JPPIPA 11(8) (2025)

Jurnal Penelitian Pendidikan IPA

http://jppipa.unram.ac.id/index.php/jppipa/index

Development of a Practical Tool for Renewable Energy Materials in P5 Activities Based on Secang Extract as a Natural Dye Sensitizer in the DSSC Circuit

Ridho Sastriwijaya[1], Dini Hadiarti[1*], Raudhatul Fadhilah[1]

[1] Faculty of Teacher Training and Education, Universitas Muhammadiyah Pontianak, Pontianak, Indonesia.

Received: June 4, 2025
Revised: August 7, 2025
Accepted: August 25, 2025
Published: August 31, 2025

Corresponding Author:
Dini Hadiarti
dinihadiarti@unmuhpnk.ac.id

DOI: 10.29303/jppipa.v11i8.12017

Abstract: In this study, a DSSC practice tool based on sappanwood (Caesalpinia sappan L.) extract as a natural dye sensitizer was developed to support renewable energy learning at the senior high school level. This research is categorized as development research, aiming to produce a renewable energy practice tool that is valid and practical. The method used in this study was Research and Development (R&D), adapted from the Thiagarajan 3D model. The results showed that the practice tool based on sappanwood extract as a natural dye sensitizer in the DSSC circuit was declared highly feasible, with an assessment score of 85% from media experts and 86% from material experts.The product trials revealed that the small-group trial achieved a feasibility score of 83%, while the large-group trial reached 86%. Both results were categorized as "highly feasible." These findings indicate that the DSSC practice tool based on sappanwood extract as a natural dye sensitizer is valid and practical for use in the learning process

Keywords: Practical tool; Research and development; Trial of the practical tool

Introduction

Energy is one of the most crucial factors in achieving sustainable development. The world's energy usage has undergone significant changes from primarily relying on biomass, such as firewood, to meet energy needs, to shifting towards fosil fuels like coal, oil, and natural gas, driven by the Industrial Revolution in the 1900s (Gunada et al., 2023; Kasmaniar et al., 2023; Setyono, 2021). The use of fossil fuels has severe environmental impacts, such as increased carbon dioxide levels in the atmosphere, acid rain, ozone layer depletion, and an increase in greenhouse gas effects (Pramudiyanto, 2020). In addition, the limited availability of fossil fuels makes them an unsustainable energy source in the long term. Therefore, alternative solutions that are more environmentally friendly and sustainable are urgently needed, one of which is the utilization of renewable energy. Among the various renewable energy sources being explored, solar energy stands out as a promising option.

Solar cell technology (photovoltaic) has become one of the promising solutions for converting solar energy into electrical energy. One type of solar cell that is currently developing is the Dye-Sensitized Solar Cell (DSSC) (Almenningen et al., 2022). The advantages of DSSCs include relatively high conversion efficiency, low production costs, and the ability to utilize environmentally friendly natural materials (Tahir et al., 2019). Natural dye sensitizer sources can be obtained from sappanwood, which contains red pigments such as brazilin and brazilein (Destiarti et al., 2024; Hemthanon et al., 2022; Nirmal et al., 2015; Sakti et al., 2019). The use of sappanwood as a natural dye sensitizer in DSSC

How to Cite:
Sastriwijaya, R., Hadiarti, D., & Fadhillah, R. (2025). Development of a Practical Tool for Renewable Energy Materials in P5 Activities Based on Secang Extract as a Natural Dye Sensitizer in the DSSC Circuit. *Jurnal Penelitian Pendidikan IPA*, *11*(8), 879–886. https://doi.org/10.29303/jppipa.v11i8.12017

circuits has previously been investigated by several researchers (Nasyori et al., 2020; Safitri et al., 2022; Zulenda et al., 2019).

Sappanwood plants in West Kalimantan are known as a source of natural dyes for food and traditional medicine. The bark of sappanwood is used to produce red pigments, which in the past became an international trading commodity (Hidayat et al., 2018; Riduana et al., 2021). Sappanwood extract (Biancaea sappan) has potential as a dye sensitizer in Dye-Sensitized Solar Cells (DSSC) (Hazar et al., 2022).

DSSCs utilizing sappanwood extract as a natural dye sensitizer not only offer potential in technical aspects but also provide added value by employing locally sourced natural materials that are widely available across various regions of Indonesia, including West Kalimantan. The availability of this material makes sappanwood-based DSSCs relevant to be developed as practical tools that are closely connected to students' local contexts. This development aligns with the goals of the Sustainable Development Goals (SDGs) (Ahmad et al., 2022; Korir et al., 2024) and Education for Sustainable Development (ESD) (Berlianti et al., 2023; Nurfatimah et al., 2022), which emphasize the importance of sustainable utilization of local resources. The integration with the Proyek Penguatan Profil Pelajar Pancasila (P5) in the Kurikulum Merdeka framework positions this research not only as a contribution to renewable energy innovation but also as a means of supporting contextual, environmentally oriented, and meaningful learning for students (Basir et al., 2024; Melati et al., 2024; Yati, 2023).

P5 is a cross-disciplinary learning approach that enables students to observe problems in their environment and seek solutions by utilizing existing local potentials. The results of interviews revealed that teachers experience obstacles in implementing P5, thus requiring adjustments in its execution. The implementation of P5, which is designed to equip students with 21st-century skills such as critical thinking, collaboration, and environmental awareness, still faces challenges, as many teachers struggle to determine appropriate learning models and provide suitable practice tools. As a result, learning tends to be theoretical and less connected to students' real-life experiences, which implies that the objectives of P5 have not been optimally achieved. Therefore, innovative, contextual, and applicable learning media are needed, one of which is through the development of renewable energy practice tools in the form of Dye-Sensitized Solar Cells (DSSC) using sappanwood extract as a natural dye sensitizer. This development not only represents a tangible application of science and technology but also serves as meaningful support for the implementation of P5 in student learning.

Students are expected to develop critical reasoning skills so that they can think logically and systematically in analyzing, making decisions, and solving problems through P5 activities (Herliandry et al., 2018; Ramdani et al., 2020; Ridho et al., 2020). These skills can be fostered through P5-based learning that addresses global issues while utilizing local content from West Kalimantan embedded in learning media. Learning media play an important role as one of the supporting elements in the success of the teaching and learning process (Aisyah, 2022; Sasmitha et al., 2023). Such media include various tools or facilities that can be used to convey information or messages, thereby attracting students' attention and increasing their interest in learning. Therefore, it is necessary to develop practical learning tools that can assist students in the learning process (Lakoy, 2022; Ulfah et al., 2021).

Practical tools are a vital component in supporting learning activities, particularly in subjects that emphasize application, such as science, technology, skills, and vocational fields (Desimarlina et al., 2021; Ramdani et al., 2019). Through the use of practical tools, students can observe, conduct experiments, and understand material directly through concrete experiences, which ultimately helps deepen their knowledge and enhance their skills comprehensively (Azmi et al., 2024; Hasbi et al., 2015). The availability of adequate practical tools can also create a more engaging learning atmosphere, foster learning motivation, and encourage the development of critical thinking and problem-solving skills. Furthermore, practical activities train students to work both independently and collaboratively in teams, which plays an important role in shaping character and cultivating a professional work ethic (Islamiah et al., 2023; Nurmayani et al., 2018).

The novelty of this research lies in the integration of developing practical learning tools based on the Kurikulum Merdeka through P5 activities with the application of renewable technology, namely Dye-Sensitized Solar Cells (DSSC) using sappanwood (Caesalpinia sappan L.) extract as a natural dye sensitizer, which has rarely been utilized. This makes it different from previous studies that generally focused on the technical aspects of DSSCs. Moreover, it offers a multidisciplinary approach that combines science, environment, and education to produce an innovative educational product that is applicable, environmentally friendly, and relevant to the needs of 21st-century learning.

A review of scientific articles shows that the development of practical tools utilizing sappanwood as a natural dye sensitizer in DSSC circuits has not been previously conducted. Through this practical tool, students can learn about the basic concepts of DSSCs, their working principles, component assembly, and the role of sappanwood extract as a natural dye sensitizer. In addition, the teaching media also illustrates the stages of constructing a DSSC based on sappanwood extract. This approach enables students to increase their awareness of environmental issues, particularly global energy challenges, while also fostering an understanding of DSSC technology development and the utilization of local natural resources for renewable energy in Indonesia.

Method

Type of Research

This study employed a Research and Development (R&D) approach using the 3D development model adapted from Thiagarajan (Arifin et al., 2024; Kadir et al., 2024). This model was applied to produce a product in the form of a renewable energy practice tool based on sappanwood extract as a natural dye sensitizer in the DSSC circuit, designed to support the Projek Penguatan Profil Pelajar Pancasila (P5) activities.

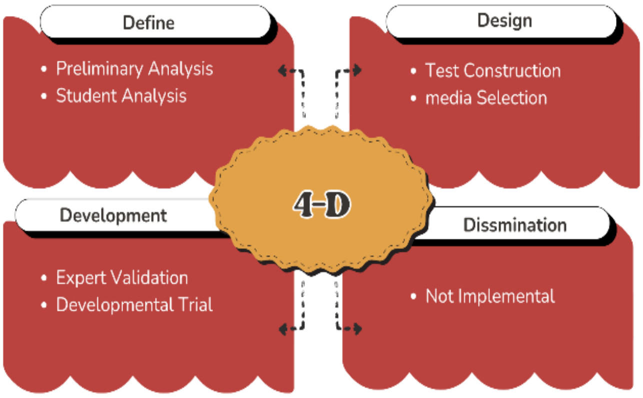


Figure 1. 4D model

Define Stage

At this stage, an initial identification was carried out regarding the learning needs of renewable energy, curriculum analysis, a literature review related to Dye-Sensitized Solar Cells (DSSC), and the potential use of sappanwood extract as a natural dye. Interviews with teachers and an analysis of students' conditions were also conducted to formulate the requirements for the practical tool to be developed.

Design Stage

This stage included the initial design of the DSSC practice tool, the determination of components, the extraction process of dye substances from sappanwood, and the schematic design of the DSSC circuit. The design was developed based on scientific principles and aligned with the learning objectives of the P5 project.

Stage Development

This stage aimed to produce a practice tool based on sappanwood extract as a natural dye sensitizer in the DSSC circuit. At this stage, validation of the research instruments, design revisions, and trials were carried out. The validation process included the evaluation of the practice tool, teacher response questionnaires, and student response questionnaires. Based on the results of the study, corrections, and expert suggestions, improvements were made to the DSSC practice tool using sappanwood extract as a natural dye sensitizer.

After the validation process by experts, the revised results were used to refine the practice tool. The validation was conducted by material experts and media experts using validation sheets with a Likert scale. The percentage of validity was calculated based on Equation 1 and matched with the criteria in Table 1 (Nuryadi, 2017).

$$\text{Percentage} = \frac{\Sigma \text{ Validator Responses}}{\Sigma \text{ Responses from Validators}} \times 100\% \quad (1)$$

Explanation:
Percentage: Percentage of learning media quality
Σ Validator Responses: Total number of validator responses
Σ Responses from Validators: The maximum possible score given by the experts

Table 1. Validation Criteria

Scorer Range	Description
≥ 81.50 – 100	very Valid
≥ 62.50 – 81.40	Valid
≥ 43.50 – 62.40	Fairly Valid
≥ 25.00 – 43.40	Not Valid

The practicality of the practical tool was determined based on data collected through a Likert-scale response questionnaire with the following categories: Strongly Agree (SA), Agree (A), Disagree (D), and Strongly Disagree (SD). Responses were gathered through two stages of product testing: a small group trial and a large group trial. The small group trial involved 10 students from SMAN 10 Pontianak, while the large group trial involved 30 students from the same school. After tabulating the scores, the practicality percentage was calculated using Equation 2 and matched against the criteria in Table 2 (Nuryadi, 2017).

$$\text{Percentage} = \frac{\Sigma \text{ Validator Responses}}{\Sigma \text{ Highest score given by the validator}} \; 100\% \quad (2)$$

Explanation:
Percentage Responses = Percentage Responses
Σ Respondents answer: Total number of respondents answer

Σ Highest score given by the respondent: total highest possible scorer from respondents

Table 2. Validation Criteria

Scorer range	Description
≥ 81.50 – 100	Very Practical
≥ 62.50 – 81.40	Practical
≥ 43.50 – 62.40	Fairly Practical
≥ 25.00 – 43.40	Not Practical

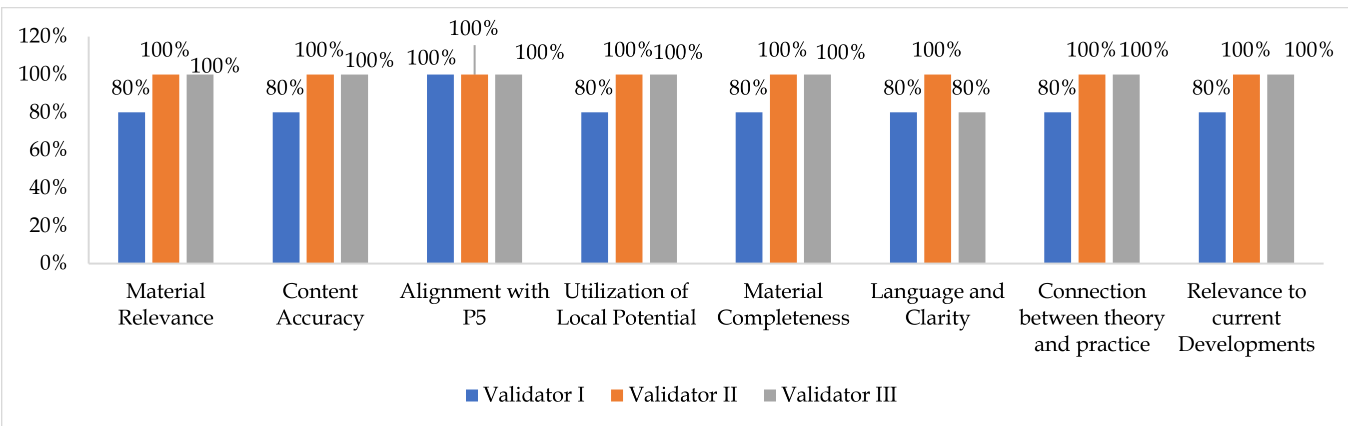
Stage Dissemination

The dissemination stage is one of the steps in the development model that aims to distribute the developed product to a broader scope, such as other schools, teacher groups, or scientific forums. However, in this study, the dissemination stage was not conducted due to time constraints, the limited scope of the research, and a primary focus only up to the validation and limited trial stages.

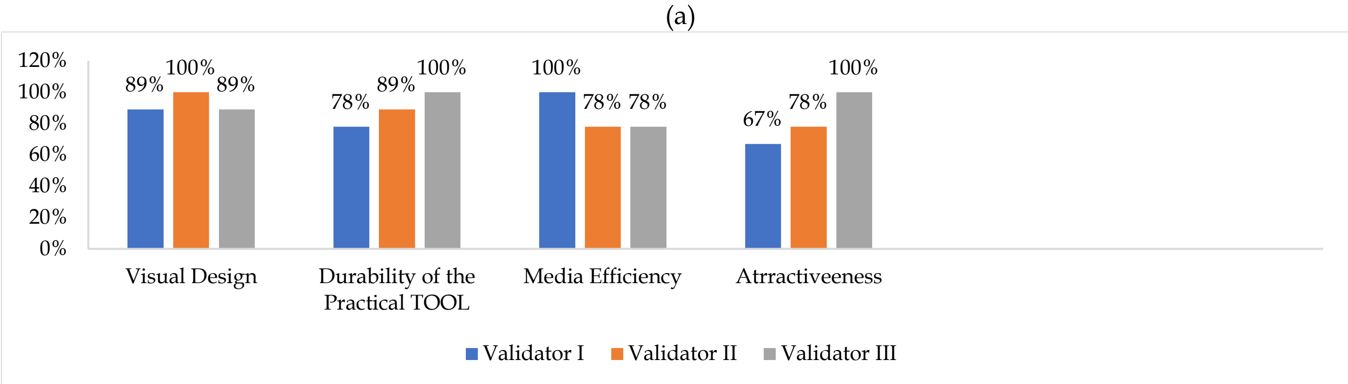
This study focused on the development and testing of a practical tool for renewable energy material, utilizing secang extract as a natural dye sensitizer in a DSSC, with SMAN 10 Pontianak as the trial subject. Accordingly, the entire development and product evaluation process was conducted on a limited scale to ensure the validity and practicality of the tool within a specific context.

Result and Discussion

This research produced a renewable energy practice tool based on Dye-Sensitized Solar Cells (DSSC) utilizing sappanwood extract as a natural dye sensitizer. The fabrication process began with the extraction of sappanwood dye, the preparation of TiO_2-based electrodes, immersion of the electrodes in the natural solution, and finally the assembly of a simple solar cell. The assembly results showed that the DSSC with sappanwood natural dye was able to generate voltage and electric current, although on a small scale. This indicates that sappanwood extract has potential as a natural dye due to the presence of brazilin and brazilein pigments, which play a role in light absorption and electron transfer.



(a)



(b)

Figure 2. (a) Validation results by subject matter experts, and (b) Validation results by media experts

Based on performance testing, the voltage produced by the DSSC using sappanwood extract was relatively stable, but its efficiency was still lower compared to DSSCs using synthetic dyes. This finding is consistent with previous studies, which reported that solar cells based on natural dyes tend to produce lower efficiency due to limitations in pigment stability and light absorption range. Nevertheless, the ability to generate energy from simple local materials is considered sufficient for use in educational contexts, particularly as a practical learning medium.

In addition to producing the DSSC, this research also developed a practical tool that can be used in project-based learning activities within the Kurikulum Merdeka. Six validators, consisting of material experts and media experts, provided an overall assessment score of 85% at the development stage, categorizing the practical tool as highly valid (reference). Figure 2 (a) (Nengsih et al., 2019) shows that aspects such as material relevance, content accuracy, alignment with P5, utilization of local resources, material completeness, language and clarity, integration of theory and practice, and relevance to current developments received a score of 86% based on the evaluation of three material experts, which is also categorized as highly valid. The highest score was obtained in the aspect of alignment with P5, with 100%, while the lowest scores were found in content accuracy, language and clarity, and the integration of theory and practice, each at 80%.

Media validation was carried out by two lecturers and one teacher, who evaluated aspects such as graphics, durability of the practice tool, media efficiency, and attractiveness, as shown in Figure 2 (b) (Nengsih et al., 2019). The average score obtained was 85%, which categorized the practice tool as highly valid. The graphics aspect received the highest score with an average of 92.66%, while the aspects of media efficiency and attractiveness obtained the lowest scores, with an average of 85.33%. The practice tool based on sappanwood extract as a natural dye sensitizer in the DSSC circuit is presented in Figure 3.

(a) (b)

Figure 3. (a) Practical tool based on secang extract as a natural dye sensitizer in the DSSC circuit. (b) Practical tool circuit diagram

The small-group trial was conducted as an initial stage to assess the feasibility of the DSSC practice tool based on sappanwood extract before being implemented on a wider scale. The results showed that the small-group trial of the practice tool using sappanwood extract as a natural dye sensitizer in the DSSC circuit obtained a score of 83%, which was categorized as highly feasible. In general, the tool could be used according to the procedure, although some limitations were still found in technical aspects and the clarity of instructions. This provided valuable input for improvement, particularly in the user guide, so that the tool could be more easily understood and operated by students.

After improvements were made based on the findings from the small-group trial, the practice tool was further tested with a larger number of participants. The results of the large-group trial of the practice tool based on sappanwood extract as a natural dye sensitizer in the DSSC circuit showed an overall feasibility score of 86%, categorized as highly feasible, with improved effectiveness in its use. Students were able to carry out the activity steps more effectively, demonstrated more positive responses, and engaged in stronger collaborative interactions. Furthermore, the practice tool successfully facilitated a more contextual understanding of renewable energy concepts, thereby making the learning process more meaningful.

The comparison of the average percentages between the small-group trial and the large-group trial of the practice tool based on sappanwood extract as a natural dye sensitizer in the DSSC circuit is presented in Figure 4.

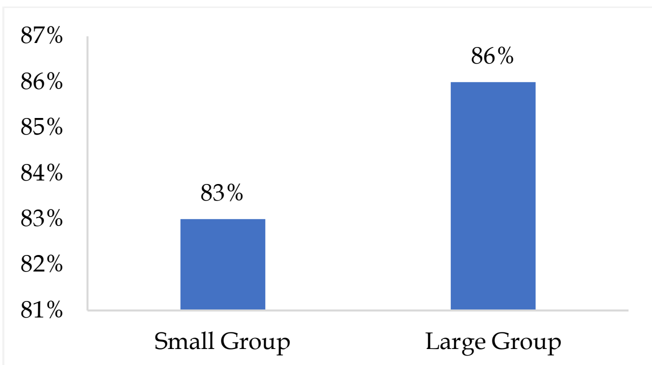


Figure 4. Comparison of small group and large group trials

Conclusion

This study produced a product in the form of a practical tool based on secang extract as a natural dye sensitizer in the DSSC circuit. The development of this practical tool is considered suitable for use. The average percentage of each evaluation result was 85% for media validation and 86% for material validation. In the small group trial, a score of 83% was obtained, while the large group trial resulted in 86%. The tool utilizes simple and efficient materials and equipment.

Acknowledgments

Gratitude is extended to Dr. Fitriani, M.Sc., Nurdianti Awaliyah, S.Si., M.Pd., Mahwar Qurbaniah, S.Pd., M.Si., Hamdil Mukhlishin, S,Pd., M.Pd., M.Si., M.Pd., Ir. Eko Julianto. ST., Mt., dan Yossi Deafirmanda. M.Pd. for serving as validators of the practical tool based on secang extract as a Natural Dye Sensitizer in the DSSC circuit. Special thanks are also conveyed to SMAN 10 Pontianak and SMAS Mujahiddin Pontianak for their valuable support and participation in this research.

Author Contributions

The research concept and design were developed by DH. The study was conducted by RS, DH, and RF. Data were analyzed and interpreted by RS, DH, and RF. RS and DH wrote the manuscript and carried out the major revisions to ensure its quality. RF was responsible for the statistical analysis, while RS and DH provided administrative, technical, and material support.

Funding

This article received no external funding.

Conflicts of Interest

The authors declare that there are no conflicts of interest.

References

Ahmad, N., Vunduk, J., Klaus, A., Dahlan, N. Y., Ghosh, S., Muhammad-Sukki, F., Dufossé, L., Bani, N. A., & Wan-Mohtar, W. A. A. Q. I. (2022). Roles of Medicinal Mushrooms as Natural Food Dyes and Dye-Sensitised Solar Cells (DSSC): Synergy of Zero Hunger and Affordable Energy for Sustainable Development. *Sustainability (Switzerland)*, *14*(21). https://doi.org/10.3390/su142113894

Aisyah, D. W. (2022). Development of Two Spaces Board Media With Ilustrated Story Boards. *Edumat (Jurnal Edukasi Matematika)*, *13*, 31–46. Retrieved from http://p4tkmatematika.kemdikbud.go.id/journals/index.php/edumat/article/view/334

Almenningen, D. M., Hansen, H. E., Buene, A. F., Hoff, B. H., & Gautun, O. R. (2022). Effect of seven different terthiophene π-spacers on dye performance in dye-sensitized solar cells. *Dyes and Pigments*, *207*(August), 110700. https://doi.org/10.1016/j.dyepig.2022.110700

Arifin, A. A., Ramdani, A., & Andayani, Y. (2024). Development of Learning Tools Based on the Culturally Responsive Transformative Teaching Model with a Socio-Scientific Issues Approach: Evaluation of Validity and Practicality. *Jurnal Penelitian Pendidikan IPA*, *10*(11), 9141–9155. https://doi.org/10.29303/jppipa.v10i11.9188

Azmi, I., Pangga, D., Ahzan, S., & Mirawati, B. (2024). Pelatihan Penyusunan Alat Peraktikum Sederhana bagi Asisten Laboratorium Fisika. *Jurnal Pengabdian Magister Pendidikan IPA Pelatihan*, *7*(4), 1833–1841. Retrieved from https://jppipa.unram.ac.id/index.php/jpmpi/article/view/10023

Basir, M., Setiawan, A., & Chandra, D. T. (2024). Design and Construct of Magnetic Induction and Force Practicum Tools to Improve Science Process Skills. *Jurnal Penelitian Pendidikan IPA*, *10*(9), 6516–6524. https://doi.org/10.29303/jppipa.v10i9.7837

Berlianti, E., Hamdu, G., & Putri, A. R. (2023). Analisis Kebutuhan Pengembangan E-Modul Berbasis Education For Suistanable Development untuk siswa Sekolah Dasar. *PEDADIDAKTIKA: Jurnal Ilmiah Pendidikan Guru Sekolah Dasar*, *10*(3), 434–445. https://doi.org/10.17509/pedadidaktika.v10i3.64413

Desimarlina, Y., Juniati, N., Ajizah, E., & Jamaluddin, J. (2021). Pemanfaatan Barang Bekas Sebagai Media Pembelajaran IPA Biologi pada Materi Virus di SMA Muhammadiyah Mataram. *Jurnal Pengabdian Magister Pendidikan IPA*, *4*(2). https://doi.org/10.29303/jpmpi.v4i2.655

Destiarti, L., Riyanto, R., Roto, R., & Mudasir, M. (2024). Facile synthesis of reduced graphene oxide using Caesalpinia sappan L. extract as green reducing agent. *Next Materials*, *2*(November 2023), 100134. https://doi.org/10.1016/j.nxmate.2024.100134

Gunada, I. W., Busyairi, A., & Ayub, S. (2023). Pelatihan Penerapan Alat Peraga Berbasis STEM Untuk Meningkatkan Sikap Ilmiah Siswa di SMP Negeri 1 Aikmel Lombok Timur. *Jurnal Pengabdian Magister Pendidikan IPA*, *6*(2), 231–237. https://doi.org/10.29303/jpmpi.v6i2.4184

Hasbi, M. A., Kosim, & Gunawan. (2015). Pengembangan Alat Peraga Listrik Dinamis (APLD) Berbasis Inkuiri Untuk Meningkatkan Penguasaan Konsep Siswa. *Jurnal Penelitian Pendidikan IPA*, *1*(1), 57–67. https://doi.org/10.29303/jppipa.v1i1.6

Hazar, I., Haitami, A., Mulijani, S., & Sutriah, K. (2022). Performance of Photovoltaic of Solar Cell Based on Natural and Synthetic Dye. *International Journal for Research in Applied Sciences and Biotechnology*, *9*(3), 53–57. https://doi.org/10.31033/ijrasb.9.3.

Hemthanon, T., & Ungcharoenwiwat, P. (2022). Antibacterial activity, stability, and hemolytic activity of heartwood extract from Caesalpinia sappan for application on nonwoven fabric. *Electronic Journal of Biotechnology*, *55*, 9–17. https://doi.org/10.1016/j.ejbt.2021.10.002

Herliandry, L. D., Harjono, A., & 'Ardhuha, J. (2018). Kemampuan Berpikir Kritis Fisika Peserta Didik Kelas X dengan Model Brain Based Learning. *Jurnal Penelitian Pendidikan IPA*, *5*(1).

https://doi.org/10.29303/jppipa.v5i1.166

Hidayat, W. A., Ardiningsih, P., & Jayuska, A. (2018). Aktivitas antioksidan dan antibakteri fraksi etil asetat buah Asam kandis (Garcinia dioica blume) terenkapsulasi gelatin. *Jurnal Kimia Khatulistiwa*, *7*(2), 33–40. Retrieved from https://jurnal.untan.ac.id/index.php/jkkmipa/article/view/25071

Islamiah, M., Rostati, R., & Triyunita, N. (2023). Pengembangan Alat Praktikum Gerak Jatuh Bebas Menggunakan Phyphox Berbasis Smartphone untuk Siswa Kelas X. *Jurnal Pendidikan MIPA*, *13*(3), 887–892. https://doi.org/10.37630/jpm.v13i3.1203

Kadir, A. K. S., & Purwaningsih, D. (2024). Development of Electronic Modules Based on Collaborative Problem Solving on Buffer Solution Materials. *Jurnal Penelitian Pendidikan IPA*, *10*(3), 1115–1123. https://doi.org/10.29303/jppipa.v10i3.5794

Kasmaniar, Yana, S., Nelly, Fitriliana, Susanti, Hanum, F., & Rahmatullah, A. (2023). Pengembangan Energi Terbarukan Biomassa dari Sumber Pertanian, Perkebunan dan Hasil Hutan: Kajian Pengembangan dan Kendalanya. *Jurnal Serambi Engineering*, *VIII*(1), 4957–4964. https://doi.org/10.32672/jse.v8i1.5668

Korir, B. K., Kibet, J. K., & Ngari, S. M. (2024). A review on the current status of dye-sensitized solar cells: Toward sustainable energy. *Energy Science and Engineering*, *12*(8), 3188–3226. https://doi.org/10.1002/ese3.1815

Lakoy, F. A. (2022). Pengembangan Media Rotasi Dinamis untuk Membangun Kemampuan Literasi Numerasi pada Pembelajaran Transformasi. *Jurnal Didaktika Pendidikan Dasar*, *6*(2), 381–396. https://doi.org/10.26811/didaktika.v6i2.692

Melati, P. D., Rini, E. P., Musyaiyadah, M., & Firman, F. (2024). Implementasi Projek Penguatan Profil Pelajar Pancasila (P5) dalam Kurikukulum Merdeka di Sekolah Menengah Atas (SMA). *Edukatif: Jurnal Ilmu Pendidikan*, *6*(4), 2808–2819. https://doi.org/10.31004/edukatif.v6i4.6762

Nasyori, A., Panturengi, I. I., & Kusuma, H. S. (2020). The Analysis of Caesalpinia Sappan L. Wood as dye Sensitizer and TiO2 Thickness Variation in Dye-Sensitized Solar Cells (DSSC). *Journal of Materials and Environmental Science*, *11*(5), 823. Retrieved from https://www.jmaterenvironsci.com/Document/vol11/vol11_N5/JMES-2020-1174-Nasyori.pdf

Nengsih, N. R., Yusmaita, E., & Gazali, F. (2019). Evaluasi Validitas Konten dan Konstruk Bahan Ajar Asam Basa Berbasis REACT. *EduKimia*, *1*(1), 1–10. https://doi.org/10.24036/ekj.v1i1.104017

Nirmal, N. P., Rajput, M. S., Prasad, R. G. S. V., & Ahmad, M. (2015). Brazilin from Caesalpinia sappan heartwood and its pharmacological activities: A review. *Asian Pacific Journal of Tropical Medicine*, *8*(6), 421–430. https://doi.org/10.1016/j.apjtm.2015.05.014

Nurfatimah, S. A., Hasna, S., & Rostika, D. (2022). Membangun Kualitas Pendidikan di Indonesia dalam Mewujudkan Program Sustainable Development Goals (SDGs). *Jurnal Basicedu*, *6*(4), 6145–6154. https://doi.org/10.31004/basicedu.v6i4.3183

Nurmayani, L., Doyan, A., & Verawati, N. N. S. P. (2018). Pengaruh Model Pembelajaran Inkuiri Terbimbing Terhadap Hasil Belajar Fisika Peserta Didik. *Jurnal Penelitian Pendidikan IPA*, *4*(2), 23–28. https://doi.org/10.29303/jppipa.v4i2.113

Nuryadi. (2017). *Buku Ajar Dasar-dasar Statistik Penelitian*. Sibuku Media.

Pramudiyanto. (2020). Energi Bersih dan Ramah Lingkungan dari Biomassa untuk Mengurangi Efek Gas Rumah Kaca dan Perubahan Iklim yang Ekstrim. *Jurnal Energi Baru Dan Terbarukan*, *1*(3), 86–99. https://doi.org/10.14710/jebt.2020.9990

Ramdani, A., Jufri, A. W., Gunawan, G., Hadisaputra, S., & Zulkifli, L. (2019). Pengembangan Alat Evaluasi Pembelajaran IPA Yang Mendukung Keterampilan Abad. *Jurnal Penelitian Pendidikan IPA*, *5*(1). https://doi.org/10.29303/jppipa.v5i1.221

Ramdani, A., Jufri, A. W., Jamaluddin, J., & Setiadi, D. (2020). Kemampuan Berpikir Kritis dan Penguasaan Konsep Dasar IPA Peserta Didik. *Jurnal Penelitian Pendidikan IPA*, *6*(1), 119–124. https://doi.org/10.29303/jppipa.v6i1.388

Ridho, S., Ruwiyatun, R., Subali, B., & Marwoto, P. (2020). Analisis Kemampuan Berpikir Kritis Siswa Pokok Bahasan Klasifikasi Materi dan Perubahannya. *Jurnal Penelitian Pendidikan IPA*, *6*(1), 10–15. https://doi.org/10.29303/jppipa.v6i1.194

Riduana, T. K., Isnindar, I., & Luliana, S. (2021). Standarisasi Ekstrak Etanol Daun Buas-Buas (premna serratifolia linn.) dan Kayu Secang (Caesalpinia sappan Linn.). *Media Farmasi*, *17*(1), 16. https://doi.org/10.32382/mf.v17i1.2045

Safitri, R. N., & Kusumawati, N. (2022). Pengaruh Kombinasi Ekstrak Kayu Secang (Caesalpinia sappan L.) dan Bunga Telang (Clitoria ternatea) pada pH Asam dan Basa sebagai Sensitizer Alami terhadap Efisiensi DSSC. *Prosiding Seminar Nasional Kimia*, *November*, 19–28. Retrieved from https://proceeding.unesa.ac.id/index.php/psnk/article/view/66%0Ahttps://proceeding.unesa.ac.id/index.php/psnk/article/download/66/51

Sakti, A. S., Saputri, F. C., & Mun'im, A. (2019).

Optimization of choline chloride-glycerol based natural deep eutectic solvent for extraction bioactive substances from Cinnamomum burmannii barks and Caesalpinia sappan heartwoods. *Heliyon*, *5*(12), e02915. https://doi.org/10.1016/j.heliyon.2019.e02915

Sasmitha, L. D., Hadiprayitno, G., Liwa Ilhamdi, M., & Jufri, A. W. (2023). Pengaruh Media Pembelajaran Berbasis Android terhadap Hasil Belajar dan Keterampilan Proses Sains Siswa. *Journal of Classroom Action Research*, *5*(Special Issue). https://doi.org/10.29303/jcar.v5iSpecialIssue.4623

Setyono. (2021). Dari Energi Fosil Menuju Energi Terbarukan: Potret Kondisi Minyak dan Gas Bumi Indonesia Tahun 2020 – 2050. *Jurnal Energi Baru Dan Terbarukan*, *2*(3), 154–162. https://doi.org/10.14710/jebt.2021.11157

Tahir, D., Satriani, W., Gareso, P. L., & Abdullah, B. (2019). Dye sensitized solar cell (DSSC) with natural dyes extracted from Jatropha leaves and purple Chrysanthemum flowers as sensitizer. *Journal of Physics: Conference Series*, *979*(1). https://doi.org/10.1088/1742-6596/979/1/012056

Ulfah, Azizah, T., & Wahyuni, E. (2021). Pengembangan Media Pembelajaran Permainan Kartu Uno Pada Pembelajaran Matematika Materi Satuan Panjang. *Prosiding Seminar Nasional Matematika Dan Pembelajarannya*, *3*(3), 955–961. Retrieved from https://osf.io/qt4mv

Yati, A. (2023). Analisis Kegiatan P5 Sebagai Penerapan Pembelajaran Pada Kurikulum Merdeka. *Seminar Nasional Pendidikan Profesi Guru Tahun 2021*, *2020*, 105–111. https://doi.org/10.30872/semnasppg.v4.3095

Zulenda, Naselia, U. A., Gustian, N., Zaharah, T. A., & Rahmalia, W. (2019). Synthesis and Characterization of the Brazilin Complex from Secang (Caesalpinia sappan Linn) Wood Extract and Its Application in Dye Sensitized Solar Cells (DSSC). *Jurnal Kimia Valensi*, *5*(1), 8–14. https://doi.org/10.15408/jkv.v5i1.8559