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Development and Validation of an Ethnochemistry Integrated Digital Pop Up Book for Acid–Base Instruction

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Abstract
This study develops and evaluates a novel ethnochemistry based digital pop-up book for teaching acid–base concepts at the senior high school level. The novelty of this research lies in integrating local Minangkabau cultural practices with interactive digital pop up media to address the abstract nature of acid–base learning. The study employed a Research and Development approach using the 4D model (define, design, develop, and limited dissemination). Data were obtained through expert validation and limited field testing involving a chemistry teacher and Grade XI students. The media combines animations, videos, interactive navigation, contextual ethnochemistry content, and formative assessments within a single digital learning platform. Expert validation results across material, language, media design, and ethnochemistry aspects indicated a highly valid category. Practicality testing demonstrated very practical outcomes in terms of usability, attractiveness, usefulness, and time efficiency. These findings confirm that the developed media offers an innovative, contextual, and effective solution for enhancing conceptual understanding and student engagement in chemistry learning.

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INTRODUCTION

Chemistry is a core scientific discipline that examines the composition, structure, properties, and transformations of matter at atomic and molecular levels, as well as their applications in everyday life. Learning chemistry is not merely about acquiring factual knowledge but also about developing students' critical thinking skills and their ability to analyze real-world phenomena. Nevertheless, chemistry is widely perceived as a challenging subject by students due to the abstract nature of many of its concepts, which require deep conceptual understanding rather than memorization. As a result, chemistry instruction must be designed to be engaging, meaningful, and supportive of students' conceptual comprehension (Tustari et al., 2025) (Wulandari & Susilaningsih, 2018). This view is consistent with recent international studies emphasizing that meaningful chemistry learning should promote conceptual integration rather than rote learning, particularly for abstract topics (Irnawati & Rahmawan, 2024).

Instructional media play a crucial role in facilitating effective learning processes. Digital learning media, in particular, have gained increasing attention due to their ability to integrate multimedia elements such as text, images, animations, audio, and video into interactive learning experiences. Recent studies have demonstrated that digital and web-based learning environments can significantly enhance students' motivation, engagement, and conceptual understanding, especially in science learning contexts that involve abstract reasoning (Ilahi et al., 2023)(Rezki et al., 2024). Research has also shown that computer simulations and interactive digital tools are effective in supporting students' understanding of complex chemical

processes by visualizing microscopic and symbolic representations (Jere & Mpeta, 2024). In addition, web-based discussion tools have been reported to promote active learning and deeper conceptual understanding through collaborative knowledge construction (Investigating the Impact of Web-Based Discussion Tools on Students' Conceptual Understanding, 2025). Various forms of digital media, including interactive presentations, educational games, and digital pop-up books, have therefore been increasingly implemented in chemistry education and shown positive impacts on learning outcomes (Rizki et al., 2024).

Despite these advantages, the integration of digital learning media in chemistry classrooms remains inconsistent. In many schools, teaching practices are still dominated by traditional media such as the chalkboard, even when adequate technological facilities are available. This situation is often influenced by teachers' limited time, insufficient technological skills, and heavy workload demands, which hinder the optimal use of digital instructional media (Mutia & Mawarnis, 2024). Consequently, learning activities tend to be monotonous and less engaging, negatively affecting students' motivation and conceptual understanding. Similar challenges have been reported in international contexts, where the lack of structured integration of digital tools limits their potential impact on students' learning (Iyamuremye et al., 2025).

Beyond technological aspects, contextual learning has been widely recognized as an effective approach to improving students' engagement and understanding in science education. One prominent form of contextual learning in chemistry is ethnochemistry, which emphasizes the integration of chemical concepts with local cultural practices and indigenous knowledge systems. Recent international research has highlighted, incorporating ethnochemistry into secondary school chemistry curricula helps bridge scientific concepts with students' cultural experiences, making learning more meaningful and relevant (Chibuye & Singh, 2024). Furthermore, systematic reviews indicate that ethnochemistry-based learning supports the development of chemical literacy, higher-order thinking skills, and 21st-century competencies (Ashari, 2025). Trends in recent studies also reveal a growing emphasis on integrating ethnoscience into chemistry learning as a way to contextualize abstract concepts and foster students' cultural awareness (Yuendita & Eli Rohaeti, 2025).

Field observations conducted in a senior high school revealed that, although facilities such as projectors, internet access, and laboratories were available, the use of digital learning media in chemistry instruction was still minimal. Teaching activities relied heavily on the chalkboard, which limited the visualization of abstract concepts and reduced student engagement. Interviews with teachers and students indicated low motivation, difficulties in understanding chemistry concepts, and limited exposure to contextual examples related to everyday life. These conditions were reflected in students' learning outcomes, where a large proportion of students did not achieve the expected learning mastery criteria (Mutia & Mawarnis, 2024). Such findings further support international evidence that inadequate use of digital and contextual learning approaches contributes to persistent learning difficulties in chemistry (Rodrigues et al., 2024).

Although previous studies have explored digital learning media and ethnochemistry separately, research that integrates interactive digital pop-up book media with ethnochemistry content particularly for acid–base topics remains limited. Acid–base material is conceptually abstract, hierarchical, and complex, yet closely related to everyday phenomena. Therefore, learning media that combine strong visualization, interactivity, and cultural context are essential to support students' conceptual understanding and engagement (Putri & Nuroh, 2025).

Accordingly, this study aims to develop a digital ethnochemistry-based pop-up book for acid–base learning in senior high school and to evaluate its effectiveness as an instructional medium. The novelty of this study lies in the integration of interactive digital pop-up book features with ethnochemistry content to bridge abstract chemical concepts and students' real-life cultural experiences. It is expected that this learning media can enhance students' motivation, conceptual understanding, and learning outcomes in chemistry learning, while also supporting the development of culturally responsive science education (Osriadi et al., 2025).

METHOD

This study employed a Research and Development (R&D) approach aimed at developing a digital pop-up book integrated with ethnochemistry content for acid–base learning in senior high school chemistry. The development procedure followed the 4D model, consisting of define, design, develop, and limited disseminate stages. The validity and practicality of the developed instructional media were evaluated through expert judgment and field testing.

Define Stage

The define stage focused on identifying fundamental problems and learning needs in acid–base instruction. This stage was conducted through classroom observations and interviews with chemistry teachers at SMAN 1 Sungayang. The analysis aimed to examine existing learning conditions, students' learning difficulties, and the availability and limitations of instructional media used in chemistry learning. The findings from this stage served as the basis for determining learning objectives, selecting relevant acid–base content, and identifying the need for an ethnochemistry-based digital pop-up book as an alternative learning medium.

Design Stage

The design stage involved planning the structure and specifications of the digital pop-up book. This included designing the learning objectives, organizing acid–base materials, and integrating ethnochemistry content derived from local cultural practices. In addition, interactive navigation features, simple practicum activities, illustrations, animations, and quizzes were designed to support students' conceptual understanding and engagement. The design stage resulted in a prototype layout and content framework of the digital pop-up book.

Develop Stage

The develop stage consisted of expert validation, product revision, and practicality testing. The developed media were evaluated by four experts in terms of content accuracy, language clarity, media design, and ethnochemistry integration. Based on the experts' feedback, revisions were made to improve the quality of the media. Afterward, a limited field trial was conducted to assess the practicality of the digital pop-up book. The participants involved in this stage were Grade XI students from classes XI.F.2 and XI.F.3 at SMAN 1 Sungayang. Practicality data were collected using student response questionnaires and supported by teacher interviews. The practicality assessment focused on ease of use, attractiveness, usefulness, and time efficiency.

Limited Disseminate Stage

The limited disseminate stage involved the distribution and implementation of the finalized digital pop-up book within the school environment. At this stage, the media were introduced to chemistry teachers and students at SMAN 1 Sungayang as a learning support tool for acid–base instruction. Dissemination was limited to the research setting and aimed to ensure the usability and feasibility of the developed media before wider implementation.

Data Collection and Analysys

Data were collected using expert validation sheets, student practicality questionnaires, and teacher interviews. Quantitative data were analyzed using percentage scores to determine the levels of validity and practicality, while qualitative data obtained from expert feedback and interviews were analyzed descriptively to support interpretation and product refinement. The percentage formula used for quantitative analysis was as follows:

$$\text{Precentage} = \frac{\Sigma \text{ score of each item}}{\text{max score of each item}} 100\%$$

Table 1. Summarizes the Data Collection Instruments and Analysis Techniques Applied in This Study.

Score Interval	Criteria
0 – 20%	Not valid/ practical
21 – 40%	Less valid/ practical
41 – 60%	Fairly valid/ practical
61 – 80%	Valid/ practical
81 – 100%	Highly valid/ practical

Source: (Denisa & Astimar, 2024).

RESULTS AND DISCUSSION

Define and Design Stages

The initial analysis indicated that chemistry learning at SMAN 1 Sungayang was still predominantly supported by conventional text-based instructional media. Such practices tend to emphasize symbolic representations while providing limited support for conceptual visualization. Acid–base topics inherently involve abstract reasoning that requires students to connect observable phenomena, microscopic

processes, and symbolic representations. When instructional media fail to support these three representational levels, students are likely to develop fragmented understanding and experience conceptual difficulties (Astafani et al., 2024).

In addition, the learning context was not strongly connected to students' everyday experiences. Learning theories emphasize that meaningful learning occurs when new information is linked to prior knowledge and familiar contexts. The absence of contextual relevance negatively affected students' engagement and learning motivation, particularly in abstract chemistry topics (Munandar et al., 2024). These findings highlight the need for instructional media that integrate visual representation, interactivity, and contextual relevance.

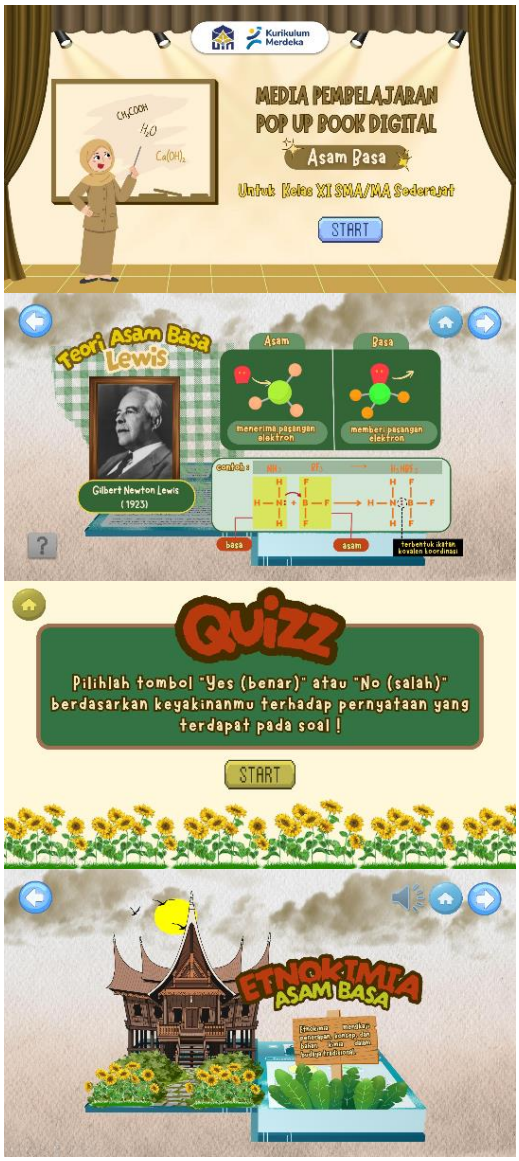

Figure 1. Design of Digital Pop Up Book

Based on these needs, the design stage focused on developing a digital pop-up book that supports active cognitive processing through multimedia elements and structured content organization. The PPTX format was selected due to its flexibility in integrating animations, audio, video, and interactive navigation, which aligns with contemporary digital learning practices (Sari & Munir, 2024). The media structure comprising learning objectives, acid–base material, ethnochemistry integration, simple experiments, and quizzes—was systematically designed to guide students from basic conceptual understanding to application and evaluation stages, supporting progressive knowledge construction (Aimmah & Amin, 2025).

To concretize the design concept described above, the visual interface, navigation flow, and content structure of the developed ethnochemistry-integrated digital pop-up book are presented in Figure 1.

Figure 1 illustrates the overall design of the ethnochemistry-integrated digital pop-up book, including the layout of the main interface, navigation buttons, content sequencing, and multimedia elements. The design reflects the results of the define and design stages by emphasizing visual representation, interactive navigation, and contextual integration to support students' conceptual understanding of acid–base topics.

Develop Stage

Validation Stage

The validity of the developed media was evaluated by four expert validators assessing material content, language, media design, and ethnochemistry integration. The results indicate that the digital pop-up book achieved a *very valid* category across all aspects, confirming its feasibility as an instructional medium.

The material validity score of 83% demonstrates that the acid–base content is scientifically accurate, systematically organized, and aligned with curriculum learning objectives. Validators confirmed that concepts, principles, and applications were presented coherently, supporting logical knowledge construction. Structured content organization enables learners to integrate new concepts into existing cognitive frameworks rather than memorizing isolated facts (Wulandari & Wardhani, 2024).

Visual representations and videos further supported conceptual understanding by concretizing abstract chemical concepts (Putri et al., 2022).

Language validity reached 81%, indicating that the linguistic presentation was clear, communicative, and appropriate for Grade XI students. Clear and concise language reduces extraneous cognitive load, allowing students to focus cognitive resources on understanding core concepts (Rihanah & Irma, 2022).

The media design aspect achieved a score of 92%, reflecting excellent quality in visual layout, navigation, and technical efficiency. Validators emphasized that the relatively small file size facilitated easy access and storage without compromising functionality. Consistent typography, balanced color composition, and intuitive navigation enhanced usability and learner control, which are critical factors in digital learning environments (Budianti et al., 2023). Interactive navigation allowed students to regulate their learning pace, supporting individual learning differences (Wijaya & Arifin, 2021).

The ethnochemistry component obtained a perfect score of 100%, indicating exemplary integration of cultural context into scientific content. Minangkabau cultural practices were meaningfully linked to acid–base concepts, functioning as conceptual anchors rather than superficial additions. Contextual and ethnoscience based learning has been shown to enhance conceptual understanding, retention, and cultural awareness in chemistry education (Aldiansyah et al., 2023).

Overall, the validation results material (82%), language (81%), media design (92%), and ethnochemistry (100%) confirm that the developed media meets high instructional standards. These findings address the first research question, demonstrating that the digital ethnochemistry based pop up book is highly valid for chemistry learning.

Practicallity Stage

Following validation and revision, the practicality of the media was evaluated through classroom implementation involving one chemistry teacher and students from two Grade XI classes (XI.F.2 and XI.F.3). Practicality was assessed across four aspects: ease of use, attractiveness, usefulness, and time efficiency.

From the teacher's perspective, the digital pop-up book was considered highly practical. The teacher reported that the media facilitated clearer explanations and increased student participation. The integration of ethnochemistry enabled students to relate chemical concepts to familiar cultural contexts, thereby strengthening contextual understanding and reducing repetitive explanations (Syafiqa et al., 2025). Instructional efficiency improved as students grasped key concepts more quickly through visual and interactive representations.

Student responses supported these findings. The ease-of-use aspect achieved scores of 88% in class XI.F.2 and 91% in class XI.F.3, indicating intuitive and accessible navigation. Ease of use is a crucial factor in digital learning, as complex interfaces can distract learners and hinder cognitive engagement (Syafitri et al., 2023). The attractiveness aspect scored 88% in both classes. Students reported that pop-up effects, animations, images, and videos enhanced their interest and sustained attention. Engaging visual elements play a significant role in maintaining focus, particularly in abstract learning materials (Riyani et al., 2023).

The usefulness aspect achieved 89% in class XI.F.2 and 90% in class XI.F.3, indicating that the media effectively supported independent learning, conceptual understanding, and learning motivation. Flexible accessibility allowed students to revisit materials anytime and anywhere, supporting self-regulated learning (Sari & Munir, 2024).

The time efficiency aspect reached 88% in class XI.F.2 and 93% in class XI.F.3. Both teachers and students agreed that the media streamlined the learning process through clear and interactive content presentation, enabling learning objectives to be achieved more efficiently (Putri & Nuroh, 2025). Overall, the average practicality scores were 88% for XI.F.2 and 90% for XI.F.3, both categorized as *very practical*. These findings address the second research question, confirming that the developed media is feasible and effective for classroom implementation.

Disseminate Stage

The dissemination stage was conducted on a limited scale after the validation and practicality testing phases were completed. At this stage, the finalized ethnochemistry-integrated digital pop-up book was introduced and distributed for

instructional use at SMAN 1 Sungayang. The dissemination involved chemistry teachers and Grade XI students who had participated in the practicality testing, allowing the media to be utilized directly in real classroom learning contexts. This limited dissemination aimed to familiarize teachers and students with the developed instructional media and to support its initial implementation as a complementary learning resource for acid–base topics. The digital format enabled easy distribution and access without requiring additional technological infrastructure, ensuring compatibility with existing school facilities. Teachers were encouraged to integrate the media into classroom activities and independent learning sessions, particularly for concept explanation and reinforcement.

Although the dissemination was not conducted on a broader institutional or regional scale, this stage confirms that the developed media is ready for classroom application and has practical potential for wider adoption. The limited dissemination also provided informal feedback regarding usability and instructional relevance, which may serve as a basis for future refinement and large scale implementation in subsequent studies.

Findings from related research support the effectiveness of culturally contextualized digital learning media in chemistry education. For example, a Weebly-based website learning media containing ethnochemical acid–base content was developed using an R&D approach and found to be highly valid and positively received by chemistry teachers and students, indicating its suitability as a learning medium for chemistry instruction (Irnawati & Rahmawan, 2024). Another study on ethnochemistry-based chemistry learning media grounded in traditional fermentation practices reported strong validity and enhanced student creativity when local cultural contexts were integrated into the learning materials (Erna et al., 2026). These studies provide empirical precedent for the value of ethnochemistry integration in instructional media and strengthen the rationale for broader dissemination and further research.

Novelty and Contribution to Chemistry Education

The novelty of this study lies in the integration of ethnochemistry within an interactive digital pop up book format for acid–base learning. Unlike previous studies that focused separately on digital media development or cultural integration, this research combines both approaches into a single instructional product that supports conceptual understanding, learner engagement, and instructional efficiency (Anindita & Wardani, 2025).

The contribution of this study is twofold. First, it provides empirical evidence that culturally contextualized digital media can achieve high levels of validity and practicality in chemistry education. Second, it offers a replicable development model for integrating local cultural contexts into digital science learning media, particularly for abstract chemistry topics. This approach addresses persistent challenges in chemistry education by bridging conceptual understanding, cultural relevance, and digital innovation (Aditia, 2024).

CONCLUSION

This study demonstrates that the ethnochemistry based digital pop-up book developed for acid–base learning is both valid and practical for classroom use. Expert validation results confirm that the media meets high standards in terms of content accuracy, instructional design, visual presentation, and integration of local cultural contexts. Practicality testing involving teachers and students indicates that the media is easy to use, engaging, and efficient in supporting learning activities. The incorporation of ethnochemical elements helps bridge abstract acid–base concepts with learners' real life experiences, thereby supporting deeper conceptual understanding and reducing learning difficulties. In addition, the digital format and interactive features enhance students' motivation and participation during learning.

Beyond its immediate instructional value, this study has important implications for chemistry education. The developed media demonstrates how local cultural knowledge can be systematically integrated into digital learning resources to make abstract scientific concepts more meaningful and contextualized. This approach supports culturally responsive pedagogy and encourages the preservation and utilization of local wisdom within formal science education. Furthermore, the findings provide a practical reference for educators and instructional

designers in developing innovative, interactive, and culturally integrated digital media for other chemistry topics or science subjects. Overall, this research contributes to the advancement of digital learning innovation and highlights the potential of ethnochemistry-based media to improve the quality and relevance of chemistry learning in senior high schools.

RECOMMENDATION

Future studies are recommended to examine the effectiveness of ethnochemistry based digital pop up books on students learning outcomes, conceptual understanding, and higher order thinking skills through experimental or quasi experimental designs. Further development may integrate augmented reality, virtual laboratories, or adaptive learning features to enrich interactivity and support diverse learning styles. Broader implementation across different regions and cultural contexts is also suggested to explore scalability and cultural adaptability. In addition, longitudinal research is needed to investigate the long-term impact of culturally integrated digital media on students motivation and scientific literacy. Teachers and curriculum developers are encouraged to utilize this media as a complementary instructional resource, particularly for abstract chemistry topics, while ensuring alignment with curriculum objectives and technological readiness in schools.

BIBLIOGRAPHY

Aditia, R. (2024). Peran dan Tantangan Teknologi Augmented Reality dalam Meningkatkan Pengalaman Pengguna Media. *Jurnal Ilmu Sosial Dan Humaniora*, *4*(1).

Aimmah, I., & Amin, M. (2025). Thiagarajan's 4-D Learning Model: A Theoretical Study and Its Application in Learning Device Development. *Journal of Education Policy Analysis*, *1*(1).

Aldiansyah, Pasa, J. I., Muttaqin, M. R., Awaliyah, N. N., & Erika, F. (2023). Literatur Review : Keterkaitan Pembelajaran Kimia Terhadap Pendekatan Etnokimia di Indonesia. *Journal of Chemistry, Education, and Science* , *7*(2).

Anindita, D., & Sulistya Wardani, N. (2025). Pengembangan Media Pop-Up Book Untuk Meningkatkan Hasil Belajar Tematik. *Jurnal Pendidikan Dan Kebudayaan*, *15*(1).

Ashari, A., & Munawwarah. (2025). Ethnochemistry Supports 21st Century Skills: Systematic Literature Review. *Hydrogen: Jurnal Kependidikan Kimia*, *13*(5), 1044–1049. https://doi.org/10.33394/hjkk.v13i5.17560

Astafani, A., Fenti Resmawati, R., & Eden Luqmanul Hakim, M. (2024). Systematic Review: Faktor-Faktor Kesulitan Belajar Materi Kimia. *JIPK* 18(2).

Budianti, Y., Rikmasari, R., & Oktaviani, D. A. (2023). Penggunaan Media Powerpoint Interaktif Untuk Meningkatkan Hasil Belajar Siswa Sekolah Dasar. *Jurnal Inovasi Pendidikan Dan Pembelajaran Sekolah Dasar*, *7*(1).

Chibuye, B., & Singh, I. Sen. (2024). Integration of local knowledge in the secondary school chemistry curriculum - A few examples of ethno-chemistry from Zambia. *Heliyon*, *10*(7).

Denisa, S. B., & Astimar, N. (2024). Pengembangan Media Flipbook Digital Menggunakan Aplikasi Heyzine pada Pembelajaran IPAS di Kelas V Sekolah Dasar. *Pendas: Jurnal Ilmiah Pendidikan Dasar*, *9*(4).

Erna, M., Adita Wulandari, P., Zulirfan, Z., Elfizar, E., Imam Rahmatullah, M., & Abdul Talib, C. (2026). Ethnochemistry-Based Chemistry Learning Media for Creativity: A Cognitive Analysis of Fermented Products from Riau, Indonesia. *Salud, Ciencia y Tecnología*, *6*, 2496.

Ilahi, R. P., Mawarnis, E. R., & Herman, M. (2023). Development of Guided-Inquiry-Based Buffer Solution E-Module. *Hydrogen: Jurnal Kependidikan Kimia*, *11*(1), 88–94. https://doi.org/10.33394/hjkk.v11i1.6869

Irnawati, I., & Rahmawan, S. (2024). Development of Weebly-Based Website Learning Media Containing Ethnochemical Acid-Base Material. *Prisma Sains : Jurnal Pengkajian Ilmu Dan Pembelajaran Matematika Dan IPA IKIP Mataram*, *12*(2).

Iyamuremye, A., Twagilimana, I., & Niyonzima, F. N. (2025). Investigating the impact of using web-based discussion tools on students' conceptual understanding and 21st century skills development in organic chemistry education. *Discover Education*, *4*(1).

Jere, S., & Mpeta, M. (2024). Enhancing Learners' Conceptual Understanding of Reaction Kinetics Using Computer Simulations – A Case Study Approach. *Research in Science Education*, *54*(6).

Munandar, H., Thayban, T., & Kurniawati, E. (2024). Pendekatan Etnokimia dalam Pendidikan Kimia: Literature Review Terhadap Berbagai Metode dan

Penerapannya. *Pentagon : Jurnal Matematika Dan Ilmu Pengetahuan Alam*, *2*(2).

Mutia, U., & Mawarnis, E. R. (2024). Exploring Integrated Instrument Complement at Practical Approach at MAN 4 Tanah Datar. *Hydrogen: Jurnal Kependidikan Kimia*, *12*(2), 218–225. https://doi.org/10.33394/hjkk.v12i2.10992

Osriadi, U. A., Mawarnis, E. R., & Da, S. (2025). Development of a Green Chemistry-Based Practicum Module Integrated with Quranic Verses for Reaction Rate Material at SMA IT Darul Hikmah Pasaman Barat. *Jurnal Pembelajaran MIPA*, *5*(1).

Putri, A., Harahap, M. K., Harahap, P. H. K., & Adelia, T. (2022). Pengaruh Penggunaan Media Audio Visual Dalam Mengembangkan Minat Belajar Siswa di Sekolah. *Jurnal Pendidikan Bahasa Dan Sastra*, (2).

Putri, C. L., & Nuroh, E. Z. (2025). The Effectiveness of Digital Pop-Up Book Media on Descriptive Writing Skills in Elementary School Students Article Information How to Cite. *Jurnal Dimensi Pendidikan Dan Pembelajaran*, *13*(1).

Rezki, R., Herman, M., Rahmi, E., & Hidayat, H. (2024). Pengembangan Powerpoint Presentation Berbasis Multipel Representasi Kimia Terintegrasi Ayat Al-Quran Pada Materi Bentuk Molekul Di Kelas Xi Sman 2 Batusangkar. *Dalton : Jurnal Pendidikan Kimia Dan Ilmu Kimia*, *7*(3).

Rihanah, A., & Irma, C. N. (2022). Kelayakan Isi Dan Bahasa Pada Buku Teks Bahasa Indonesia Di Sma Negeri 1 Sirampog. *Hasta Wiyata*, *5*(1).

Riyani, S., Setiawan, A., Lubis, A., & Wahyudi, S. (2023). Analisis Efektifitas E-Learning Sebagai Media Pada Pembelajaran TIK. *Journal Of Social Science Research*, *3*(2).

Rizki, G., Mawarnis, E. R., & Herman, M. (2024). Developing Quran-Integrated E-Modules on Salt Hydrolysis: A Learning Cycle 8E Approach for 11th Grade of Senior High School Students. *Hydrogen: Jurnal Kependidikan Kimia*, *12*(6), 1264–1274. https://doi.org/10.33394/hjkk.v12i6.12697

Rodrigues Araújo, L., Euzebio, J., Neto, S., Tenório Da Silva, J. R. R., & Leite, B. S. (2024). Digital Technologies in Chemistry Teaching in the Journal Chemistry Education Research and Practice: an analysis through a Systematic Literary Review. *Am. J. Sci. Educ*, *11*, 12001.

Sari, A. P., & Munir, M. (2024). Pemanfaatan Teknologi Digital dalam Inovasi Pembelajaran untuk Meningkatkan Efektivitas Kegiatan di Kelas. *Digital Transformation Technology*, *4*(2).

Syafiqa, S. N., Mawarnis, E. R., & Aftika, D. (2025). Development of the Pancasila Student Profile Strengthening Project Module Based on Regional Potential on Sustainable Lifestyle at SMAN 3 Rupat. *International Journal of Contextual Science Education*, *3*(1).

Syafitri, A., Wijaya, I., Radyuli, P., & Popi Radyuli. (2023). Uji Praktikalitas Pengembangan Media Pembelajaran Informatika Menggunakan Aplikasi Articulate Storyline.3 Kelas X di SMK Dhuafa Padang. *DIAJAR: Jurnal Pendidikan Dan Pembelajaran*, *2*(2).

Tustari, R., Herman, M., Sari, D. A., Mawarnis, E. R., & Herman, H. (2025). Analysis of Student Misconceptions Using the Three-tier Diagnostic Test on Atomic Structure Class X Material at SMA N 1 Lintau Buo. *Hydrogen: Jurnal Kependidikan Kimia*, *13*(1), 119–129. https://doi.org/10.33394/hjkk.v13i1.14633

Wijaya, A. M., & Arifin, I. (2021). Media Pembelajaran Digital Sebagai Sarana Belajar Mandiri Di Masa Pandemi Dalam Mata Pelajaran Sejarah. *Jurnal Sandhyakala*, *2*(2).

Wulandari, C., & Susilaningsih, E. (2018). Makroskopis, Mikroskopis, Simbolik Pada Materi Asam Basa. *Jurnal Phenomenon*, *8*(2).

Wulandari, O. A., & Wardhani, I. S. (2024). PT. Media Akademik Publisher Media Dan Gaya Belajar Siswa: Strategi Dalam Pembelajaran Efektif. *Jurnal Medika Akademik*, *2*(11).

Yuendita, D., & Eli Rohaeti. (2025). Research Trends on the Integration of Ethnoscience in the Learning of Chemistry as the Development of Chemical Literacy: A Systematic Review. *Indonesian Journal of Educational Research and Review*, *8*(1).