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Development of a Virtual Laboratory For Bacterial Culture as a Biology Learning Media

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Abstrak: Penelitian ini bertujuan untuk mengembangkan aplikasi laboratorium virtual berbasis Android berjudul "Bacterial Culture" sebagai media pembelajaran inovatif dalam mata kuliah Mikrobiologi. Aplikasi ini mensimulasikan proses kultur bakteri, termasuk persiapan media, teknik sterilisasi, inokulasi, dan analisis hasil. Penelitian ini merupakan penelitian dan pengembangan (R&D) menggunakan model Borg dan Gall yang disesuaikan menjadi enam tahap. Tahap validasi desain meliputi validasi oleh ahli media dan materi, yaitu dosen mikrobiologi, serta uji coba kelompok kecil yang melibatkan mahasiswa semester 3 Pendidikan Biologi di IAIN Kudus. Hasil validasi oleh ahli menunjukkan bahwa media ini memperoleh skor validitas sebesar 91,6% (sangat valid), dan uji kepraktisan oleh mahasiswa semester 3 memperoleh skor 61,6% (istimewa). Temuan ini menunjukkan bahwa laboratorium virtual "Bacterial Culture" merupakan media pembelajaran yang dapat mendukung pemahaman mahasiswa dalam praktikum kultur bakteri sebelum dilakukannya praktikum di laboratorium. Penelitian ini berkontribusi pada kemajuan pendidikan berbasis teknologi yang selaras dengan Kurikulum Merdeka Belajar Kampus Merdeka (MBKM).
Kata kunci: Kultur Bakteri; Pendidikan; Mikrobiologi; Laboratorium Virtual.

Abstract: This research aims to develop a virtual laboratory Android application entitled "Bacterial Culture" as an innovative learning media in Microbiology courses. This application simulates the bacterial culture process, including media preparation, sterilization techniques, inoculation, and analysis of results. This research is a Research and Development (R&D) study using the Borg and Gall model which was adapted into six stages. The design validation stage includes validation of media and material experts, namely microbiology lecturers and small group trials involving third semester Biology Education students at IAIN Kudus. The results of expert validation by microbiology course lecturers show that this media obtained a validity score of 91.6% (very valid), and practicality testing by 3rd semester students obtained a score of 61.6% (Special). These findings indicate that the virtual laboratory "Bacterial Culture" is a learning medium that can support students' understanding of bacterial culture practicum before carrying out practicum in the laboratory. This study contributes to the progress of technology-based education which is aligned with the Independent Campus Learning Curriculum (MBKM).
Keyword: Bacterial Culture, Educational, Microbiology, Virtual Laboratory.

1. Introduction

Microbiology is one of the important courses in Biology Education because it provides students with an understanding of various aspects of microorganisms, including their characteristics, roles and techniques for studying them, such as bacterial culture. One of the important components in learning microbiology is practical work in the laboratory. However, obstacles that are often faced in microbiology practicum are limited laboratory facilities, lack of tools and materials, and the risk of contamination or accidents that can occur when working with microorganisms [1].

These limitations cause the implementation of microbiology practicum to be less than optimal. According to data from the Ministry of Education and Culture [2], more than 60% of biology laboratories at universities in Indonesia face challenges in supporting microbiology practicum activities, including bacterial culture. These challenges are often caused by contamination, procedural errors, and a lack of student understanding of proper techniques before beginning the practicum. As a result, students' practical competencies, particularly in isolation, inoculation, and microorganism identification techniques, remain low [3].

Technological developments provide opportunities to overcome these obstacles, one of which is through the development of virtual laboratories. Virtual laboratories allow students to carry out digital practical simulations with minimal risk. This media not only helps in overcoming limited facilities, but also provides an interactive and flexible learning experience [4]. Previous research shows that the use of virtual laboratories can improve students' conceptual understanding and analytical skills in practicum-based courses [5]. Based on the results of the analysis of learning media needs that had been carried out before the research, all 18 respondents strongly agreed that virtual laboratories needed to be developed to simulate the practicum process for training efforts before real practicum in the laboratory.

The bacterial culture practical virtual laboratory is designed to simulate important processes such as medium preparation, sterile techniques,

inoculation, and results analysis with the aim that students can understand the practical steps in depth before carrying out real activities in the laboratory [6]. The choice of bacterial culture material as virtual laboratory material or theme was based on the results of an analysis of learning media needs which stated that 64.6% of respondents chose a Microbiology course which required the development of a virtual laboratory, so researchers developed a virtual laboratory entitled "Bacterial Culture" as a learning medium for the course. Microbiology.

This is in line with the technology-based learning approach, which is expected to support learning outcomes in accordance with the Independent Campus Learning Curriculum (MBKM) implemented in tertiary institutions [2]. This research aims to develop a virtual bacterial culture practical laboratory as a learning medium in microbiology coursesThis development is expected to serve as a learning tool that supports students' understanding of bacterial culture practices before conducting practicum in the laboratory.

2. Research Method

This type of research is research and development (R&D), namely research to produce a product [7]. The resulting product is the android application virtual laboratory namely 'Bacterial Culture', which is a college level biology learning application in the form of bacterial culture simulation practicum in microbiology courses. This research and development step uses the Borg & Gall development model [8]. The reason for choosing this model is based on the systematic and sequential steps and is quite clear in explaining each step.

The location of this research is IAIN Kudus, Ngembalrejo, Bae, Kudus Regency, Central Java. The subjects and data sources in this research are media validators (experts) and a sample of 3rd semester biology education students IAIN Kudus. The data in this research includes need assessment data in the introduction, assessment data from validators, preliminary test data and field trial data.

Need assessment data and trial data were collected using a questionnaire sheet with the help of Google forms, while validation data was obtained through a written questionnaire. Trial data was obtained after respondents tried using the 'Bacterial Culture' virtual laboratory application developed by researchers. Respondents were asked to fill out a questionnaire to assess the suitability of the product being developed. Apart from that, researchers also collected data from respondents regarding input for the application. Data analysis was carried out using the Rasch Model assisted by the Ministep application [9]. The analysis is carried out by looking at the Unidimensionality table, namely by looking at the raw variance value explained by measures.

3. Results and Discussion

This development research procedure refers to the ten R&D procedural steps of the Borg & Gall model, namely: (a) potential and problems; (b) data collection; (c) product design; (d) design validation; (e) design revision; (f) small group trials; (g) revision; (h) large group trials; (i) revision; and (j) mass production [8]. These ten steps were then adapted and modified into six steps as follows: (a) potential and problems; (b) data collection; (c) product design; (d) design validation; (e) design revision; (f) small group trials.

These six steps are the result of modifications which are limitations of the research, namely related to the revision and mass production stages because researchers have not yet distributed Android application products to microbiology lecturers and biology students on a large scale or equivalent to dissemination via the Play Store/AppStore application. Several stages in this research, namely as follows:

a. Potential and Problems

The implementation of this potential and problem stage was carried out by researchers by conducting a literature review regarding the importance of learning microbiology, what the curriculum should be, how microbiology learning should be in the 5.0 era, and practical problems in microbiology

courses. At this stage the researcher analyzed the Microbiology Material by studying the learning outcomes which refer to the Independent Campus Learning Curriculum (MBKM) [2].

b. Data Collection

At this stage the researcher collects data starting from a literature review supporting the introduction of this development research to taking need assessment data before the development research is carried out. The results of this data collection became the basis for developing the virtual laboratory application 'Bacterial Culture'.

c. Product Design

At this stage the researcher began to create the design and layout of the menu display and content for the application product being developed, namely the 'Bacterial Culture' application, starting from the appearance and content. At this stage the researcher coordinates, checks and monitors the progress of making the application. Layout and content design using the Canva, Pinterest and Google applications. Meanwhile, the application development design uses the help of the Articulate Storyline 3 application.

The appearance of the virtual laboratory application 'Bacterial Culture' is as follows:

Figure 1. The appearance of the virtual laboratory 'Bacterial Culture' application

d. Design Validation

At this stage, after the product has been successfully developed, the next step is for researchers to carry out product validation tests. The validation test was carried out with a material expert validator, namely the Microbiology Course Supervisor, which was carried out by filling out a written assessment questionnaire.

This assessment sheet is given to the validator in order to collect validation data, as well as suggestions for improving and increasing the quality of the Virtual Laboratory product that has been designed, so that it can be seen whether the product that has been developed is suitable or not for use in Biology learning, especially Microbiology courses. The assessment aspects of this product are based on the assessment components of the National Education Standards Agency (BSNP) which consist of quality aspects, graphic aspects and interactive aspects.

At this stage the validator provides assessments and also suggestions regarding product development. The validation results were carried out using

15 questions with a maximum score of 60 resulting in a score of 55, so the analysis used a Likert scale as follows:

$$Validasi = \frac{55}{60} x\ 100\% = \ 91{,}666666667\%$$

Based on the Likert scale calculation, the virtual validation value of the "Bacterial Culture" laboratory is 91.6%, which is in the **VERY VALID** category.

Some notes and input for the application are as follows: 1) The font size is the same, 2) There are several tools in the practice menu that cannot be clicked directly, 3) The use of background sound is too loud, and 4) There are several parts of the text that are too large and too dense so it is a bit uncomfortable to read because the text size is small.

After receiving notes and input from expert validators, the research team then coordinated to revise and perfect the application that had been developed.

e. Design Revision

Design revisions are carried out after receiving notes from validation experts. Design revisions were carried out using the help of the Canva application to design the layout and content of the application. After the product design had been revised, the researcher developed revisions to the Articulate Storyline 3 application and readjusted the triggers.

f. Small Group Trials

Small Group Trials were carried out on 3rd semester biology education students who had previously taken the Microbiology course in 2nd semester. These small group trials were related to the use of applications that had been developed after being validated and revised. At this stage the research team distributed the 'Bacterial Culture' application file (APK) and the GForm link for the practicality questionnaire sheet which consisted of 4 aspects including media design aspects, material presentation aspects, media format aspects, and media use aspects with a total of 20 questions. question.

After data analysis, it was discovered that the application developed was good and innovative without input from 22 respondents. The following

are the results of small group trials which have been analyzed using the Rasch model

Table 1. Unidimensionalitas

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TABLE 24.0 ANALISIS PRAKTIKALITAS.xlsx          ZOU250WS.TXT  Dec 08 2024 01:58
INPUT: 22 PERSON  20 ITEM  REPORTED: 22 PERSON  20 ITEM  3 CATS MINISTEP 5.8.2.0
-------------------------------------------------------------------------------

     Table of STANDARDIZED RESIDUAL variance in Eigenvalue units = PERSON information units
                                      Eigenvalue   Observed   Expected
Total raw variance in observations     =     38.7731 100.0%         100.0%
  Raw variance explained by measures   =     22.7731  58.7%          58.0%
    Raw variance explained by persons  =     15.3351  39.6%          39.0%
    Raw Variance explained by items    =      7.4380  19.2%          18.9%
  Raw unexplained variance (total)     =     16.0000  41.3% 100.0%   42.0%
    Unexplned variance in 1st contrast =      6.5080  16.8%  40.7%
    Unexplned variance in 2nd contrast =      3.3547   8.7%  21.0%
    Unexplned variance in 3rd contrast =      2.4821   6.4%  15.5%
    Unexplned variance in 4th contrast =      1.8520   4.8%  11.6%
    Unexplned variance in 5th contrast =      1.0507   2.7%   6.6%

Essential Unidimensionality (Rasch/Common variance) =  61.6%
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Table 2. *Raw variance explained by measures criteria*

Score	Description
<20%	Not Fulfilled
>20%	Fulfilled
>40%	Good
>60%	Very good

Table 3. *Unidimensionality criteria*

Score	Description
<15%	Unexpected Variance
<20%	Bad
>20%	Minimal
20%-40%	Enough
>40%	Good
>60%	Special

The results show that the Raw variance explained by measures is 58.7%, where this category means that the Virtual Laboratory media "Bacterial Culture" is **Good**. Meanwhile, the results of the practicality test when viewed from the unidimensionality criteria show that the raw variance of the virtual practicality data for the "Bacterial Culture" laboratory is 61.6% which is in the **Special** category, based on the unidimensionality criteria in Rasch modeling [9].

The development of the virtual laboratory application "Bacterial Culture" aligns with constructivist learning theory, which emphasizes that learners construct knowledge through active engagement and interaction with their learning environment. According to Jonassen (1994), technology-based learning tools such as virtual laboratories can provide an authentic and interactive context that facilitates deeper understanding [10]. This application allows students to simulate bacterial culture procedures in a controlled and guided environment, enabling them to practice without the risks associated with traditional laboratory settings, such as contamination or procedural errors.

Research by Rutten, van Joolingen, and van der Veen (2012) supports the effectiveness of virtual laboratories in enhancing practical competence [11]. Their meta-analysis found that students who used virtual laboratories before physical practicum sessions demonstrated improved understanding and procedural accuracy. Similarly, the study conducted by Chang et al. (2017) highlighted that virtual lab applications in microbiology education reduced errors and increased student confidence during physical lab work [12]. The findings from the small group trials in this study, where students rated the application highly for its usability and innovative design, align with these observations.

Moreover, the results of this study also corroborate the principles of the Independent Campus Learning Curriculum (MBKM), which emphasizes flexibility and technological integration in learning. By introducing a virtual laboratory, educators can offer students a personalized and adaptive learning experience, ensuring that they acquire the necessary competencies in bacterial culture techniques. The practicality results, evaluated through the Rasch model, further affirm the effectiveness of this application, categorizing it as "**Good**" and "**Special**," which highlights its potential to address the challenges commonly faced in microbiology practicum activities.

4. Conclusion

This research produces a virtual laboratory Android application 'Bacterial Culture' which is suitable for use by biology students. The Virtual Laboratory "Bacterial Culture" helps students understand the practical work of making culture media and microbial inoculation on media with microbiology practical work such as sterilization and isolation. Stage by stage it has proceeded according to the path, referring to the research stages that have been determined, namely the ten R&D procedural steps from the Borg & Gall model which were adapted and modified into six steps. This media has been validated by experts, namely lecturers in the Microbiology course, with validation analysis results of 91.6% (very valid) and media practicality of 61.6% (special).

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