JTK: Jurnal Tadris Kimiya 10, 1 (June 2025): 24-34
Website: http://journal.uinsgd.ac.id/index.php/tadris-kimiya/index
ISSN 2527-9637 **(online) ISSN** 2527-6816 **(print)**

Development of STEAM-Based Electronic Practicum Module on the Topic of Saponification

Dewi Handayani[1*], Wardah Izzati Agustiningtias[1], Nurhamidah[1], Yosie Andriani[2]
[1]Chemistry Education, Faculty of Teacher Training and Education, Universitas Bengkulu, Bengkulu, Indonesia
[2]Institute of Climate Adaptation and Marine Biotechnology (ICAMB), Universiti Malaysia Terengganu (UMT), Mengabang Telipot 21030, Kuala Nerus, Terengganu, Malaysia.
[*]E-mail: d.handayani@unib.ac.id

Received: April 2025; Accepted: May 2025; Published: June 2025

Abstract

The integration of STEAM (Science, Technology, Engineering, Arts, and Mathematics) approaches in chemistry education offers new opportunities to foster active, interdisciplinary, and skills-oriented learning. However, practical resources that align with this pedagogical framework, particularly in laboratory instruction, remain limited. This study aims to develop and evaluate a STEAM-based electronic practicum guide on the topic of saponification, focusing on its feasibility, student responses, and its effectiveness in enhancing students' psychomotor skills. The development process followed the 4D model (Define, Design, Develop, and Disseminate), with implementation limited to the development stage. Participants included fourth-semester chemistry education students. The practicum guide underwent expert validation and was trialed through student feedback and performance-based observation of psychomotor competencies. The results revealed that the practicum guide achieved a high validity score (87.8%), received very positive student responses (93.1%), and significantly supported the development of psychomotor skills, with an average performance score of 94.2%. These findings suggest that the STEAM-based practicum guide is both feasible and effective as an instructional tool, offering meaningful and engaging learning experiences in chemistry laboratories. The study contributes to the advancement of innovative practicum materials and supports the implementation of STEAM principles in science education.

Keywords: electronic practicum guide, psychomotor skills, saponification, STEAM

DOI: https://doi.org/10.15575/jtk.v10i1.44033

1. Introduction

Utilization of technological advances is carried out by educators to find and utilize learning resources and teaching materials for their students (Riyani & Wulandari, 2022). Educators are required to be creative in the learning process by utilizing technology so that learning can be learner-centered, one of which is in the process of implementing learning in practicum activities (Lutfi et al., 2022). Practicum is a form of learning that takes place inside and outside the laboratory, practicum activities require students to play an active role in solving a particular problem using the tools, materials, and methods provided (Rahmawati et al., 2021). Practical activities are used as a reference for educators to monitor the development of students' psychomotor abilities, especially in the field of science both at school and college levels (Sultanni et al., 2023). The implementation of practicum activities will require a practicum module as a support so that the practicum carried out runs well (Rahmawati et al., 2021). The practicum module used by educators to assist practicum activities should be an attractive practicum module with the use of technology that can combine text with images, videos and animations (Annisa & Sari, 2021). An interesting practicum guide will increase practitioners' interest in carrying out practicum and greatly help practitioners understand practicum procedures without direct guidance (Astuti et al., 2021).

Based on the results of observations and interviews by chemical education students in the implementation of practicum in the Chemical Education Study Program, the practicum guide used is still in the form of printed modules and only contains text so that it is still less interesting for students. Students also experience difficulties during practicum implementation and the time used is not effective. Practical activities are carried out in the form of groups, in 1 group usually only one to two people are actively involved in practicum activities. Most students still look passive in practicum activities, this results in a low psychomotor assessment of students in practicum activities. This agrees with research conducted by Nestiadi et al. (2024) that students' science process skills are still not seen well in the implementation of general biology practicum activities, students are still confused in carrying out practicum activities, such as; students still have difficulty ensuring the objects observed, many students are passive to ask questions because they feel confused about what they have to do, using tools / materials there are some students who still do not know how to use the tools used in practicum activities. An innovation is needed so that practicum activities run effectively, and can trigger student enthusiasm in carrying out practicum activities so that the achievement of Course Learning Outcomes (CPMK) in organic chemistry II courses.

The innovation that can be done to solve existing problems is to create an electronic practicum guide which is an electronic-based teaching material that can train students in carrying out activities in the laboratory to achieve planned practicum objectives (Dari & Nasih, 2020). The application used to develop electronic practicum guides is the canva application, which is an online-based application that provides an alternative convenience in designing and inserting videos, links, text, audio, images, barcodes, google drives, and youtube which can make the teaching materials made more attractive (Rohma & Sholihah, 2021; Puspita et al., 2021). The use of electronic practicum guides can help students in participating in practicum activities, besides that the learning approach can be used so that the planned objectives can be achieved and the activities carried out involve student activeness. This electronic practicum guide is also in line with 21st century learning principles that support independent learning and increase direct student involvement (Alexon & Handayani, 2024).

The learning approach that can be applied in practicum activities is the STEAM (Science, Technology, Engineering, Art and Mathematic) approach. In the STEAM approach, there is an additional element of art (arts) in learning activities so that it can direct students to be able to develop skills in the 21st century (Ardhini & Hamimi, 2023). The STEAM approach in practicum activities can help students to achieve the expected practicum objectives, because STEAM emphasizes the importance of collaboration, creativity, and critical thinking in learning (Amahoroe et al., 2020). The saponification practicum activities that are usually carried out are monotonous because the work steps presented are not interesting and students only follow the procedures given without anything designed by themselves.

STEAM is developed by raising daily issues into learning, so that learning becomes more meaningful because students will be more interested and feel the benefits of the theory they have learned in real life. Learning with the STEAM approach not only teaches students about theories, but also teaches how to apply them in everyday life (Mu'minah, 2020). The results of research Utaminingsih et al. (2023) explained that the use of STEAM-based teaching materials in learning can improve students' concepts about the material taught because the STEAM approach provides an interesting learning experience for students to explore science more actively and creatively.

As with the practicum activities that will be carried out, students can connect the concept of saponification theory that they have obtained with everyday life, which is by solving a problem through experiments. Experiments that can be connected to the theory they have obtained are making soap that they use every day using technology based on manufacturing techniques according to the existing composition rate, then students can also make interesting soap designs to create new things. Therefore, this research uses the STEAM approach, because it can shape students to be able to solve real-life problems, make updates by designing something, discovering /designing new things, increasing their creativity in making things, mastering technology and providing new experiences in learning (Fitriyah & Ramadani, 2021).

The researcher is interested in making a learning tool that can help students in carrying out practicum activities. Developing an engaging and technology-integrated practicum guide within a STEAM framework is essential to address students' psychomotor challenges and to enhance the quality of chemistry instruction, especially in experimental topics such as saponification.

2. Research Method

The research focuses on the context of chemistry education, particularly in improving practical competencies in organic chemistry through STEAM based learning media. This research is a type of development research (research and development) or abbreviated as R & D. The development model used in this research is the 4-D model (Four D Models), where according to Thiagarajan this model consists of the defining stage (define), the design stage (design), the development stage (develop) and the dissemination stage (disseminate). This research is only limited to the develop stage. The define stage consists of (1) Initial Analysis is carried out by conducting interviews with lecturers teaching organic chemistry II courses and students who have taken organic chemistry II courses. (2) analysis of student needs is carried out by distributing questionnaires to students to find out what kind of teaching materials are needed by students to help their practicum activities. (3) Task Analysis is carried out for the content of the material to be conveyed in the electronic practicum guide to be developed and determines the tasks that need to be done by students. (4) Analysis of Learning Objectives is carried out by analyzing the Semester Learning Plan (RPS) of organic chemistry II course.

The design stage consists of the (1) Preparation of Research Instruments consisting of expert validation sheets, student response questionnaires and psychomotor assessment sheets. (2) Media Selection The media used to develop this electronic practicum guide is the canva application. (3) Format selection is carried out to facilitate the preparation of electronic practicum guides and sort the components in electronic practicum guides. (4) Initial Design is carried out to design the general presentation of the product before the product is developed.

The develop stage consists of (1) Product Development, this electronic practicum guide is developed based on the initial design reference that has been made with the help of the canva application. (2) Product validation is carried out by providing a validation sheet consisting of aspects of content, presentation, usability, language, STEAM approach to the validator. (3) Revision stage I, which are improving the product according to the suggestions and input from the validator. (4) Small-scale trials (student responses) were carried out by giving response questionnaires to students who had to be filled in after they carried out the practicum using the developed practicum guide. (5) Revision stage II, which is to improve the product according to the suggestions and input from the validator. (6) Large-scale trial (Implementation), carried out to determine the psychomotor value of students when carrying out the practicum, the assessment is carried out using a psychomotor observation sheet.

This research was conducted at Bengkulu University with the test subjects in this development were fourth semester students of Chemistry Education, Bengkulu University Academic Year 2023/2024. The research instruments used in this study consisted of interview sheets, student needs questionnaires, product validation sheets, student response questionnaires and psychomotor assessment sheets. There are two types of data in the research, which are quantitative data and qualitative data. Qualitative data was obtained through input from validators and respondents. While quantitative data comes from validation questionnaires, student response questionnaires, and psychomotor assessment sheets using a Likert scale.

3. Result and Discussion

3.1. Define

The define stage is the process of establishing and defining learning requirements by collecting various information related to the main problems that occur in the learning process. At this stage several steps are carried out, the results of the Initial Analysis there are still obstacles in the implementation of organic chemistry II practicum on the topic of saponification so it is necessary to develop an electronic practicum guide for the topic of saponification.

The results of the analysis of student needs that have been obtained will then be used as a reference to develop a practicum guide that suits the needs of students where as many as 97.7% of students choose to agree if a STEAM-based electronic practicum guide is developed on the topic of saponification.

The material applied to the STEAM-based electronic practicum guide is saponification material, and the tasks that must be done by students are preparing the necessary tools and materials, carrying out practicum activities, working on pretest and posttest questions, and making a final practicum report.

Practical activities that can be carried out in accordance with saponification material are soap making and testing of soap properties, so that the learning objectives in this saponification material are that students are able to make simple soap and students are able to test the properties of soap.

3.2. Design

The design stage is carried out to design the draft and composition of the electronic practicum guide to be developed. The things done at this stage are Preparation of expert validation sheets, student response questionnaires and psychomotor assessment sheets; Media Selection The media used to develop this electronic practicum guide is the canva application because this application can create teaching materials such as practicum guides with attractive designs and there are templates so that users only need to re-modify and we can also add video, image and animation features (Zebua, 2023).

The components that must be in the practicum guide include cover, practicum title, practicum objectives, theoretical basis, tools and materials, work procedures, questions, practicum implementation, and practicum report format (Prastowo, 2011). The final product of this product development is a STEAM-based electronic practicum guide in which Science, Technology, Engineering, Art, and Mathematics are integrated.

The initial design of the STEAM-based electronic practicum guide on the topic of saponification, which are (a) The content of the practicum guide product which includes the cover and cover page of the practicum guide, main menu, instructions for use page, laboratory rules page, learning outcomes page, STEAM introduction page, practicum page (theoretical basis, pretest, tools and materials, experimental procedures, posttest, and observation results sheet), practicum final report page and researcher profile page. (b) STEAM aspects which include how STEAM integration in electronic practicum guides and its application in practicum activities.

3.3. Development

This development stage aims to produce a STEAM-based electronic practicum guide on the topic of saponification. The stages carried out include:

3.3.1. Development of an Electronic Practicum Guide

This electronic practicum guide was developed based on the initial design reference that had been made with the help of the Canva application. The final form of this practicum guide is in the form of electronic teaching materials that can be accessed through electronic devices such as smartphones, laptops, or computers. This development is also based on aspects of the STEAM approach so that the electronic practicum guide developed is based on the STEAM approach. The STEAM aspects of the development of electronic practicum guides can be seen in Table 1.

Table 1. Table of STEAM Aspects in Guide Development

Aspect	Practical Guide Development Section
Science	Determining the components that must be included in the practicum guide.
	Determination of material saponification presented in the theoretical basis.
	Determination of STEAM aspects presented in the practicum guide and applied in practicum activities
Technology	Create a design with the canva application and then convert it into a flipbook with the heyzine website.
	Make a video tutorial of the experiment using a smartphone and edit it with the help of the capcut application.
	Create pretest and posttest questions presented with google form
	Using google drive as a place to collect student final reports.
Engineering	Design an electronic lab guide according to a predetermined format.
	Design work steps and video tutorials for the experiment
Art	Determining the design of the practicum guide so that the resulting product is attractive.
	Determination of colors, font types, animations and images used.
Mathematics	Determination of image size, font, position of animation presented in the practicum guide.
	Pay attention to the layout between subchapters and paragraphs, the distance between sentences and the spacing used.
	Design the amount of ingredients used in the lab work steps.

As for some parts of the electronic practicum guide that was developed as Figure 1.

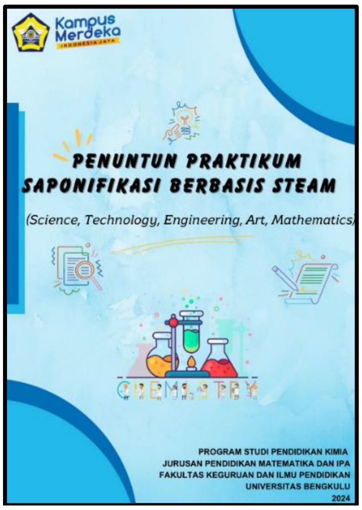

Figure 1. Electronic Practicum Guide Cover

3.3.2. Expert Validation

This feasibility assessment aims to determine whether or not the STEAM-based electronic practicum guide on the topic of saponification developed is feasible. The results of media expert validation are presented in Table 2.

Table 2. Table of Analysis Results of Expert Validation Assessment

Aspect	Score (%)	Criteria
Contents	88.6	Very Valid
Presentation	88.4	Very Valid
Usege	90	Very Valid
Language	86.3	Very Valid
STEAM	85.7	Very Valid
Average (%)	87.8	Very Valid

The content quality aspect shows that the concept of the material presented is in accordance with the practicum activities to be carried out, which is about saponification, the practicum activities presented are complete and clear which include soap making activities and testing soap products. The experimental video tutorials presented are in accordance with the practicum activities, which are soap making activities and testing soap properties, so that the video tutorials can help students understand the experimental steps presented. According to Habibah (2013) The use of media in learning has the advantage that learning video media can make time more effective and delivery of messages more efficient, so that something that wants to be communicated in learning activities can be delivered quickly.

The presentation quality aspect shows that the material presented in the theoretical basis of the electronic practicum guide is clear and systematic where this material is presented from simple to complex material. This aspect of presentation also shows that the cover design, font type, size, and color used in this electronic practicum guide contrast with the background and are consistent because there is not too much color and font selection.

The quality of use aspect shows that the developed electronic practicum guide is easy to use, practical and efficient. This practicum guide is also easy to use because accessing it only requires a link provided by and can be used anywhere and anytime using electronic devices. The preparation of teaching materials for learning activities must fulfill the elements of novelty, practicality or easy to use, and interesting so that it can motivate students in the learning process (Yuliana et al., 2021).

The language quality aspect shows that the electronic practicum guide developed has accuracy in the selection of sentences and the language used is in accordance with the Improved Spelling (EYD). The sentences and language used do not cause double meanings, the language used is simple and easy to understand and the writing of chemical symbols and elements has been written correctly according to the rules of scientific writing. The clarity of the use of sentences in earning media and does not cause multiple interpretations will make it easier for students to learn the media.

The quality aspect shows that the developed electronic practicum guide has integrated STEAM as seen from the existence of each STEAM aspect in the developed electronic practicum guide and is able to encourage students to understand the five sciences. STEAM skills must be mastered by students in the learning process because it will strengthen them in understanding the world more thoroughly and be ready to face future challenges, so educators must encourage students to develop these STEAM skills (Kusmiarti et al., 2023).

3.3.3. Phase I Revision

At the expert validation stage there were several suggestions and inputs given by the validator for the product that had been developed. The results of this advice and input will later be used as a reference for stage I product revision.

3.3.4. Small Scale Trial

Products that have gone through the validation and revision stages are then carried out a small-scale trial to obtain student responses to the STEAM-based electronic lab guide on the topic of saponification developed. The results of this small group trial were used to revise the product to be used in the large group test. This small group trial was conducted on 4th semester students of class B of Chemistry Education, Bengkulu University, totaling 22 people. The results of the student response questionnaire analysis can be seen in Table 3.

Table 3. Table of Analysis Results of Student Response Questionnaire

Aspect	Score (%)	Criteria
Presentation	94.2	Very Good
Language	93.0	Very Good
Usability	92.5	Very Good
Usage	93.4	Very Good
Media	92.0	Very Good
Average (%)	93.1	Very Good

The presentation aspect shows that the content of this electronic practicum guide contains material that is easily understood by students, clear practicum objectives, the appearance of images, illustrations and videos in electronic practicum guides that are interesting, clear and easy to understand. The existence of experimental video tutorials can help students in carrying out practicum activities. According to Ardiman et al. (2021) learning videos can explain abstract explanations and are very good at explaining a process and can motivate students to learn. The language aspect shows that the electronic practicum guide presented uses text or writing that can be read clearly, clear and easy to understand language and uses communicative and informative language so that the information conveyed in this practicum guide can be conveyed well to students and is easy to understand.

The usefulness aspect shows that the developed electronic practicum guide has an experimental video that can help students understand the practicum steps, which are soap making and testing the properties of soap to be carried out. This STEAM-based electronic practicum guide also facilitates students to carry out practicum activities independently because this electronic practicum guide can be used flexibly where and when using electronic devices. The use aspect shows that the developed electronic practicum guide is easy to use because there are clear instructions for use that are easy for students to understand. Access to enter this electronic practicum guide is easy because it is accessed through a link given to students and can be accessed anywhere and anytime using electronic devices connected to the internet.

The media aspect shows that this developed electronic practicum guide has an attractive design, has illustrations on the cover and content that are harmonious and proportional, the text or writing on this practicum guide is easy to read because it has a variety of simple letters. Ramadhani & Mahardika (2015) state that in writing teaching materials the variety of letters used should not be too much because will make it difficult for students to find what is important.

3.3.5. Phase II Revision

The results obtained from the student response questionnaire show that the student response to the developed electronic practicum guide gets an average score of 93.1% which indicates that the electronic practicum guide is feasible to use as a guide in carrying out the practicum, but from the comments and suggestions given by students through the response questionnaire that has been distributed there are still parts that need to be revised or improved in the electronic practicum guide. The comments and suggestions given by students will be used as a reference in stage II revision.

3.3.6. Large Scale Trial

Large-scale trials were conducted on 21 students of semester 4 class A of Chemistry Education, Bengkulu University. The implementation of saponification practicum activities carried out with the help of STEAM based electronic practicum guides is also based on the STEAM aspects contained in the practicum implementation. The application of STEAM aspects in saponification practicum activities can be seen in Table 4.

Researchers also observed the psychomotor abilities of students during practicum using practicum guides. The results of the analysis of student psychomotor assessment when carrying out practicum using STEAM-based practicum guides on the topic of saponification are presented in Table 5.

Table 4. Table of STEAM Aspects in Practicum Activities

Aspek	Practicum Activity Section
Science	Advanced understanding of the saponification reaction as a theoretical basis.
	Selection of plant extracts that can be used as natural colorants
	Students' understanding in measuring the pH of soap during the saponification reaction has been completed.
Technology	The use of a stirring rod to stir the soap solution so that the solution thickens as a sign that the reaction between oil and base (NaOH) has been completed.
	The use of silicone soap molds to mold soap products to produce attractive shapes.
	Use of a hotplate to heat the soap solution in the soap properties testing experiment.
Engineering	Students design extracts that are used as natural colorants.
	Students design the composition of the oil used in the experiment.
	Students design the composition of natural colorants and fragrances given to the soap solution.
Art	Coloring the soap using natural dyes.
	Soap mold selection.
Mathematics	Students weigh the NaOH used.
	Students determine the concentration of NaOH used.
	Students measure the oil used.
	Students provide the dosage of plant extracts used as natural colorants in soap and soap fragrances.
	Students measure the pH of the soap that has been made.

Table 5. Table of Student Psychomotor Analysis Results

Aspect	Score (%)	Criteria
Preparation Stage	95.2	Very Good
Implementation Stage	89.7	Very Good
Final Stage	97.6	Very Good
Average (%)	94.2	Very Good

The description of the data from the observation of students' psychomotor assessment is as follows:

3.3.6.1. Preparation Stage

The activities assessed at this stage, which is the use of laboratory safety equipment which includes lab coats, masks, gloves and closed shoes, obtained a percentage of 96.4% in the very good category. Making a flow chart as a requirement to enter the lab obtained a percentage of 89.3%. Skills in preparing and taking tools and materials that will be used in practicum activities obtained a percentage of 100% with a very good category.

3.3.6.2. Implementation Stage

The activities assessed at this stage, which is the skill of weighing solids using an analytical balance, obtained a percentage of 94.0% in the very good category, this shows that most students have been able to use an analytical balance to weigh solids. The skill of pouring solids and stirring substances obtained a percentage of 86.9% in the very good category, this shows that most students have been able to pour solids from the watch glass and stir the substance to be dissolved well. The skill of measuring the volume of solution in a measuring cup is done with the eye position parallel to the volume limit of the measuring cup (using a concave meniscus). This skill obtained a percentage of 85.7% in the very good category, this shows that most students have been able to measure the volume of solution in a measuring cup using the lower meniscus well.

The skill of pouring the solution from the measuring cup into another container obtained a percentage of 90.5% in the very good category. This shows that most students have been able to pour the solution into another container through the wall of the container that is in contact with the lip of the measuring cup without any solution spilling. The skill of putting solids into test tubes obtained a percentage of 89.3% in the very good category. This shows that most students have been able to put solids into test tubes well. The skill of carrying out the experiment from beginning to end obtained a percentage of 95.2% with a very good category. This shows that most students have carried out the experiment from start to finish and are actively involved in practicum activities. The skill in writing down the experimental data obtained a percentage of 100% with a very good category. This shows that students have been able to write the observation data in the observation table that has been provided.

3.3.6.3. Final Stage

The activities assessed at this stage are skills in disposing of waste, students get a percentage of 100%. This shows that students have fulfilled all indicators where students have disposed of experimental waste in accordance with the waste disposal bins that have been provided in the laboratory. skills in washing, wiping, returning and tidying up experimental equipment, students obtained a percentage of 100% with a very good category.

The psychomotor improvement observed reflects the success of integrating STEAM into chemistry instruction. Students not only performed the lab work with improved technical skills but also demonstrated better understanding of the chemical concepts involved in saponification, as reflected in their post-lab reports and reflective discussions. Furthermore, this development supports the notion that well-designed digital learning media can enhance students' engagement and skill acquisition in chemistry, particularly when aligned with curriculum outcomes and 21st-century learning frameworks.

4. Conclusion

Based on the results of the research that has been conducted, it can be concluded that the STEAM-based electronic practicum guide on the topic of saponification developed is declared feasible for use as a practicum guide. The developed electronic practicum guide received a positive response from both product experts and students. Researchers also conducted a large-scale trial to see students' psychomotor abilities in practicum activities using the developed electronic practicum guide and found that there was an increase in students' psychomotor abilities in carrying out practicum activities. The developed electronic practicum guide has several benefits, it can add students' insights into how to make soap and how to test the properties of soap, facilitate students to learn independently because there are experimental video tutorials and add students' insights into the relationship between science, technology, engineering, art and mathematics applied in practicum activities. The developed STEAM-based electronic practicum guide is not only feasible and well-received but also effectively enhances students' psychomotor performance in the laboratory. This innovation is suitable for implementation in chemistry education, particularly for experimental topics that require integration of conceptual understanding and laboratory skills. The guide serves as a model for future development of digital practicum materials aligned with STEAM and chemistry curriculum goals.

References

Alexon, & Handayani, D. (2024). The development of e-LKPD with a culture-based integrated learning model (MPTBB) to improve student learning outcomes on buffer solution material. *International Journal of Information and Education Technology*, *14*(1), 141–150. https://doi.org/10.18178/ijiet.2024.14.1.2034.

Amahoroe, R. A., Arifin, M., & Solihin, H. (2020). Penerapan desain praktikum berbasis STEM pada pembuatan tempe dari fermentasi biji nangka (*Artocarpus heterophyllus*) untuk meningkatkan literasi sains siswa SMK. *Molluca Journal of Chemistry Education (MJoCE)*, *10*(2), 89-100.

https://doi.org/10.30598/MJoCEvol10iss2pp89-100

Annisa, K., & Sari, M. (2021). Pengembangan e-modul praktikum berorientasi chemoentrepreneurship (CEP) pada materi sifat koligatif larutan kelas XII IPA SMA. *Edusainstika: Jurnal Pembelajaran MIPA, 1*(2), 69-72. http://dx.doi.org/10.31958/je.v1i2.4488

Ardhini, W. B., & Hamimi, E. (2023). Analisis kebutuhan pengembangan e-modul berbasis STEAM untuk memfasilitasi kemampuan berpikir kreatif siswa pada materi usaha dan pesawat sederhana. *Proceedings of Life and Applied Sciences*, 252-261, Malang: Universitas Negeri Malang. Retrieved from http://conference.um.ac.id/index.php/LAS/article/view/8231

Ardiman, K., Tukan, M. B., & Baunsele, A. B. (2021). Pengembangan video pembelajaran berbasis praktikum dalam pembelajaran daring materi titrasi asam basa kelas XI SMAN 5 Pocoranaka. *Jurnal Beta Kimia, 1*(1), 22-28. https://doi.org/10.35508/jbk.v1i1.5130

Astuti, Y., Suciati, R., & Lestari, S. (2021). Pelatihan pembuatan media pembelajaran tulang daun (*leaf skeleton*) di masa pandemi Covid-19. *JMM (Jurnal Masyarakat Mandiri), 5*(3), 939-948. https://doi.org/10.31764/jmm.v5i3.4995

Dari, R. W., & Nasih, N. R. (2020). Analisis keterampilan proses sains mahasiswa pada praktikum menggunakan e-modul. *Edu Sains: Jurnal Pendidikan Sains dan Matematika, 8*(2), 12-21. https://doi.org/10.23971/eds.v8i2.1626

Fitriyah, A., & Ramadani, S. D. (2021). Pengaruh pembelajaran STEAM berbasis PjBL (Project-Based Learning) terhadap keterampilan berpikir kreatif dan berpikir kritis. *Inspiratif Pendidikan, 10*(1), 209-226. https://doi.org/10.24252/ip.v10i1.17642

Habibah, U. (2013). Meningkatkan aktivitas dan hasil belajar matematika siswa madrasah ibtidaiyah melalui model paikem. *Journal of Elementary Education, 2*(2), 6-11. Retrieved from https://journal.unnes.ac.id/sju/index.php/jee/article/view/2737

Kusmiarti, R., Paulina, Y., Rustinar, E., Zakaria, J., Puspidalia, Y. S., & Hasbullah, A. (2023). Respon mahasiswa dan dosen terhadap modul sintaksis bahasa Indonesia berbasis STEAM. *KEMBARA: Jurnal Keilmuan Bahasa, Sastra, dan Pengajarannya, 9*(1), 176-188. https://doi.org/10.22219/kembara.v9i1.24172

Lutfi, A., Dwiningsih, K., Azizah, U., Yonata, B., & Nasrudin, H. (2022). Laboratorium virtual sebagai media pembelajaran kimia untuk menyongsong implementasi kurikulum merdeka. *Prosiding Seminar Nasional Kimia*, 94-100. Surabaya: Jurusan Kimia FMIPA, Universitas Negeri Surabaya. Retrieved from https://proceeding.unesa.ac.id/index.php/psnk/article/view/88

Mu'minah, I. H. (2020). Implementasi STEAM (science, technology, engineering, art and mathematics) dalam pembelajaran abad 21. *Bio Educatio, 5*(1), 65-73. https://doi.org/10.31949/be.v5i1.2105

Nestiadi, A., Leksono, S. M., & Kurniasih, S. (2024). Pengembangan modul praktikum biologi umum berbasis case method untuk meningkatkan keterampilan proses sains mahasiswa pendidikan ilmu pengetahuan alam. *Jurnal Pendidikan Abad Ke-21, 2*(1), 13-20. https://doi.org/10.53889/jpak.v2i1.391

Prastowo, A. (2011). Panduan kreatif membuat bahan ajar inovatif. Yogyakarta: Diva Press.

Puspita, K., Nazar, M., Hanum, L., & Reza, M. (2021). Pengembangan E-Modul praktikum kimia dasar menggunakan aplikasi canva design. *JIPI (Jurnal IPA & Pembelajaran IPA), 5*(2), 151-161.

https://doi.org/10.24815/jipi.v5i2.20334

Rahmawati, R., Laksmiwati, D., Al Idrus, S. W., Hakim, A., & Supriadi, S. (2021). Pengembangan modul praktikum kimia organik I berbasis problem based learning (PBL) dalam meningkatkan keterampilan sains. *Jurnal Pijar Mipa, 16*(2), 176-179. https://doi.org/10.29303/jpm.v16i2.2474

Ramadhani, W. P., & Mahardika, I. K. (2015). Kegrafikaan modul pembelajaran fisika berbasis multirepresentasi. Seminar NasionaL Fisika Dan Pembelajarannya. Malang: Universitas Negeri Malang

Riyani, N. L. V. E., & Wulandari, I. G. A. A. (2022). Pengembangan LKPD interaktif berbasis STEAM pada kompetensi pengetahuan ips siswa kelas V di SD No. 3 Sibanggede. *Jurnal Ilmiah Universitas Batanghari Jambi, 22*(1), 285-291. http://dx.doi.org/10.33087/jiubj.v22i1.2046

Rohma, A., & Sholihah, U. (2021). Pengembangan media audio visual berbasis aplikasi canva materi bangun ruang limas. *Jurnal Pendidikan Matematika Universitas Lampung, 9*(3), 292-306. http://dx.doi.org/10.23960/mtk/v9i3.pp292-306

Sultanni, M. S., Suwahono, S., & Nada, E. I. (2023). Kajian fenomenologi aspek manipulating pada kemampuan psikomotorik peserta didik dalam pembelajaran praktikum. *Jurnal Education And Development, 11*(2), 266-272. https://doi.org/10.37081/ed.v11i2.4375

Utaminingsih, E. S., Raharjo, T. J., & Ellianawati, E. (2023). Development of an E-module based on STEAM on the topic of human blood circulation. *Jurnal Penelitian Pendidikan IPA, 9*(7), 5333-5340. https://doi.org/10.29303/jppipa.v9i7.3719

Yuliana, F. H., Fatimah, S., & Barlian, I. (2021). Pengembangan bahan ajar digital interaktif dengan pendekatan kontekstual pada mata kuliah teori ekonomi mikro. *Jurnal PROFIT Kajian Pendidikan Ekonomi Dan Ilmu Ekonomi, 8*(1), 36-46. http://dx.doi.org/10.36706/jp.v8i1.13875

Zebua, N. (2023). Potensi Aplikasi canva sebagai media pembelajaran praktis guru dan peserta didik. *Educativo: Jurnal Pendidikan, 2*(1), 229-234. https://doi.org/10.56248/educativo.v2i1.127