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Development of a Virtual Tissue Culture Laboratory to Improve the Cognitive Abilities of Vocational School Students Studying Plant Agribusiness

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Abstract

The problem that arises during tissue culture learning is the limited laboratory facilities. The imbalance between the amount of equipment and the number of students causes the practicum to be carried out in turns for a long time, and is less efficient. The impact is that most students, after being assessed, obtain scores that are not as expected. Due to these problems, efforts are needed to utilize multimedia in virtual laboratories. This study aims to develop a virtual tissue culture laboratory at the Agribusiness Plant and Horticulture Vocational School and analyze the feasibility and effectiveness of the virtual tissue culture laboratory at the Agribusiness Plant and Horticulture Vocational School. This study uses the ADDIE (Analysis, Design, Development, Implementation, and Evaluation) development model. The experimental method used is a one-group pre-test-post-test design, with the selected sample being the XI ATPH class, which has 36 students in the experimental class and 36 students as instrument testing subjects. The results showed that the virtual laboratory was categorized as feasible for tissue culture learning based on assessments by media and material experts. The virtual laboratory was also considered very practical for tissue culture learning. Based on the N-Gain Score calculation, the virtual laboratory improved tissue culture learning outcomes with a high category. This study concludes that the virtual laboratory can overcome the problem of limited practical facilities.

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INTRODUCTION

Plant Food and Horticulture Agribusiness (ATPH) is one of the departments at vocational high schools (SMK) that focuses on agricultural technology. Some of the learning materials taught include conventional and modern farming systems. Some of these include tissue culture, which is related to the aseptic vegetative propagation of plants. SMKN 1 Singgahan is a vocational school in Tuban Regency that conducts face-to-face teaching and learning of this subject using lecture methods and practical work in shifts.

The problem that arises during the learning process is the limited laboratory facilities. The equipment available at the school only includes 1 Laminar Air Flow, 1 Autoclave, and 1 Hot Magnetic Stirrer. In contrast, ideally, 6 Laminar Air Flows, 2 Autoclaves, 4 Hot Magnetic Stirrers, and a more spacious incubation room are needed to support the lessons in one learning group. The imbalance between the amount of equipment and the number of students caused the practicum to be conducted in shifts for a long time, making it less efficient.

Another problem was the students' lack of understanding of the material, leading to poor learning outcomes. This was evidenced by the observations of 36 students conducted from August 21 to October 11, 2024, which showed that 73% of students scored below the Learning Objective Completion Criteria (KKTP). The students' low scores were due to the complexity of the tissue culture material, which consisted of the names of chemical compounds and calculations. They required precision in carrying out practical activities.

With advances in computer technology, one way to overcome this is to simulate some practical activities using multimedia, which is known as a dry laboratory or virtual laboratory. Simply put, Amanio et al. (2022) state that a virtual laboratory imitates a real laboratory. A virtual laboratory is a medium that is made to resemble and simulate the real conditions of a laboratory for practice before entering the actual laboratory.

Virtual laboratories are not considered a substitute or competitor for real laboratories, but rather an opportunity to bridge the gaps found in real laboratories, including experiments that are too expensive in equipment and materials. The time required to carry out experiments is significantly reduced, and routine procedures for processing experimental results become more effective and efficient. According to other research, using virtual laboratories for practical activities only requires less time than conducting practical work directly in a laboratory (Hensen et al., 2020).

Another study on the Development of Virtual Laboratories on plant tissue culture to improve student learning outcomes by Hartini et al. (2019) found that the Virtual Laboratory media developed is suitable for application in learning and can improve student learning outcomes on plant tissue culture. However, it must still be developed as an Android and WEB-based application. The development of a web-based virtual laboratory uses the Articulate Storyline application, an interactive learning media creation application. Articulate Storyline is one of the multimedia authoring tools used to create media with content in the form of a combination of text, graphics, sound, animation, and video (Amiroh, 2020). By utilizing these features, the virtual tissue culture laboratory can be accessed by students online via computers or mobile devices.

This study aims to develop a virtual tissue culture laboratory at the Agribusiness Plant and Horticulture Vocational School and to analyze the feasibility and effectiveness of the virtual tissue culture laboratory at the Agribusiness Plant and Horticulture Vocational School. This study is expected to make students feel comfortable while learning and create a practical, enjoyable, and easy-to-understand learning atmosphere, thereby improving student learning outcomes. The results of this study are expected to overcome problems that arise during practical learning. In addition, the results of this study can also be used as a reference for teachers to try to innovate in overcoming similar problems and to improve students' competence in learning the process of vegetative plant propagation.

METHOD

The media development design in this study was adapted from the ADDIE development model (Alodwan et al., 2018), which consists of five stages of development: Analysis, Design, Development, Implementation, and Evaluation. Educational development research includes development, product validation, testing, and evaluation. The development procedure for the "Virtual Plant Tissue Culture Laboratory to Improve Students' Cognitive Abilities" includes the following stages:

a. Analysis: Limitations of the laboratory, low cognitive value of tissue culture
b. Design: Instrument grid, research instruments, instrument testing, and storyboard
c. Development: media creation, media and material expert validation, revision
d. Implementation: pretest, media application, post-test, practicality testing
e. Evaluation: Can be developed further.

A sample is a part of the number and characteristics possessed by the population. Suppose the population is large and researchers cannot study everything, for example, due to limited funds, workforce, or time. In that case, researchers can use samples taken from the population (Sugiyono, 2016). In this study, the sample selected was ATPH class XI, with 36 students in the experimental class and 36 as instrument testing subjects.

The assessment results by media experts and subject matter experts for the feasibility test were analyzed using the Content Validity Ratio (CVR) method to calculate validity. In contrast, reliability was calculated using the Interclass Correlation Coefficients (ICC) method. Meanwhile, the feasibility of the test items was tested using item validity and reliability tests, item difficulty levels, item discrimination, and item distractor effectiveness. The method used to test effectiveness was a one-group pre-test-post-test design, which was based on students' learning outcomes in the experimental class, which were then analyzed using the N-gain test to determine the. Meanwhile, the practicality test was conducted by 36 students in the 11th grade of the Food Crops and Horticulture Agribusiness Competency at SMKN 1 Singgahan. The results were analyzed to calculate the reproducibility coefficient (Kr) and scalability coefficient (Ks) scores to determine the practicality of each aspect.

RESEARCH RESULTS AND DISCUSSION

Research Results

This research is a development and evaluation study of a virtual tissue culture laboratory to improve the cognitive abilities of vocational high school students in agribusiness using the ADDIE model, which consists of the stages of analysis, design, development, implementation, and evaluation. The results of the first stage, analysis, revealed a low understanding of tissue culture material and limited tissue culture laboratory facilities. The second stage was design, which involved identifying product specifications, creating and designing initial product designs, and developing product assessment instruments. The third stage was development, which involved creating virtual laboratory media, validating, and revising products. The fourth stage was implementation, which involved applying the virtual plant tissue culture laboratory to 36 students in the ATPH class XI as the experimental class. The final stage was evaluation, which involved improving the system based on data from the previous stages.

In the media feasibility test, media experts validated the media to test its feasibility based on five aspects, namely initial appearance, media format, media content, Virtual Laboratory characteristics, and design. The validation results by media experts for all aspects were analyzed, and a score of 84 % was obtained, which is categorized as very feasible for use as teaching media for students. Meanwhile, subject matter experts conducted material validation to test suitability based on four aspects: content quality, instructional quality, substance of tissue culture, and technical quality. The validation results by media experts for all aspects were analyzed and yielded a score of 94%, which falls into the highly suitable category for teaching media to students.

The effectiveness test was conducted in stages: normality, homogeneity, and N-Gain. The normality test on the pretest and post-test results was conducted using the Kolmogorov-Smirnov

test method with the help of SPSS 21 software. Analysis of the pretest results showed a statistical value of 0.970 with a significance value of 0.434, so it can be concluded that the data follows a normal distribution because the Sig value is greater than 0.05. Meanwhile, the analysis of the post-test results showed a statistical value of 0.955 with a significant value of 0.155, so it can be concluded that the data follows a normal distribution because the Sig value is greater than 0.05. The results of the homogeneity test of the pretest and posttest data, analyzed using SPSS, showed that the significance value of the pretest and posttest data was 0.254. From the homogeneity data of the pretest and posttest, the significance value is > 0.05, so the data can be said to be homogeneously distributed. The analysis of media effectiveness was obtained from the results of the post-test and pre-test with one trial, which was then calculated to obtain the N-Gain score. The calculation results obtained an N-Gain score of 0.76, which is in the high category, or in percentage form, 76%, which is in the effective category. Based on the interpretation of the effectiveness of the N-Gain score, it can be concluded that the plant tissue culture laboratory effectively improves student learning outcomes.

The practicality test of the Virtual Laboratory was conducted by 36 students in grade XI of the Agribusiness Competency in Food Crops and Horticulture at SMKN 1 Singgahan to assess the practicality of the virtual tissue culture laboratory in improving the cognitive abilities of vocational school students in agribusiness. The results of the practicality test analysis of the four aspects assessed, namely interest, material, language, and competence, obtained a reproducibility coefficient or Kr of 0.91. This coefficient is still above the practicality requirement threshold of 0.90. These results are reinforced by the scalability test, which obtained a score of 0.72, which is still above the requirement of 0.60. Based on the practicality test, considering the reproducibility coefficient and scalability coefficient values, it can be concluded that the Virtual Laboratory for tissue culture learning is deemed “practical.”

Discussion

This study aimed to develop a Virtual Tissue Culture Laboratory to improve students' cognitive abilities in tissue culture material. The implementation process followed the ADDIE model, which consists of five stages: (1) Analysis, (2) Design, (3) Development, (4) Implementation, and (5) Evaluation (Suryani et al., 2024). The analysis involves identifying needs and characteristics and reviewing the curriculum and technology (Nurrokhman et al., 2025). The analysis results showed a low level of understanding of tissue culture material. This is due to students' low interest in learning, their tendency to use mobile phones during lessons, and teachers' uninteresting teaching methods. The following analysis result is the limited laboratory facilities, which affect the practical work process at school because students must take turns to use them. Laboratory facilities are one of the factors causing learning difficulties, as stated by Fatah et al. (2021), who said that the factors causing learning difficulties stem from an unsupportive learning atmosphere, a weak learning foundation, an unfavorable learning environment, teaching design, lesson delivery, and teaching aids that are not suitable for the needs.

Virtual laboratories have received favorable reviews from media experts for their application in teaching tissue culture material. The factors that influence this suitability include: 1) attractive media display with a harmonious color combination and balance between colors and text; 2) expert involvement in the development process; 3) completeness of material, animation, suitability of material with learning objective indicators, and ease of correcting answers; 4) ease of use of the navigation menu and online presentation that resembles a real laboratory. This is in line with the opinion of Annisa et al. (2020) that learning media components, including images, text, audio, and animations, must be easily accessible and operable to make it easier for students to absorb the material provided.

Subject matter experts assess that virtual laboratories are highly suitable for use as learning media. This is influenced by: 1) clear quality and content objectives, including material accuracy,

material completeness, concept suitability, image completeness, and material clarity; 2) instructional quality, including providing learning opportunities, consistency in material presentation, accuracy of illustration presentation, logical presentation, ability to encourage motivation, and suitability of questions to the material; 3) Technical quality, including multimedia quality related to audio-visual aspects and programming quality. The feasibility of this multimedia-based interactive virtual laboratory is also in line with what Alshatri et al. (2019) stated, namely that the learning process using audio-visual media helps students to understand the concept of learning optimally as a teaching aid. Lampropoulos et al. (2021) also stated that videos can be a valuable means to create a richer virtual experience and as a complementary educational tool that can enrich the teaching and learning process, increasing student motivation, engagement, and enjoyment.

The effectiveness of using virtual laboratories was obtained through the N-Gain Score calculation. The results showed that learning in an experimental class using virtual laboratories effectively improved students' cognitive abilities. Based on the Kamus Besar Bahasa Indonesia (KBBI), which defines the word effective as successful or able to bring results, virtual laboratories can be said to be successful in improving students' cognitive abilities in network culture material. The effectiveness of the media developed for this learning is also due to the fact that it has undergone a series of feasibility and practicality tests by experts. In addition, based on observations during learning, students could maximize the use of the teaching aids without being constrained by the limitations of practical facilities. This shows that virtual laboratories are one of the learning media that can overcome problems related to practical school facilities. One factor that most likely contributed to this improvement was the high level of student motivation triggered by using ICT-based interactive learning media (Soamole, 2024). Putri (2021) states that students' absorption and memory of lesson material can increase significantly if the information acquisition process involves the senses of hearing and sight. Supraptono et al. (2025) say that media technology is important in modern education, functioning as a vital tool for knowledge transmission and increasing student participation in learning activities.

Based on practicality tests conducted on users, as seen from the reproducibility coefficient and scalability coefficient values, it can be concluded that the virtual laboratory for tissue culture learning is "efficient." In line with the meaning of the word practical, which is easy and enjoyable, several indicators that show the interest of respondents received perfect scores, such as having an attractive appearance, being easy to understand, being able to motivate, not being boring to use, the availability of complete information related to tissue culture steps, and the virtual laboratory being adapted to the actual laboratory. In line with the research by Arimbawa et al. (2024), this learning medium has met the established standards of practicality or readability after testing the practicality on computers and smartphones.

The virtual tissue culture laboratory in Vocational High Schools (SMK) can be categorized as highly feasible, effective, and practical for enhancing students' cognitive abilities. The novelty in this research is (1) the development of a virtual laboratory as a learning medium for tissue culture material, (2) there are sequential work steps accompanied by images, simulations, and learning evaluation questions, and (3) it can be applied directly on mobile phones by students with expertise in Food Crop and Horticulture Agribusiness.

CONCLUSION

Based on the results and discussion in this study, it can be concluded that: (1) The developed virtual laboratory is suitable for tissue culture learning processes. (2) The developed virtual laboratory is efficient for tissue culture learning processes. (3) The virtual laboratory improves students' cognitive competencies in tissue culture material.

REFERENSI

Amiroh. (2020). *Mahir Membuat Media Interaktif*. Yogyakarta: Pustaka Ananda Srva

Alodwan, T., & Almosa, M. (2018). The Effect of a Computer Program Based on Analysis, Design, Development, Implementation, and Evaluation (ADDIE) in Improving Ninth Graders' Listening and Reading Comprehension Skills in English in Jordan. *English Language Teaching*, *11*(4), 43. https://doi.org/10.5539/elt.v11n4p43

Alshatri, S. H. H., Wakil, K., Jamal, K., & Bakhtyar, R. (2019). Teaching Aids Effectiveness in Learning Mathematics. *International Journal of Educational Research Review*.

Amanio, Y. K. V., Legaspino, C. O., Mondido, J. R. C., Somosot, I. S., & Borlio, J. G. (2022). Investigating The Academic Experience of Science Education Students with Virtual Laboratory Classes: A Convergent Parallel Approach. *Asia Pacific Journal of Educators and Education*, *37*(2), 281–299. https://doi.org/10.21315/apjee2022.37.2.14

Annisa, A. R., Putra, A. P., & Dharmono. (2020). Kepraktisan Media Pembelajaran Daya Antibakteri Ekstrak Buah Sawo Berbasis Macromedia Flash. *Jurnal Inovasi Pendidikan Sains*, *11*(1), 72–80.

Arimbawa, G. P. A., Ariawan, I. P. W., & Parwati, N. N. (2024). Pengembangan Virtual Lab Untuk Meningkatkan Kemampuan Berpikir Kritis Siswa SMP Kelas VIII Pada Mata Pelajaran Matematika. *JKTP: Jurnal Kajian Teknologi Pendidikan*, *7*(1), 046. https://doi.org/10.17977/um038v7i12024p046

Fatah, M., Suud, F. M., & Chaer, M. T. (2021). Jenis-Jenis Kesulitan Belajar dan Faktor Penyebabnya Sebuah Kajian Komperehensif pada Siswa SMK Muhammadiyah Tegal. *Psycho Idea*, *19*, 1–5.

Hartini, H., Narulita, E., & Iqbal, M. (2019). Pengembangan Virtual Laboratory pada topik kultur jaringan tumbuhan untuk meningkatkan hasil belajar siswa. *JIPVA (Jurnal Pendidikan IPA Veteran)*, *3*(1), 1-16.

Hensen, C., Glinowiecka-Cox, G., & Barbera, J. (2020). Assessing differences between three virtual general chemistry experiments and similar hands-on experiments. *Journal of Chemical Education*, 97(3):616–625

Lampropoulos, G., Barkoukis, V., Burden, K., & Anastasiadis, T. (2021). 360-Degree Video in Education: An Overview and a Comparative Social Media Data Analysis of the Last Decade. *Smart Learning Environments*, *8*(1).

Nurrokhman, T., Khumaedi, M., & Sutopo, Y. (2025). Application of Android-Based E-Module in Occupational Health, Safety, and Environmental Protection and Industrial Work Culture Material. *Journal of Vocational and Career Education*, *50124*(121).

Putri, R. P. (2021). Analisis Penggunaan Media Pembelajaran Berbasis Video Pada Pembelajaran Tematik Terpadu Di Sekolah Dasar. *Journal of Basic Education Studies*.

Soamole, H. (2024). Penggunaan Media Interaktif Berbasis ICT dalam Meningkatkan Motivasi Belajar Siswa Kelas VII di MTsN 1 Sanana. *JIPDAS : Jurnal Ilmiah Pendidikan Dasar*, *2*(2), 89–97.

Sugiyono. (2016). *Metode Penelitian Kuantitatif, Kualitatif, dan R&D*. Bandung : Alfabeta

Supraptono, E., Wagino, W., Abidin, A. F. Bin, Yusro, M., & Koto, R. D. (2025). Enhancing Student Understanding in Electrical Engineering: An Android-Based e-Learning Approach. *International Journal of Information and Education Technology*, *15*(6), 1150–1160. https://doi.org/10.18178/ijiet.2025.15.6.2318

Suryani, T., Anis, S., Mediaty Arief, U., Raya, J., Tonjong, K., & Brebes, K. (2024). The Development of a Digital Electronics Trainer for Teaching Fundamentals of Electronics Engineering. *Journal of Vocational and Career Education*, *9*(2), 132–139. https://doi.org/10.15294/jvce.v9i2.29004