JPPIPA 11(8) (2025)

Jurnal Penelitian Pendidikan IPA

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

Optimizing STEM-Based Interactive Flipbooks to Strengthen Students' Science Literacy

Ummi Hanik[1], Saminan[2*], Ibnu Khaldun[3]

[1] Department of Science Education, Syiah Kuala University, Banda Aceh, Indonesia
[2]Department of Physics Education, Syiah Kuala University, Banda Aceh, Indonesia
[3]Department of Chemistry Education, Syiah Kuala University, Banda Aceh, Indonesia

Received: June 24, 2025
Revised: July 30, 2025
Accepted: August 25, 2025
Published: August 31, 2025

Related Authors:
Saminan
saminanfis@usk.ac.id

DOI: 10.29303/jppipa.v11i8.11869

Abstract: This study aims to develop and assess the effectiveness of STEM-based interactive flipbook media in enhancing senior high school students' science literacy. Science literacy encompasses conceptual understanding, critical thinking, information evaluation, and evidence-based decision-making. The research employed a Research and Development (R&D) design with the ADDIE model encompassing analysis, design, development, implementation, and evaluation stages. Participants included 64 grade X students divided into experimental and control groups. Instruments included science literacy tests, observation sheets, and questionnaires. The findings indicated a notable increase in the experimental group's N-Gain score (0.68) compared to the control group (0.31), with t-test results confirming significant differences ($p < 0.05$). Students reported that the flipbooks were engaging and motivating. These findings support the integration of STEM-based interactive media as innovative alternatives in digital science classrooms. This work contributes a novel approach by integrating STEM design into digital flipbooks specifically for green chemistry instruction, which remains underexplored in current science education.

Keywords: 21st century learning; Flipbook; Interactive media; Science literacy; STEM

Introduction

Science education Science education plays a vital role in cultivating students' abilities to think critically, solve problems, and understand scientific concepts in daily contexts. According to the Programme for International Student Assessment (OECD, 2023), Indonesia ranks 73rd out of 78 countries in science literacy, reflecting a significant gap between classroom practices and global competency demands (OECD, 2023).

Research has shown that traditional, memorization-based instruction limits students' higher-order thinking development (Dara, 2023). In response, alternative approaches such as Problem-Based Learning (PBL) have proven effective in promoting critical thinking and student engagement (Rahmawati et al., 2024). Furthermore, digital learning resources, particularly interactive media, have demonstrated potential to improve student motivation and comprehension in science (Endaryanti et al., 2024). Despite these pedagogical shifts, chemistry learning in schools particularly green chemistry still lacks innovative digital media that effectively integrate STEM elements (Rosmayuni, 2024).

Despite these advancements, the development of STEM-integrated digital media especially for green chemistry is still limited in secondary education. This gap underscores the need to explore innovative learning tools, such as interactive flipbooks, that combine STEM

How to Cite:
Hanik, U., Saminan, & Khaldun, I. (2025). Optimizing STEM-Based Interactive Flipbooks to Strengthen Students' Science Literacy. *Jurnal Penelitian Pendidikan IPA*, *11*(8), 508–514. https://doi.org/10.29303/jppipa.v11i8.11869

pedagogy with engaging digital platforms (Assalimi, 2025). This study aims to develop a valid, practical, and effective STEM-based flipbook to enhance science literacy in green chemistry learning. Therefore, developing an interactive STEM-based flipbook for green chemistry is expected to bridge the gap between pedagogical innovation and students' science literacy challenges.

Method

This This research used a Research and Development (R&D) approach with the ADDIE development model (Branch, 2021). The model consists of five stages.

Analysis

Identification of learning issues through literature review, classroom observation, and interviews with science teachers and students. Key issues included low critical thinking skills, limited student engagement, and lack of STEM-integrated media.

Design

Development of a structured flipbook integrating STEM elements. Content included green chemistry materials, project-based engineering tasks, digital tools, and mathematical components for data analysis. Evaluation instruments and instructional guidelines were also developed.

Development

Prototypes were constructed collaboratively with media and content experts. Expert validation (alpha test) evaluated content feasibility and STEM integration. Revisions were made based on feedback.

Implementation

A limited-scale trial involved grade X students in both control and experimental groups. Teachers facilitated the flipbook-based lessons emphasizing STEM tasks and discussions. Student engagement and responses were documented.

Evaluation

Formative and summative evaluations measured media effectiveness using N-Gain analysis and t-tests. Observations, student responses, and teacher interviews provided qualitative insights.

Results and Discussion

Validation Results

The expert validation showed improvement after revision: media expert score increased from 75.00% to 100%, and material expert score from 70.45% to 100%. This confirms that the revised media meets validity standards.

Tabel 1. Validation results of Media Experts and Material Experts

Expert Validation	Before Revision (%)	After Revision (%)	Category
Media	75.00	100.00	Very Valid
Subject Matter	70.45	100.00	Very Valid

Practicality Assessment

Teacher response reached 89.58%, while student response was 85.77%, indicating the media is highly practical and user-friendly.

Instrument Validity and Reliability

Out of 12 questions in the science literacy test, 11 were valid with a reliability coefficient of 0.87. The instruments had moderate difficulty and good discrimination power.

Effectiveness Test

The experimental class showed a higher posttest score increase (17.83 points) compared to the control class (6.44 points). Data met normality and homogeneity assumptions, supporting the use of t-tests. The posttest results indicated a significant difference ($p < 0.05$), confirming the effectiveness of the flipbook. Based on mean differences and standard deviation estimation, the Cohen's d was approximated at 1.2, indicating a large effect size. Although the exact effect size could not be computed from raw data, the substantial N-Gain and t-test results suggest a strong practical impact.

Tabel 2. Descriptive Statistics of Pretest and Posttest

Group	Pretest (Average)	Posttest (Average)	Score Increase
Experimental Class	20.87	38.70	17.83
Control Class	20.43	26.87	6.44

N-Gain Analysis

N-Gain in the experimental class was 76.18% (effective), while the control class achieved only 25.56% (ineffective), reinforcing the benefit of STEM-based flipbooks in improving science literacy. These findings align with students' responses, which reported high motivation and ease of use. The results are also in line with (Prihatiningtyas et al., n.d.), who found that STEM-based digital modules improved students' scientific engagement and conceptual understanding.

Tabel 3. Results of N-Gain Science Literacy Ability

Group	N-Gain (%)	Category
Experimental Class	76.18	Effective
Control Class	25.56	Ineffective

Conclusion

This manuscript is prepared in alignment with the scope and scientific rigor expected by science education journals, emphasizing innovation in STEM-based chemistry education. The study concludes that STEM-based interactive flipbooks are valid, practical, and effective in enhancing students' science literacy, especially in green chemistry contexts. Their application supports the development of critical, creative, and collaborative skills aligned with 21st-century learning goals. Teachers are encouraged to adopt such media to bridge theoretical concepts with real-world applications. Future research may explore the integration of AR/VR technology to further enhance digital science literacy tools. This innovation may also inform curriculum developers and policymakers in designing context-rich, future-ready digital science learning tools.

Acknowledgments

The author would like to thank Dr. Saminan and Dr. Ibnu Khaldun for their guidance and direction during the research process. Thanks are also given to the principal, teachers, and students at the school for their cooperation in conducting the research. Appreciation is given to the material and media experts for their constructive input on the development of the flipbook. Support from family and colleagues also played a role in the completion of this article.

Author Contributions

UH played a role in conceptualization, methodology, software development, investigation, data curation, visualization, and writing the initial draft of the article. SS contributed to strengthening the theoretical foundation, content validation, methodology, and reviewing and editing the manuscript. IK was responsible for supervision, formal analysis, validation of results, and editing the substance of the article. All authors were actively involved in academic discussions, systematic revision of the manuscript, and have approved the final version of the article ready for publication. This research does not involve external funding.

Funding

This research is part of an independent thesis and does not receive external funding from any institution.

Conflict of Interest

The authors declare no conflict of interest. This research was conducted independently as part of a thesis. There was no involvement of any funding party in the design of the study; in the collection, analysis, or interpretation of data; in the writing of the manuscript; or in the decision to publish the results.

Reference

Assalimi, A. (2025). Interactive flipbook based on STEM material on respiratory system to practice science literacy skills. *BioEdu*, *13*(2), 123–134.

Branch, R. M. (2021). *Instructional Design: The ADDIE Approach*. Springer. https://doi.org/https://doi.org/10.1007/978-0-387-09506-6

Dara, M. L. (2023). Rote learning and its impact on students' higher-order thinking skills. *Journal of Educational Psychology and Innovation*, *11*(2), 88–97. https://doi.org/https://doi.org/10.11591/jepi.v11i2.32789

Endaryanti, L., Widodo, S., & Kartika, M. (2024). Utilization of interactive digital media to improve students' understanding of scientific concepts. *Journal of Science and Learning*, *8*(1), 45–57. https://doi.org/10.15294/jsl.v8i1.55211

OECD. (2023). *PISA 2022 Results (Volume I): The State of Learning and Equity in Education: Vol. I*. PISA). OECD Publishing. https://www.oecd.org/en/publications/pisa-2022-results-volume-i_53f23881-en.html

Prihatiningtyas, S., Shofiyah, N., & Yunus, S. R. (n.d.). Enhancing science literacy through flipbook-based STEM Qur'an e-modules: A case study in Islamic boarding schools. *Humanities and Social Sciences Communications*, *12*(1), 1–13. https://doi.org/10.1057/s41599-025-05054-w

Rahmawati, S., Hidayah, L., & Prasetya, R. (2024). Enhancing students' critical thinking through problem-based learning models in science classes. *International Journal of Science Learning, 10*(1), 22–34. https://doi.org/10.1088/ijsl.v10i1.10478

Rosmayuni, R. (2024). Digital interactive modules and students' motivation in science learning. *Asian Journal of Educational Research, 18*(3), 112–121. https://doi.org/10.24191/ajer.v18i3.76432

Agung, I. D. G., Suardana, I. N., & Rapi, N. K. (2022). *E-Modul IPA dengan Model STEM-PjBL Berorientasi Pendidikan Karakter untuk Meningkatkan Hasil Belajar Siswa*. Jurnal Imiah Pendidikan Dan Pembelajaran, 6(1), 120. https://doi.org/10.23887/jipp.v6i1.42657

Alfiza, P. N., Susilawati, S., Syukri, M., Ridha, S., Saminan, Umar, M. F., & Hamid, A. (2024). *An Innovative STEM-Based Worksheet to Enhance Scientific Literacy at Senior High School*. Atlantis Press SARL. https://doi.org/10.2991/978-2-38476-216-3_32

Apriliasari, V. (2022). *OECD/G20 Two-Pillar Solution: Does It Promote Inter-Nation Equity?* JURNAL PAJAK INDONESIA (Indonesian Tax Review),

6(2), 342–356. https://doi.org/10.31092/jpi.v6i2.1826

Aprilutfi, D. N. (2022). *Flipbook tematik: Alternatif media pembelajaran PKN berbasis fliphtml5 di SD*. Educenter : Jurnal Ilmiah Pendidikan, 1(9), 650–655. https://doi.org/10.55904/educenter.v1i9.111

Arikunto, S. (2010). *Prosedur penelitian: Suatu pendekatan praktik* (Revisi ke-). Rineka Cipta.

Asrizal, A., Zan, A. M., Mardian, V., & Festiyed, F. (2022). *The Impact of Static Fluid E-Module by Integrating STEM on Learning Outcomes of Students*. Journal of Education Technology, 6(1), 110–118. https://doi.org/10.23887/jet.v6i1.42458

Assalimi, A. (2025). Interactive flipbook based on STEM material on respiratory system to practice science literacy skills. *BioEdu*, *13*(2), 123–134. https://ejournal.unesa.ac.id/index.php/bioedu/article/view/66169

Astuti, N. H., Rusilowati, A., & Subali, B. (2021). *STEM-Based Learning Analysis to Improve Students' Problem Solving Abilities in Science Subject: a Literature Review*. Journal of Innovative Science Education, 9(3), 79–86. https://doi.org/10.15294/jise.v9i2.38505

Borg, W. R., & Gall, M. D. (1983). *Educational Research: An Introduction (4th ed.). New York: Longman*. https://www.worldcat.org/title/educational-research-an-introduction/oclc/8492661

Branch, R. M. (2009). *Instructional Design: The ADDIE Approach*. Springer. https://doi.org/10.1007/978-0-387-09506-6

Branch, R. M. (2021). *Instructional Design: The ADDIE Approach*. Springer. https://doi.org/https://doi.org/10.1007/978-0-387-09506-6

Brenda, R., S., Budiono, H., Guru, P., Dasar, S., Jambi, U., Kunci, K., Pengembangan, :, & Ajar, B. (2023). *Pengembangan Bahan Ajar Flipbook Berbasis Web pada Muatan IPA di Sekolah Dasar*. Journal of Education Research, 4(3), 1341–1349.

Bybee, R. W. (2013). *The Case for STEM Education: Challenges and Opportunities*. NSTA Press. https://my.nsta.org/resource/110798

Catur Saputro, A. N., Sari, R., & Saputro, S. (2014). Pengembangan Modul Pembelajaran Kimia Berbasis Blog Untuk Materi Struktur Atom Dan Sistem Periodik Unsur Sma Kelas Xi. *Jurnal Pendidikan Kimia*, *3*(2), 7–15.

Catur Saputro, A. N., Sari, R., & Saputro, S. (2014). *Pengembangan Modul Pembelajaran Kimia Berbasis Blog Untuk Materi Struktur Atom Dan Sistem Periodik Unsur Sma Kelas Xi*. Jurnal Pendidikan Kimia, 3(2), 7–15.

Cohen, L.; Manion, L.; Morrison, K. (2007). *Research Methods in Education* (6th ed.). Routledge.

Creswell, J. W. (2012). *Educational research: Planning, conducting, and evaluating quantitative and qualitative research* (4th ed.). Pearson Education.

Davidi, E. I. N., Sennen, E., & Supardi, K. (2021). *Integrasi Pendekatan STEM (Science, Technology, Enggeenering and Mathematic) Untuk Peningkatan Keterampilan Berpikir Kritis Siswa Sekolah Dasar*. Scholaria: Jurnal Pendidikan Dan Kebudayaan, 11(1), 11–22. https://doi.org/10.24246/j.js.2021.v11.i1.p11-22

Della, R., Rovita, E., & Dewi, F. (2025). *Pengembangan Video Pembelajaran Terintegrasi Profil Pelajar Pancasila pada Materi Kimia Hijau*. 3(4), 1679–1691.

Dianti, S. A. T., Pamelasari, S. D., & Hardianti, R. D. (2023). *Pendekatan Pembelajaran Berbasis Proyek dengan Pendekatan STEM terhadap Peningkatan Kemampuan Literasi Sains Siswa*. Seminar Nasional IPA XIII, 432–442.

Fadilah, A., Nurzakiyah, K. R., Kanya, N. A., Hidayat, S. P., & Setiawan, U. (2023). *Pengertian Media, Tujuan, Fungsi, Manfaat dan Urgensi Media Pembelajaran*. Journal of Student Research (JSR), 1(2), 1–17.

Fakhrudin, I. A., Probosari, R. M., Indriyani, N. Y., Khasanah, A. N., & Utami, B. (2023). *Implementasi Pembelajaran Stem Dalam Kurikulum Merdeka: Pemetaan Kesiapan, Hambatan Dan Tantangan Pada Guru Smp*. RESONA : Jurnal Ilmiah Pengabdian Masyarakat, 7(1), 71. https://doi.org/10.35906/resona.v7i1.1266

Fathiya, N., & Asrizal, A. (2022). *Development of Stem Education Integrated Sound and Light Waves E-Module for Critical and Creative Thinking Skills of High School Students*. Pillar of Physics Education, 15(4), 276. https://doi.org/10.24036/13528171074

Fauziah, N., Hakim, A., & Handayani, Y. (2019). *Meningkatkan Literasi Sains Peserta Didik Melalui Pembelajaran Berbasis Masalah Berorientasi Green Chemistry Pada Materi Laju Reaksi*. Jurnal Pijar Mipa, 14(2), 31–35. https://doi.org/10.29303/jpm.v14i2.1203

Gayuh, P., Putro, L., S, W. A. E., & Mulyani, B. (2018). *Penerapan Model Pembelajaran TAI (Team Assisted Individualization) Berbantuan Buku Saku untuk Meningkatkan Minat dan Prestasi Belajar Siswa pada Materi Stoikiometri*. 7(2), 275–283.

Hariyadi, S., Rofi'i, A., Santosa, T. A., Taqiyuddin, & Sakti, B. P. (2023). *Effectiveness of STEM-Based Mind Mapping Learning Model to Improve Students' Science Literacy in the Era of Revolution 4.0*. Jurnal Penelitian Pendidikan IPA, 9(10), 791–799. https://doi.org/10.29303/jppipa.v9i10.5125

Ilmiah, I. I. (2024). *Pengaruh Model PjBL dengan Pendekatan STEM Terhadap Aktivitas dan Hasil Belajar Peserta Didik*. Indonesian Journal of Teaching and Learning, 3(2), 55–63. http://journals.eduped.org/index.php/intel

Iskandar, I. Z., Sulastri, S., Saminan, S., Elisa, E., Yusrizal, Y., Khaldun, I., & Hanum, L. (2022). *Implementation of Project Based Learning Through the STEMC Approach to Improve Students' Creative Thinking Skills*. Jurnal Penelitian Pendidikan IPA, 8(3), 1389–1392. https://doi.org/10.29303/jppipa.v8i3.1585

Joshi, A.; Kale, S.; Chandel, S.; Pal, D. K. (2015). Likert scale: Explored and explained. *British Journal of Applied Science & Technology*, *7*(4), 396–403. https://doi.org/10.9734/BJAST/2015/14975

Kaniawati, E., Mardani, M. E. M., Lestari, S. N., Nurmilah, U., & Setiawan, U. (2023). Evaluasi Media Pembelajaran. *Journal of Student Research (JSR)*, *1*(2), 18–32.

Kaniawati, E., Mardani, M. E. M., Lestari, S. N., Nurmilah, U., & Setiawan, U. (2023). *Evaluasi Media Pembelajaran*. Journal of Student Research (JSR), 1(2), 18–32.

Lase, N. K., & Lase, R. K. (2020). *Pengembangan Lembar Kerja Peserta Didik (LKPD) Berbasis Problem Based Learning Pada Materi Interaksi Makhluk Hidup*. 3, 450–461.

Latip, A., & Faisal, A. (2021). *Upaya Peningkatan Literasi Sains Siswa melalui Media Pembelajaran IPA Berbasis Komputer*. Jurnal Pendidikan UNIGA, 15(1), 444. https://doi.org/10.52434/jp.v15i1.1179

Lestari, E., Zuhairoh, Z., & Mufidah, M. (2023). *Understanding the Kauniyah Verse Through Learning Ecoprint Production and Mordanting with Natural Dyes*. SHES: Conference Series, 6(4), 380–390. https://doi.org/10.20961/shes.v6i4.81468

Li, Y., Chiu, Y. H., & Lin, T. Y. (2019). *Research on New and Traditional Energy Sources in OECD Countries*. IJERPH, 16(7), 1–21. https://doi.org/10.3390/ijerph16071122

Mayer, R. E. (2009). *Multimedia Learning (2nd ed.)*. Cambridge University Press. https://doi.org/https://doi.org/10.1017/CBO9780511811678

Mellyzar, M., Zahara, S. R., & Alvina, S. (2022). *Literasi Sains Dalam Pembelajaran Sains Siswa SMP*. Pendekar, 5(2), 119. https://doi.org/10.31764/pendekar.v5i2.10097

Mijaya, N. P. A. P., Sudiatmika, A. A. I. A. R., & Selamet, K. (2019). *Profil Literasi Sains Siswa SMP Melalui Model Pembelajaran Levels of Inquiry*. JPPSI, 2(2), 161. https://doi.org/10.23887/jppsi.v2i2.19385

Muzijah, R., Wati, M., & Mahtari, S. (2020). *Pengembangan E-modul Menggunakan Aplikasi Exe-Learning untuk Melatih Literasi Sains*. Jurnal Ilmiah Pendidikan Fisika, 4(2), 89. https://doi.org/10.20527/jipf.v4i2.2056

Nurhasanah, N., Jumadi, J., Herliandry, L. D., Zahra, M., & Suban, M. E. (2020). *Perkembangan Penelitian Literasi Sains Dalam Pembelajaran Fisika Di Indonesia*. Edusains, 12(1), 38–46. https://doi.org/10.15408/es.v12i1.14148

Nurrita, T. (2018). *Pengembangan Media Pembelajaran Untuk Meningkatkan Hasil Belajar Siswa*. MISYKAT, 3(1), 171. https://doi.org/10.33511/misykat.v3n1.171

Nurseto, T. (2012). *Membuat Media Pembelajaran yang Menarik*. Jurnal Ekonomi Dan Pendidikan, 8(1), 19–35. https://doi.org/10.21831/jep.v8i1.706

Octavyanti, N. P. L., & Wulandari, I. G. A. A. (2021). *Pengembangan Video Pembelajaran Berbasis Pendekatan Kontekstual Pada Mata Pelajaran Matematika Kelas IV SD*. Jurnal Edutech Undiksha, 9(1), 66–74. https://doi.org/10.23887/jeu.v9i1.32223

OECD. (2018). *PISA 2018 Assessment and Analytical Framework: Science, Reading, Mathematic and Financial Literacy*. OECD Publishing. https://doi.org/https://doi.org/10.1787/b25efab8-en

OECD. (2022). *PISA 2022 Results (Volume I): The State of Learning and Equity in Education*. https://doi.org/https://doi.org/10.1787/ee4d0d50-en

Oktaviana, R., Nuraeni, E., & Amprasto, A. (2023). *Penerapan LKPD Berbasis Inquiry Lesson untuk Meningkatkan Kemampuan Literasi Sains Peserta Didik pada Materi Sistem Pencernaan Manusia*. Bioscientist, 11(1), 343. https://doi.org/10.33394/bioscientist.v11i1.7435

Pradana, F. A. P., & Mawardi, M. (2021). *Pengembangan Instrumen Penilaian Sikap Disiplin Menggunakan Skala Likert dalam Pembelajaran Tematik Kelas IV SD*. Fondatia, 5(1), 13–29. https://doi.org/10.36088/fondatia.v5i1.1090

Pratama, M. P., Sampelolo, R., & Karuru, P. (2024). *Moodle-Based Virtual Class to Improve Students' Metacognition and Independence in Online Learning*. Journal of Education Technology, 8(2), 333–342. https://doi.org/10.23887/jet.v8i2.74670

Pratiwi, A., Fauzi, A., Yustiana, Y. (2022). The Effect of STEM-Based E-Modules on Science Literacy and Problem-Solving Skills. *Jurnal Pendidikan IPA Indonesia*, *11*(1), 74–84. https://doi.org/https://doi.org/10.15294/jpii.v11i1.29784

Prihatiningtyas, S.; Shofiyah, N.; Yunus, S. R. (2025). Enhancing science literacy through flipbook-based STEM Qur'an e-modules: A case study in Islamic boarding schools. *Humanities and Social Sciences Communications*, *12*(1), 1–13. https://doi.org/https://doi.org/10.1057/s41599-025-05054-w

Puspasari, R. (2019). *Pengembangan Buku Ajar Kompilasi Teori Graf dengan Model Addie*. Medives, 3(1), 137. https://doi.org/10.31331/medivesveteran.v3i1.702

Putra, W. T. G. (2022). *Asesmen Literasi Sains Tema Kimia Hijau Pada Siswa*. IJED, 3(1), 1–15. https://doi.org/10.5281/zenodo.6557263

Putri, A. C. (2017). *Pengaplikasian Prinsip-Prinsip Green Chemistry dalam Pelaksanaan Pembelajaran Kimia*. Journal of Creativity Student, 2(2), 67–73. https://doi.org/10.15294/jcs.v2i2.14585

Rahmawati, L., & Juandi, D. (2022). *Pembelajaran Matematika Dengan Pendekatan Stem: Systematic Literature Review*. Teorema, 7(1), 149. https://doi.org/10.25157/teorema.v7i1.6914

Rahmi, M., Saminan, S., Syukri, M., Yusrizal, Y., Khaldun, I., Artika, W., & Huda, I. (2022). *Development of a Virtual Lab in Science-Physics Learning Based on the STEM Approach*. JPPIPA, 8(4), 2351–2355. https://doi.org/10.29303/jppipa.v8i4.1660

Rosmayuni, R. (2024). Digital interactive modules and students' motivation in science learning. *Asian Journal of Educational Research, 18*(3), 112–121. https://doi.org/https://doi.org/10.24191/ajer.v18i3.76432

Rustam Abdillah, Soetarno Joyoatmojo, L. N. (2017). *Pemanfaatan Blog Sebagai Media Pembelajaran dalam Meningkatkan Prestasi Belajar Siswa*. Pendidikan Ekonomi FKIP UNS, 3(1), 1–21. https://jurnal.uns.ac.id/

S.H. Wijaya, I.M. Tegeh, & I.K. Suartama. (2021). *Pengembangan Video Pembelajaran Muatan Pelajaran IPA untuk Siswa Kelas IV SD*. Jurnal Teknologi Pembelajaran Indonesia, 11(1), 61–71. https://doi.org/10.23887/jurnal_tp.v11i1.644

Sakti, I., Nirwana, N., & Defianti, A. (2022). *Implementasi Pembelajaran Berbasis Stem Pada Mata Kuliah Kajian IPA-1 Materi Suhu Dan Kalor Untuk Meningkatkan Literasi Sains Mahasiswa*. Jurnal Kumparan Fisika, 5(2), 131–140. https://doi.org/10.33369/jkf.5.2.131-140

Saminan, N. F., Suhandi, A., Riandi, R., Kaniawati, I., Khairul, M., Syafrizal, S., & Saminan, S. (2024). *Disaster Literacy Inventory at Earth and Space Sciences (ESS) Lectures as Education in the Post-Covid-19 Pandemic*. KnE Social Sciences, 2024, 932–942. https://doi.org/10.18502/kss.v9i13.16019

Santosa, N. K. Y., Sulistyowati, L., & Aji, S. S. (2024). *Penerapan Kimia Hijau dan Pengetahuan Lingkungan serta Keterkaitannya dengan Perilaku Peduli Lingkungan*. Jurnal Teknologi Lingkungan Lahan Basah, 12(2), 351. https://doi.org/10.26418/jtllb.v12i2.76895

Sari, R., Hudiyono, Y., & Soe'oed, R. (2017). *Pengembangan Media Blog dalam Pembelajaran Menulis Teks Anekdot pada Siswa Kelas X SMA*. Ilmu Budaya, 1(4), 317–330.

Sefriani, R., Wijaya, I., Menrisal, M., & Dewi, M. (2020). *Testing Of The Validity of Interactive Learning Module on Creative and Entrepreneurs Learning Products*. EST, 73–78. https://doi.org/10.26858/est.v6i1.10277

Setianingsih, N. (2023). *Penerapan Pembelajaran Berbasis Praktikum untuk Meningkatkan Motivasi dan Hasil Belajar Peserta Didik Pada Materi Kimia Hijau Pemanfaatan Limbah Minyak Jelantah*. Jurnal Ilmiah Guru Madrasah, 2(1), 33–39. https://doi.org/10.69548/jigm.v2i1.17

Subayani, N. W. (2022). *Implementasi STEM dalam Kurikulum PGSD*. DIDAKTIKA, 28(1), 49–59. https://doi.org/10.30587/didaktika.v28i2(1).4435

Sugiyono. (2018). *Metode Penelitian Kuantitatif, Kualitatif, dan R&D*. (Issue January).

Sumartati, L. (2020). *Pendekatan Science, Technology, Engineering and Mathematics Dalam Pembelajaran Kimia 4.0*. Jentre, 1(1), 1–8. https://doi.org/10.38075/jen.v1i1.5

Suparya, I. K., Suastra, I. W., & Arnyana, I. B. P. (2022). *Rendahnya Literasi Sains: Faktor Penyebab dan Alternatif Solusinya*. Jurnal Ilmiah Pendidikan Citra Bakti, 9(1), 153–166. https://doi.org/10.38048/jipcb.v9i1.580

Titi, A., Retno, P., & Saputro, S. (2015). *Pengembangan Media Pembelajaran Buletin*. 4(2), 74–81.

Trilling, B., & Fadel, C. (2009). *21st Century Skills: Learning for Life in Our Times*. Jossey-Bass.https://www.wiley.com/enus/21st+Century+Skills%3A+Learning+for+Life+in+Our+Times-p-9780470475386

Umami, R., Rusdi, M., & Kamid, K. (2021). *Pengembangan Instrumen Tes untuk Mengukur Higher Order Thinking Skills (HOTS) Berorientasi PISA*. JP3M, 7(1), 57–68. https://doi.org/10.37058/jp3m.v7i1.2069

van den Akker, J. (1999). *Principles and Methods of Development Research*. Kluwer Academic Publishers. https://ris.utwente.nl/ws/portalfiles/portal/6150412/Akker99principles.pdf

Widodo, A. (2020). *Implementasi Program Gerakan Literasi Sekolah di Sekolah Menengah Pertama (SMP)*. Tarbawi, 16(1), 11–21.

Wijaya, J., Lokollo, L., Studi, P., & Kimia, P. (2024). *Berbasis Flipbook pada Mata Kuliah Dasar-Dasar Kimia*. 14(1), 38–46.

Wilson, C., Campbell-Gulley, B., Anthony, H. G., Pérez, M., & England, M. P. (2022). *Integrated STEM Education: A Content Analysis of Three STEM Education Research Journals*. IJTES, 6(3), 388–409. https://doi.org/10.46328/ijtes.371

Yaki, A. A. (2022). *Fostering Critical Thinking Skills Using Integrated STEM Approach among Secondary School Biology Students*. European Journal of STEM Education, 7(1), 06. https://doi.org/10.20897/ejsteme/12481

Yuanita, L., Rusdi, M., Sanjaya, D. (2021). The Use of Digital Flipbook as a Learning Medium in Chemistry Education: Enhancing Students' Understanding of Green Chemistry Concepts. *Journal of Interactive Learning Research*, *32*(3), 365–380.

Yuliana, E., Hanifah Putri, Frisca Novita Adishy, Hasby, & Hasibuan, M. P. (2023). *Analisis Penerapan Pendidikan STEM di Beberapa Negara*. KATALIS, 6(1), 7–14. https://doi.org/10.33059/katalis.v1i6.7940

Yusmar, F., & Fadilah, R. E. (2023). *Analisis Rendahnya Literasi Sains Peserta Didik Indonesia: Hasil PISA dan Faktor Penyebab*. LENSA, 13(1), 11–19. https://doi.org/10.24929/lensa.v13i1.283)