator gave suggestions on how AR-based practicum instructors could be used properly. The suggestions are as follows:

1. The application of 3D models cannot be rotated as a whole
2. Images of human pathogens cannot identify which ones are exposed to the virus
3. Undirected questions

4. Images of pathogens in plants cannot appear in 3D
5. Not consistent in writing foreign languages (must be italicized)

Based on these suggestions, revisions were made to the practicum guide and the AR application. Table 8 below is the revised data from the validator team.

Table 8. Suggestions for improving the practical guide

No	Before Revision	After Revision
1.	The language used in the Practical Guide using augmented reality technology is not consistent in foreign language writing and is not italicized	The language used in the Practical Guide using augmented reality technology has been improved for foreign language writing
2.	 There is no rotation or 3D button in the application	 There is a rotation or 3D button in the application
3.	 The picture hasn't appeared yet 3D when the AR application is opened	 The 3D image has appeared
4.	Inaccurate pattern of structuring or constructing question sentences for questions about the lytic cycle and lysogenic cycle	The question sentence pattern for the questions has been corrected according to the lithic and cyclic material lysogenic

No	Before Revision	After Revision
5.	a. Silakan identifikasi patogen apa saja yang menginfeksi manusia tersebut  Unrevised image of human pathogens	a. Silakan identifikasi patogen apa saja yang menginfeksi manusia tersebut  The image has been replaced with an image of a human infected by the virus

The developed practicum guide has been improved and adjusted to the suggestions and input of the validator, so this practicum guide needs to be tested again. The limitations experienced by researchers in developing this practicum guide are technical factors. When an error occurs in the device being used, both lecturers and students need a long time to find a solution to the problem. In the future, if this technology is used, it will be necessary to have a more detailed understanding of the operation of AR technology. In addition, there are limitations in reference in developing practicum guides based on AR technology. So that it is difficult for researchers to find information related to the title. However, this AR technology promises to improve the quality of education in the future. This technology can be applied to other disciplines, for example, in the field of physics and planetary motion matter. In addition, in the field of Architecture and Design, AR is used to visualize the design of buildings in a physical environment before construction begins. This technology provides a 3D model of the project on a real scale, making it easier to communicate and verify the design.

3.3.4 Limited Trial Phase

This stage represents the final phase of product development, involving a two-step trial process. The first trial included 5 respondents, while the second trial involved 25 respondents, all of whom were seventh-semester students from the Biology Education Study Program at FKIP, University of Muhammadiyah Bengkulu. The purpose of this limited trial was to evaluate student responses to the use of the AR-based practicum guide.

Based on the questionnaire results, the practicum guide was rated as good in aspects such as linguistics, presentation, multimedia display, programming, and overall benefits. These findings align with Astuti's (2023) research, which highlighted the effectiveness of AR-based virtual laboratories in terms of conceptual clarity, user satisfaction, multimedia relevance, and perceived benefits. The average results from the student response questionnaire showed an impressive response rate of 88.1% out of 100%, underscoring the high acceptance and effectiveness of the AR-based practicum guide.

After knowing the results of the response from the students, data was collected again to 2 lecturers in charge of the Microbiology course. The data collection aims to find out the response and response of lecturers to AR-based practicum guides. Based on the average results of the questionnaire, an average percentage of 92.4% was included in the very good category. The average results of the questionnaire obtained are shown in Figure 5 below.

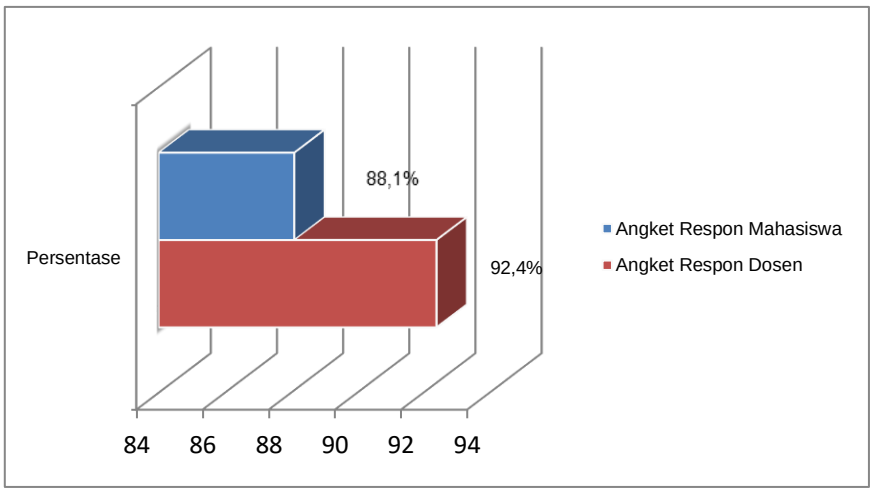


Figure 5. Obtaining the average results of student and lecturer response questionnaires

Discussion

One of the applications that displays 3D virtual objects into a real environment is the AR application. AR applications are used as teaching aids to make it easier for students to understand the material (Kamelia, 2015). AR is a technology that bridges the virtual and physical worlds to make learning more interesting and enjoyable (Nadeem Muhammad, 2022). The research on the development of AR technology-based practicum guides has differences compared to other relevant research. The marker is designed to be able to display the rotation of the entire 3D image, including the view from the top, bottom, right side, and left side. This rotation serves to provide students with a thorough understanding of certain concepts or theories. Additionally, AR provides a more realistic and interactive experience compared to computer-based simulations. To develop this product, stages of R&D are required.

The define stage involved conducting a needs analysis to assess the importance of practicum activities, the required media, and the content and format of the practicum guide. This was achieved by distributing questionnaires to students. The results indicated that 70% of students considered practicum activities to be crucial, particularly for Virus material, as these activities helped them better understand and conceptualize viruses. Practicum activities are seen as vital because they enhance process skills such as observing, analyzing, interpreting, communicating, and inferring. As Eliyarti (2019) suggests, practicum activities are essential for improving scientific skills.

Additionally, 100% of students reported that they had never conducted a practicum on Virus material due to limitations in tools and materials. Furthermore, 99% of students expressed their agreement on the need to develop a practicum guide for Virus material, particularly one incorporating 3D and video-based elements, which had not been available before. This data reveals that over 50% of respondents provided positive feedback, indicating strong student support for the development of an AR-based practicum guide for Virus material.

The development of practicum guides must be complete, clear, and systematic so that it makes it easier for students to understand the steps of practicum activities. Then, the practicum guide must be designed attractively by presenting 3D images, text, and videos. Until now, practicum guides only contain pictures and text, which causes students to lack a good understanding of the practicum process. In accordance with the opinion of Ahmad (2020), one of the factors that make it difficult for students to learn and understand the material through practicum activities is that the design of the practicum module is less attractive to students. The development of practicum guides using AR-based visual media using Android is one of the best breakthroughs. The use of AR in practicum activities certainly helps in explaining the material through examples that are difficult for students to understand.

The design stage involves organizing and preparing materials based on the syllabus of the microbiology course and creating a practicum guide integrated with AR technology. This process utilized software tools such as Vuforia, Blender 3D, Unity, and Photoshop. A marker was developed to link the AR elements with 3D models on Android devices, and this marker was incorporated into the practicum guide, which was then prepared for printing.

The final steps included validation, revision, and testing as part of the development process. Validators provided several suggestions, including refining foreign language writing, adding 3D rotation buttons, improving 3D drawings, and making the questions and visuals more specific. These revisions were essential for enhancing the quality of the practicum guide. Comments and feedback from experts on the AR-based practicum handbook were crucial in refining and improving the developed media, aligning with the importance of expert input in producing effective learning resources (Hani, 2020).

The development stage involved validating the AR-based practicum guide through evaluations by three experts. The validity test assessed aspects such as content, presentation, practicality, language, and the alignment between material and media. The results yielded an average score of 85.8%, categorizing the guide as "very good." Following validation, a small group trial was conducted using questionnaires to gather feedback from students and lecturers.

The trial results showed that the AR-based practicum guide was rated "very good" by both lecturers and students, with average response scores of 92.4% and 88.1%, respectively. These findings confirm that the practicum guide is suitable for both students and lecturers. This aligns with the research of Siahaan (2019), which reported that AR-based practicum guides were highly effective, achieving an average expert validity score of 86.74%. These results underscore the potential of AR technology to enhance practicum activities and support effective teaching and learning.

The development of AR technology-based practicum guides is only carried out up to the third stage, namely development. This is due to the covid-19 period which is not possible to disseminate considering that it is not allowed to gather large crowds. The development of AR technology-based practicum guides uses language that is in accordance with PUEBI standards, proper sentence structure, regularity in the use of terms, and good use of symbols, so that products in the form of AR-based practicum guides are worth using. The response from students and lecturers is very good, this can be seen from the enthusiasm of students and lecturers during practicum activities in the laboratory. AR-based practicum instructors can improve intellectual ability, learning motivation, learning independence, and individual professionalism (Andarsi, 2023).

Based on the results in the field, the AR technology-based practicum instructors that have been developed provide a significant improvement in three student abilities, namely cognitive, affective and psychomotor abilities. AR technology-based practicum guides can stimulate student motivation to explore activities in depth. This is because the guide developed provides an interesting presentation. After the practicum activities are over, students find it easy to understand the material because the information presented is through the help of AR technology. The material presented in 3D form provides a clear and comprehensive understanding. This technology is very helpful for students in making observations, analyses, and drawing conclusions. One of the successes in improving the quality of learning can be seen in improving students' ability to understand the material. This opinion is supported by Rachim's research (2024), which reveals that AR has a significant impact on the world of education and has great potential in improving the quality of learning.

AR technology-based practicum guides can stimulate student learning activityThe fact that AR can provide a space for students to be actively involved in understanding practicum guides, understanding the material, completing each practicum step and trying to use the tools that have been provided. AR allows elusive concepts to be easy to understand, while paving the way for deeper understanding. In line with Rofi'i's (2023) opinion that the use of AR in learning provides a significant increase in literacy and digitalization skills. This can be obtained if the presentation of the material is easy to understand so that there is a motivation for students to carry out more in-depth activities. The

technology used in learning has an impact on today's students because technology can develop motivation and technological skills (Apryanto, 2022). Although AR is beneficial, keep in mind that active learning is also related to students' interests and motivation. Students who have high motivation tend to be active students in the learning process.

AR technology-based practicum guides are very important to use because they can make a positive contribution and educational progress in the future. Although the positive potential of AR as a learning medium is very promising, there are challenges that need to be overcome. Some aspects that must be considered in the integration of technology into learning are technical aspects, educational infrastructure, and relevant content development. The use of AR technology is currently the first step in preparing the digital generation, which will provide future innovations in education. It is hoped that in the future, the practicum guides that have been developed today can be disseminated and innovated again into superior products that are able to improve the quality of learning in the classroom.

4. CONCLUSION

The AR technology-based practicum guide that has been developed is valid and tested with a validity percentage of 85.8%, which is included in the very good category. The development of AR technology-based practicum guides uses language that is in accordance with PUEBI standards, proper sentence structure, regularity in the use of terms, and good use of symbols, so that products in the form of AR-based practicum guides are worth using. The positive response from lecturers and students to the use of AR shows that this technology is well-received as a complement to the practicum learning process. The development of accurate and innovative AR products requires adequate training and support so that lecturers can develop AR technology into the curriculum and learning practices appropriately and optimally. Therefore, in the future, further development needs to be carried out by paying attention to the level of motivation and effectiveness of students in order to produce quality products.

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