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Development of a Biology Virtual Laboratory (V-Lab) for Microscopic Observations about Onion Cells and Cassava Plant Cells

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Abstract: This research aims to develop a virtual laboratory (v-lab) using Adobe Animate cc 2023 with a project-based evaluation to help students get to know microscopes and understand the steps of their use, especially observe about onion cells and cassava plant cells. This research also aims to evaluate the V-Lab which was developed through validation by validators and effectiveness test by respondents to produce valid, practical and effective media for Biology learning. The research method use Research and Development (R & D) from the 4D model. Data were obtained using a questionnaire given to several validators and respondents amount 39 students. Data analysis was conducted quantitative by calculating the percentage of assessments from validators and respondents and then qualitative analysis with describe the assessment result with validation criteria. The validation results from material experts show that the substance of the material in this V-Lab has been explained with the right concept, easy to understand and systematic. The validation results from media experts show that this media has clear and interested display and navigation with consistent functions.The results of the trial on students showed a higher response to the usability aspect, which means that the media developed can provide knowledge and understanding to get to know microscopes, provide experience as if they were using a real microscope and the use of this V-lab can overcome the limited availability of microscopes in practical activities. The validity of the material and the V-lab media developed makes this media very suitable and interesting to use in biology learning, especially in getting to know microscopes and making simple observations about cells. The limitations of microscope units in the laboratory is no longer a problem to realizing effective learning.

Abstrak: *Penelitian ini bertujuan untuk mengembangkan laboratorium virtual (virtual laboratory/v-lab) menggunakan Adobe Animate cc 2023 dengan disertai evaluasi berbasis proyek untuk membantu mahasiswa mengenal mikroskop dan memahami langkah penggunaannya terutama pada pengamatan sel irisan bawang merah dan gabus ubi kayu. Tujuan lainnya juga untuk mengevaluasi V-Lab yang dikembangkan melalui validasi dari para ahli dan uji efektifitas dari responden hingga dihasilkan media yang valid, praktis dan efektif untuk pembelajaran Biologi. Metode penelitian menggunakan Research and Development (R & D) dari model 4D. Data*

diperoleh menggunakan kuesioner yang diberikan terhadap beberapa validator ahli materi dan ahli media serta responden yang berjumlah 39 orang mahasiswa. Analisis data dilakukan secara kuantitatif dengan menghitung persentase penilaian dari validator serta responden dan selanjutnya analisis kualitatif dengan mendeskripsikan hasil penilaian terhadap kriteria validasi. Hasil validasi dari ahli materi menunjukkan bahwa substansi materi pada V-Lab ini telah dijelaskan dengan konsep yang tepat, mudah dipahami dan sistematis. Hasil validasi dari ahli media menunjukkan bahwa media ini memiliki tampilan yang jelas dan menarik serta fungsi navigasi yang tepat dan konsisten. Hasil uji coba terhadap mahasiswa menunjukkan respon yang lebih tinggi terhadap aspek daya guna yang berarti media yang dikembangkan dapat memberikan pengetahuan dan pemahaman untuk mengenal mikroskop, memberikan pengalaman seolah-olah mereka menggunakan mikroskop secara nyata dan penggunaan V-lab ini dapat mengatasi keterbatasan ketersediaan mikroskop dalam kegiatan praktikum. Adanya validitas terhadap materi dan media V-lab yang dikembangkan menjadikan media ini sangat layak dan sangat menarik digunakan dalam pembelajaran biologi khususnya dalam mengenal mikroskop dan melakukan pengamatan sederhana mengenai sel. Keterbatasan mikroskop di laboratorium tidak lagi menjadi masalah untuk dapat mewujudkan pembelajaran yang efektif.

Keywords: *Virtual Laboratory, Adobe Animate Cc, Project-Based Evaluation*

INTRODUCTION

One of the essences of learning science is science as a process or also known as science process skills. Learning activities that can build scientific process skills are primarily observation and experimentation. Ideally science learning should be done in the laboratory. A laboratory with complete tools and substances for experiments will provide a more meaningful learning experience. In fact, the IAI Yasni Bungo Tadris IPA study program does not yet have a complete laboratory, for example, there are only 2 microscope units, whereas many students will use them. This causes practical activities to be ineffective.

Biology learning, especially about the use of a microscope, if it is not practiced directly, certainly does not realize the essence of science as a process or does not develop scientific process skills for students. Apart from that, students also do not get experience and competence as science teachers. If this problem is not resolved then learning will become less meaningful because students only learn theoretically.

The limitations of microscope units in the laboratory is no longer a problem for conducting practicums. Currently, innovations have emerged in multimedia technology, namely virtual laboratories. This laboratory is designed using software or applications with virtual images of tools and substanstion that can be used with a computer/smartphone to provide users with an experience as if they were in a real laboratory. Students can still recognize various types of microscopes, understand their parts or components and carry out observation steps such as using a microscope directly.

If the problem of limited microscope units is not resolved, students will never learn about microscopes and will not understand how to use them. The long-term impact will be the problem when they later teach in schools and cannot teach students to use microscopes that must be available in the school laboratory. Therefore, the use of this

virtual technology can be the best solution to build self-skills in using microscopes.

Experiment activities with virtual laboratory can make the learning process more interesting, interactive, efficiency learning time, improve the quality of learning and the learning process becomes more flexible by being able to be done anywhere and anytime (Elia & Nana, 2020). Virtual laboratories can be useful in student learning by implementing practical activities that are low in cost and risk. (Federal et al., 2021) recommends that all levels of schools can use a virtual laboratory learning platform that can provide a long-term solution to improve students' laboratory skills. The use of virtual microscopes can still provide scientific process skills experience. This is supported by the results of research by (Hidah & Sudibyo, 2022) which states that the use of virtual labs can improve students' science process skills and scientific attitudes. (Haryadi & Pujiastuti, 2020) also stated that the application of physics learning using virtual labs can be an interactive learning medium that improves students' science process skills.

(Yuliana & Saragih, 2025) also stated that the use of virtual labs can stimulate students' creativity because they can carry out experiments repeatedly so that they can understand the concepts they have learned in more depth. This is in line with the finding that virtual laboratories provide opportunities for students to practice intensively and independently, which has a positive impact on their mastery of concepts and the development of their creativity (Muhajarah & Sulthon, 2020).

A comparison of the use of a real microscope with a virtual laboratory microscope has been conducted by (Chang et al., 2021) on the topic of histology, the results of which explain that the use of a microscope with digitized virtual slides has a higher acceptance rate and better diagnostic capabilities compared to the use of a real microscope with real glass.

There are various types of software that can be chosen in designing this virtual laboratory (v-lab) and one of them is Adobe Animate CC 2023. This software is multimedia used in creating animations which was previously known as Adobe Flash from Adobe Systems (Supit et al., 2021)

There has been several previous studies regarding this virtual laboratory. Among them is research conducted by (Minarni et al., 2023) regarding "Development of V-lab based on Adobe Flash CS6 on chemical equilibrium material". (Firdaus et al., 2022) about "Development of interactive online microscopes on cell biology material to revitalize online practical learning". (Meilina et al., 2023) regarding "Analysis of the effectiveness of virtual practicums using the Android-based Everycircuit application in learning in the Covid-19 pandemic era". (Herman, 2024) regarding "Development of learing multimedia using macromedia flash 8 in PAI subject at SMP".

All of this research shows the success of the virtual lab media developed. There are various types of applications used in making it, such as Adobe Flash, EveryCircuit, Adobe Animate CC 2020 and Macromedia Flash 8. Each has advantages and disadvantages.

The use of Adobe Animate CC 2023 and project-based evaluation functions as the main innovations that have not been explored by previous studies. The material chosen is also different from other studies, namely regarding microscopes by describing their types, recognizing their components and understanding the steps of their use such as using a microscope directly. In addition, innovation is also with project-based evaluation through the creation of a smartphone microscope. In addition, other studies using Adobe Animate in the development of interactive learning media also confirmed its effectiveness in improving

students' understanding of the material and interactivity (Lahinta, 2025). However, the use of the latest version of Adobe Animate CC 2023 and the integration of project-based evaluation as the main innovation still need to be studied further to fill the existing research gap and maximize the potential of this technology in the context of modern learning (Dwinanto et al., 2024).

This research aims to develop a biology virtual laboratory (v-lab) using Adobe Animate CC 2023 which is proven to be valid based on the assessment of media and substance expert validators and is also proven to be effective from student responses.

The research methodology uses research and development from the 4D model (Thiagarajan and Semmel) which consists of the Define stage (defining research objectives), Design stage (designing media), Develop stage (developing media with validator and respondent assessments) and Disseminate stage (disseminating research results to make them more useful).

This research not only aims to develop a virtual laboratory but also explore its impact in improving students' scientific skills especially in using microscopes with the right steps and exploring its impact on improving the effectiveness of Biology learning.

Based on the description above, research has been carried out with the title "Development of a Biology Virtual Laboratory (V-Lab) for Microscopic Observation about Onion Cells and Cassava Plant Cells Using Adobe Animate CC 2023 with Project Based Learning Evaluation".

METHODS

This type of research is development research (Research and Development/R&D) with 4D model pioneered by Thiagarajan and Semmel. This model consists of a definition stage, a design stage, a development stage and a disseminate stage.

In general, the definition stage is carried out by analyzing development needs, product development requirements that are in accordance with user needs and the appropriate development research model to use (Fayrus & Slamet, 2022). At this research definition stage, researchers conduct a needs analysis about the need to produce a virtual laboratory especially microscopes. The unit of real microscopes available is not enough for practical learning for all students. The design stage is the initial stage of designing the future product developed. The product design must be adapted to the material
and course learning outcomes (Nilasari et al., 2025). At this research design stage, researchers began designing virtual laboratory media about the introduction of microscopes and their use. The application or software used in making this media Adobe Animate CC 2023. Researchers create an initial design or draft with a story board about the items contained in the virtual laboratory from the initial login to various menu options.

At the develop stage, learning media is developed or created based on the design that has been prepared in the previous stage. At this stage, a trial is also carried out to see the interaction and user experience of the media that has been developed. If errors or deficiencies are found, improvements will be made (Riani Johan et al., 2023). At this research development stage, researchers prepare media assessment instruments that will be given to substansion validators and media validators to determine the feasibility of the virtual laboratory that has been designed. The media will be revised based on the validator's suggestions. After getting a good assessment or the media is suitable for use, a trial will be conducted on the research subjects.

The subject of this research was first semester Tadris IPA IAI students Yasni Bungo. The choice of this class is based on considerations of the course being

implemented, namely basic biology which begins with an introduction to the microscope. This research requires assessment from experts known as validators to validate the product in the form of virtual laboratory media being developed. Validators are differentiated into substance validators and media validators.

The dissemination stage is the final stage which aims to socialize or promote the product that has been developed so that more parties can benefit from it. The success of this stage is highly dependent on user analysis, selection of distribution strategies, proper timing, and selection of effective media to reach the target audience. Thus, the dissemination stage not only functions as a promotion, but also as a process of ensuring that the product can be implemented widely and sustainably (Dubinina & Spinola, 2020). (Sihombing, 2024) explains that some things that need to be considered when carrying out dissemination are: (1) user analysis, (2) determining strategy and theme, (3) choosing the time, and (4) choosing media.

The data collection technique in this virtual laboratory (v-lab) development research is by giving questionnaires to substance validators, media validators and students as users. This instrument is in the form of a sheet containing a statement. In the questionnaire with closed statements, answer choices are available in the form of a Likert scale with categories; Strongly Agree (SS; score 4), Agree (S; score 3), Disagree (TS; score 2) and Strongly Disagree (STS; score 1).

The validator makes an assessment by giving a check mark on each instrument statement. Indicators of substance validation include aspects of learning or suitability of substantion with lecture achievements and the use of media that can provide knowledge and experience in learning. This approach is important to ensure that the instruments used are not only theoretically relevant, but also applicable in real learning contexts, so that they can increase the effectiveness of learning and student learning outcomes (Smith, A., & Johnson, R. 2023). Other aspect indicators are the assessment of the concept of substance is related to the accuracy of the theory, evaluation questions and project steps. Finally aspect of this substance validation concerns the effectiveness of media use. Validation of the virtual lab media that has been developed is related to the appearance aspect such as selection of text/writing, animation, layout, audio and menus. Other aspect indicators are the media navigation aspect and finally the technical aspect related to the ease of use of the media.

The assessment of each validator will be added up and calculate the percentage. The final validation is obtained by calculating the average between the first validator and the second validator (substance validators and media validators each amount two people). The average percentage obtained then converted with a criteria table to determine whether the media is valid or not. On the instrument sheet there is also a comments column for validators to write criticism or suggestions regarding the media that has been developed.

Media that has been validated based on the validator's assessment will be tested on 39 student respondents to determine its effectiveness. They also put a check mark on each instrument statement. The indicators of the effectiveness test consist of technical usage aspects, program content presentation aspects and usability aspects.

The technical usage aspect is related to the clarity of the instructions for using the media, the study of the substance and the practical steps and project activities which are easy to understand and implement well. Recent research confirms that clear and easy-to-understand instructions are essential for users to access and use media effectively without technical barriers. For example, in

the development of educational film media integrated with the deep dialogue learning model, the aspects of readability and ease of use are the main focus, where user-friendly usage guides and easy-to-read fonts greatly support the effectiveness of the media (Yudi Wahyudin et al., 2024). The presentation aspect of program content is related to the attractiveness of the display media, especially in the selection of animation, audio, and navigation. The usability aspect is related to the benefits of using media that can provide knowledge and experience in learning and solve the problem about limitations of microscopes in practical activities.

The results of the media effectiveness test are obtained by adding up all student assessments and determining the percentage and calculating the average value. The values obtained will also be converted with a criteria table to determine whether the developed media is interesting or not. The students as respondent can also write their criticisms and suggestions on the instrument sheet (Afifah et al., 2025).

RESULTS AND DISCUSSION

Result

The research results are described based on each stage of the 4D development model.

1. Define phase

This stage describes the results of the analysis of the problems that cause the need for media development, analysis of student learning characteristics, analysis of appropriate assignments for students, analysis of the learning substance regarding microscope practicum and analysis of learning outcomes

a. *Front-end Analysis*

The results of the initial analysis of problems related to the limitations of microscopes were only two for many students thus causing learning to be ineffective.

b. *Learner Analysis*

Analysis of student learning characteristics related to science process skills which prioritize observation or investigation activities in learning. Science concepts should not be given textually but obtained contextually through practical activities. This will support learning to be more meaningful.

c. *Task Analysis*

Learning science, especially biology, requires a lot of observation using a microscope. In basic biology courses, students have to make several observations with a microscope, including observing onion cells and the anatomy of plant organs. Therefore, it is very necessary for students to understand how to use a microscope correctly.

d. *Concept Analysis*

This analysis identifies the main concepts of the substance regarding microscopes such as the history of microscopes, types of microscopes, microscope parts and their functions.

e. *Specifying Instructional Objectives*

Learning oucomes about microscope such as; (1) Get to know various types of microscopes, (2) Identify the parts of a microscope and their functions, (3) use a microscope with the right steps to observe an object, (4) working on creating microscope smartphone media.

2. Design Phase

At this stage a design is made for the product to be developed. Researchers collaborate with multimedia experts. The researcher created a design on a story board, then a multimedia expert designed the software and application using Adobe Animate CC 2023.

The initial design displays the title of the virtual lab substance as well as information about the institution and study program from the researcher. Users or students will then be directed to log in before entering the main menu. On the main menu there are other

menu options including instructions for using v-lab, learning achievment, substance studies, practicum activities and evaluations.

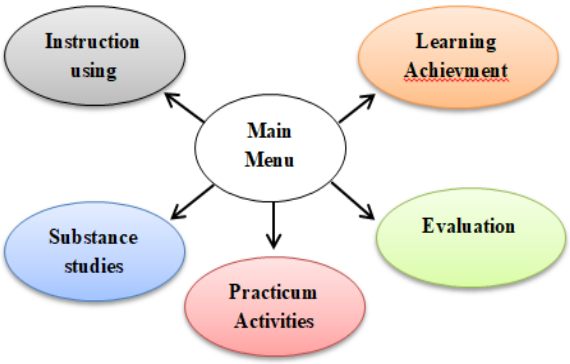

Figure 1. Menu options in the virtual lab

Instruction using introduce the buttons in the virtual lab and how to use them. Learning achievment regarding the competencies that must be achieved after learning with a virtual lab. Subtance studies consist of history of the microscope, types of microscopes, parts of a microscope and their functions. Practicum activities is a virtual practice of using a microscope with systematic steps like using a real microscope.

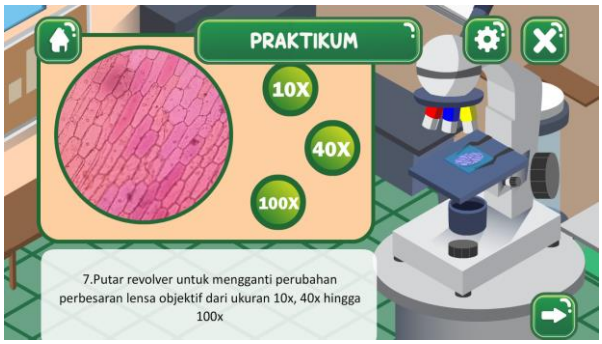

Figure 2. An example of one of the steps of using a microscope on this media

The practicum observes onion cells and cassava plant cells to observations with different ocular lens magnifications. Evaluation menu consists of a written evaluation by working on test questions and an evaluation with a project activity called a 'smartphone microscope'. Students first watch a video about making this project, then study the steps and prepare the tools and materials to then work on it.

3. Develop phase

At the development stage, the product is ready to be designed and will then be assessed by validators.The results of the assessment by the substance validator, media validator and effectiveness test from students as respondents can be seen in the table below.

Table 1. Validation result by substantion media validators and trial responses form respondents

Assessment Result	Main Percentage	Criteria
Substance Validator	89,78 %	Very Valid
Media Validator	93,75 %	Very Valid
Responses about Technical Usage	90,63 %	Very Interesting
Responses about Presentin Content	87,05 %	Very Interesting
Responses about Usability	91,07 %	Very Interesting

Based on the table above, it can be seen that the results of subtantion validation 89,78% have achieved the 'Very Valid' criteria. The validator evaluated that the substance of the virtual laboratory developed support lecture achievements, explains the theory accurately and the use of media can provide knowledge and experience in learning.

The result of media validation 93,75% which means it has achieved the 'Very Valid' criteria. The validator evaluated that the media
has used text or writing that can be read well, interested animations, appropriate layout, clear audio sound, menu with various choices and easy to understand and use media navigation.

The results of student responses about technical usage 90,63% which means it has achieved the 'Very Interesting' criteria. The instructions for using the media are clear, the description of the substance can also be read well, and the practical steps and project activities can be carried out.

The results of student responses about presenting Content 87,05% have achieved the 'Very Interesting' criteria. Students

evaluated that the media had an attractive appearance with appropriate selection of animation, audio and navigation.

The results of student responses about usability 91,07% have achieved the 'Very Interesting' criteria. Students evaluaed that the use of media can provide knowledge and experience in learning and be a solution to the problem of limited microscopes for practical activities.

Based on the results of validation and effectiveness test confirm that this virtual lab can be used to support the implementation of virtual learning practicums.

4. Disseminate phase

At this stage the researcher plans to socialize the use of this media through workshops for students and teachers in secondary schools and Islamic boarding schools, especially students majoring in science. This aims to make the media developed more widely useful.

Discussion

Based on the assessment from the validator and student responses, it can be stated that the virtual laboratory media developed is very valid and very interested for use virtual practical learning. This is in accordance with the research purposes to produce virtual lab media that is proven to be valid, practical and effective. This virtual laboratory is a solution to the problem of limited microscopes so that students can still get to know microscopes and simulate their use.

Previously, students were less familiar with the parts of a microscope and did not know how tu use it. With this virtual lab, they can learn about various types of microscopes, get to know their parts and their respective function, and learn how to use them step by step. This certainly supports the achievment of learning objectives.

This research is different from other virtual laboratory research because the media has been designed with various menu option to provide a meaningful learning experience. They get to know various types of microscopes and identify the parts of microscopes commonly used in schools. The use of virtual microscopes also illustrates the same steps as their real use so that students will still be abe to guide students when they later teach at school. Another virtual lab research on microscopes was conducted by (Firdaus et al., 2022) with their research regarding development of an interactive online microscope. This research focuses on the use of microscopes which begins with reading the procedures then doing the practicum and finally making a practical report. This clearly shows the difference with the virtual lab that has been developed. Another innovation from the virtual lab that was developed is the existence of project-based evaluation.

The result of the validator's validity and the high students responses indicate that the media developed greatly supports biology learning, especially virtual microscope use practicums. Media that has been proven to be valid, practical and effective means that it can be used by educators and students anywhere who have limited microscope units so that learning becomes effective and achieve learning purpose.

CONCLUSION

This development research has produced a product, namely a virtual laboratory (v-lab) about a microscope which shows a virtual simulation of its use to observe onion cells and the inside of cassava plants. This study is different from other virtual microscope laboratory studies because it displays systematic steps for using a microscope as in real practicums to show clear observation results from various lens magnifications. Another innovation is the existence of a project-based evaluation that displays the steps for making a 'microscope smartphone'.

Therefore, users of this virtual laboratory will be able to provide meaningful knowledge and experience in learning for students.

The validation results from the material validator reached a percentage of 89.78, the validation results from the media validator reached 93.75 and the effectiveness test on students reached a percentage of 90.63 for technical use, 87.05 for content presentation and 91.07 for usability. This proves that the media that has been developed is proven to be valid, practical and effective.

Through the results of this research, the problem of microscope limitations can be overcome by using a virtual laboratory. Students can still recognize the parts of a microscope and use it with the correct procedural steps in observing objects. This provides an experience like using a real microscope. This is because the media displays a microscope image that is exactly the same as the available unit example. The virtual lab also introduces the parts of the microscope and their functions. The steps of use are also systematic, starting from placing the preparation, setting the object table to using macro and micro magnification. This shows a picture like the use of a real microscope and students can finally see the results of observations using the ocular lens.

The existence of project-based evaluations develops students' skills to create learning media that has functions like a microscope, known as a smartphone microscope. The use of virtual laboratories can also increase students' independence in learning because they can continue to use them without being limited by time and classes.

However, the researcher still provides suggestions for further researchers to be able to integrate interactive assessments in the use of this virtual laboratory (v-lab) and expand its usability testing. This is so that the media that has been developed becomes better and provides more benefits to educators and students in supporting learning objectives.

REFERENCES

Afifah, N., Tang, J., & Zain, S. (2025). *Efektivitas Penggunaan Media Pembelajaran Interaktif Berbasis Aplikasi Canva terhadap Hasil Belajar Dasar-Dasar Kejuruan Siswa Kelas X APHP UPT SMK Negeri 8 Pinrang*. *5*, 733–742.

Chang, J. Y. F., Lin, T. C., Wang, L. H., Cheng, F. C., & Chiang, C. P. (2021). Comparison of virtual microscopy and real microscopy for learning oral pathology laboratory course among dental students. *Journal of Dental Sciences*, *16*(3), 840–845. https://doi.org/10.1016/j.jds.2021.03.011

Dubinina, E., & Spinola, S. (2020). *Dissemination and outreach plan*. *101004887*.

Dwinanto, A., Bouty, A. A., Latief, M., Novian, D., & Rijal, B. S. (2024). *Development of interactive learning media using Adobe Animate for computational thinking materials*. *6*(2), 112–120. https://doi.org/10.37905/jji.v6i2.28064

Elia, M. R., & Nana. (2020). Penerapan Problem Based Learning Berbantuan Virtual Lab Phet pada Pembelajaran Fisika Guna Meningkatkan Pemahaman Konsep Siswa SMA : Literature Review. *Jurnal Pendidikan Fisika Tadulako Online (JPFT)*, *8*(1), 87–92.

Fayrus, & Slamet, A. (2022). *Model Penelitian Pengembangan (R n D)*.

Federal, T., Ilaro, P., & State, O. (2021). *Oladejo2021*. *3*(1).

Firdaus, Z., Izza, J. N., Aruna, A., Novaldi, M. D., & Setiawan, D. (2022). Pengembangan mikroskop online interaktif pada materi biologi sel guna revitalisasi pembelajaran praktikum daring. *JINoP (Jurnal Inovasi Pembelajaran)*, *8*(1), 95–105. https://doi.org/10.22219/jinop.v8i1.189

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Haryadi, R., & Pujiastuti, H. (2020). PhET simulation software-based learning to improve science process skills. *Journal of Physics: Conference Series*, *1521*(2), 0–6. https://doi.org/10.1088/1742-6596/1521/2/022017

Herman, M. F. (2024). *Development of Learning Multimedia Using Macromedia Flash 8 in PAI Subject at SMP*. *27*(2), 355–364.

Hidah, L., & Sudibyo, E. (2022). Penerapan Model Discovery Learning Berbasis Mobile Virtual Laboratory Untuk Meningkatkan Keterampilan Proses Sains Dasar. *Pensa: E-Jurnal Pendidikan Sains*, *10*(2), 185–192. https://ejournal.unesa.ac.id/index.php/pensa/article/view/44737%0Ahttps://ejournal.unesa.ac.id/index.php/pensa/article/download/44737/40041

Lahinta, A. (2025). *Pengembangan Media Pembelajaran Interaktif Mata Pelajaran Bahasa Inggris Menggunakan Aplikasi Adobe Animate Kelas VII Di SMP Negeri 3 Gorontalo Abstrak*. *5*(1).

Meilina, I. L., Rohmah, A. A., F, D. S. N., A, L. L., & Farikha, N. (2023). Studi Literatur Efektivitas Virtual Laboratorium Pada Pembelajaran Fisika. *Jurnal Ilmu Pendidikan Dan Pembelajaran*, *1*(2), 40–50. https://doi.org/10.58706/jipp.v1n2.p40-50

Minarni, M., Epinur, E., Yusnidar, Y., & Ramadani, Y. (2023). Laboratorium Virtual Berbasis Adobe Flash Cs6 Profesional Materi Kesetimbangan Untuk Kimia Dasar I Prodi Pendidikan Kimia. *Jurnal Zarah*, *11*(1), 53–61. https://doi.org/10.31629/zarah.v11i1.4810

Muhajarah, K., & Sulthon, M. (2020). Pengembangan Laboratorium Virtual sebagai Media Pembelajaran: Peluang dan Tantangan. *Justek : Jurnal Sains Dan Teknologi*, *3*(2), 77. https://doi.org/10.31764/justek.v3i2.3553

Nilasari, N., Valentin, N., Asrori, M., & Nurhabib, F. (2025). *Implementasi Pemasaran Pendidikan Berbasis Media Digital di SMAN 3 Ponorogo*. *15*(1).

Riani Johan, J., Iriani, T., & Maulana, A. (2023). Penerapan Model Four-D dalam Pengembangan Media Video Keterampilan Mengajar Kelompok Kecil dan Perorangan. *Jurnal Pendidikan West Science*, *01*(06), 372–378.

Sihombing, B. (2024). *Model Pengembangan 4D (Define , Design , Develop , dan Disseminate) dalam Pembelajaran Pendidikan Islam*. *4*, 11–19.

Supit, A. V., Komansilan, T., & Rianto, I. (2021). Pengembangan Media Pembelajaran Ipa Berbasis Mobile Bagi Siswa Sekolah Dasar. *Edutik : Jurnal Pendidikan Teknologi Informasi Dan Komunikasi*, *1*(5), 500–512. https://doi.org/10.53682/edutik.v1i5.2832

Yudi Wahyudin, A., Dyah Aminatun, Mp., Berlinda Mandasari, Mp., Fatimah Mulya Sari, Mp., Intan Hamzah, Mp., Mutiara Ayu, Mp., Lulud Oktaviani, Mp., & Rahmat Alamsyah, Mp. (2024). *Basic Principles of English Language Teaching* (Vol. 1).

Yuliana, I., & Saragih, M. (2025). *Analysis of Students ' Creativity in Designing Comics with Project-Based Learning Model at Sanggar Belajar Kepong , Malaysia*. *10*(1), 95–106.