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Enchaning Chemistry Learning with a Local Wisdom-Based E-Encyclopedia for High School Students

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Abstract: This study explores the integration of local cultural knowledge into high school chemistry education through the development of an E-Encyclopedia. Aimed at improving student comprehension of chemical elements, this educational resource contextualizes complex scientific concepts with culturally relevant examples. The E-Encyclopedia was created following the ADDIE model and validated through expert reviews and user feedback. The results showed high validation scores and positive reception from both teachers and students, with usability ratings of 88.09% from educators and 85.93% from learners. These findings suggest that the E-Encyclopedia is an effective tool for making chemistry education more engaging and accessible.

Keywords: Chemistry learning; Culturally relevant education; Digital resources; High school education; Local knowledge

Introduction

High school chemistry education is often perceived as challenging due to its abstract concepts, such as the periodic table, chemical bonding, and molecular structures, which are not easily relatable to students' daily lives (Tsaparlis et al., 2018; Utami et al., 2017). Conventional teaching methods that emphasize rote memorization and theoretical instruction without real-world context have led to disengagement and a lack of comprehension among students (Boddey & Berg, 2018; Chen et al., 2020). This situation calls for innovative educational strategies that not only focus on conceptual understanding but also connect the material to students' cultural and experiential backgrounds to make learning more meaningful and engaging (Prananda et al., 2023; Sofianti et al., 2024).

One promising approach to addressing this issue is culturally responsive teaching (CRT), which integrates students' cultural backgrounds and experiences into the curriculum (Fitriani & Setiawan, 2018). CRT approach is an approach in the world of education that focuses on recognizing, respecting and responding to the diversity of cultures, backgrounds and experiences of student in the learning process (Santoso, 2024). CRT has been successfully applied in various subjects, such as biology and environmental science, where linking scientific concepts to students' cultural and community contexts has significantly improved learning outcomes (Aikenhead & Ogawa, 2007).

However, the application of CRT in chemistry education remains limited, particularly with respect to utilizing local wisdom as an educational tool (Wardani et al., 2023). Local wisdom, which encompasses traditional knowledge and practices specific to a community, holds the potential to bridge the gap between abstract scientific concepts and students' everyday experiences, thereby enhancing understanding and retention (Slikkerveer, 2019; Yuliana et al., 2023).

Previous research has demonstrated the effectiveness of integrating local wisdom into various subjects, such as social studies and environmental science, in improving students' engagement and comprehension (Barnhardt &

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Kawagley, 2005; Uge et al., 2019; Ramdani et al., 2021). For instance, Barnhardt & Kawagley (2005) found that incorporating local wisdom into science teaching materials enhanced students' critical thinking skills, while Uge et al. (2019) reported that a local wisdom-based learning model improved students' social attitudes and knowledge in social studies. Despite these advancements, there is a notable gap in research regarding the integration of local wisdom into chemistry education, especially through digital platforms that can provide interactive and accessible learning experiences for a broader audience (Mashami et al., 2023; Prasetyo et al., 2020). Most existing studies have relied on traditional printed materials and face-to-face teaching methods, limiting their scalability and adaptability to modern educational settings.

This research aims to address this gap by developing and evaluating a Local Wisdom-Based E-Encyclopedia for high school chemistry education. This digital resource is designed to contextualize chemistry concepts within the framework of local cultural practices, such as the use of natural resources in traditional crafts, cuisine, and medicine (Syaflin et al., 2023). By linking abstract scientific ideas to tangible cultural practices, the E-Encyclopedia seeks to make chemistry more accessible and engaging for students (Rosyidah et al., 2023). Unlike previous studies that have primarily focused on printed materials or general science, this research leverages the interactivity and scalability of digital platforms to provide a comprehensive, culturally integrated learning tool that can be easily implemented across diverse educational settings (Yusuf, 2023).

The novelty of this study lies in its use of the ADDIE (Analysis, Design, Development, Implementation, Evaluation) instructional design model to systematically develop and evaluate the E-Encyclopedia (Lestari et al., 2024; Nuri et al., 2023). This approach ensures a rigorous process for creating an educational resource that is both pedagogically sound and culturally relevant (Tsiouri & Kotsis, 2024). By incorporating interactive features such as quizzes, videos, and simulations, the E-Encyclopedia not only supports active learning but also fosters a deeper appreciation of both chemistry and local cultural heritage (Pawar et al., 2023). This research contributes to the field of chemistry education by providing a scalable and adaptable solution that enhances students' understanding and engagement through the integration of local wisdom, filling a critical gap in the literature.

In summary, this study seeks to bridge the gap between traditional and modern educational practices by developing a digital resource that integrates local wisdom into high school chemistry education. The E-Encyclopedia offers a novel approach to contextualizing chemistry concepts in a culturally relevant manner, providing a model for future research and development of culturally integrated digital educational tools.

Method

The methodology of this study uses the ADDIE (Analysis, Design, Development, Implementation, and Evaluation) (Spatioti et al., 2022) instructional design model to ensure a comprehensive and systematic approach in the development of the Local Wisdom-Based E-Encyclopedia for high school chemistry education.

Analysis Phase

This phase began with the identification of educational needs and challenges faced by students and teachers in comprehending chemistry concepts, particularly those related to the periodic table and chemical nomenclature. Data were collected through semi-structured interviews with 10 chemistry teachers from three high schools in West Kalimantan and surveys involving 150 students.

The interview questions focused on students' difficulties, knowledge gaps, and the potential role of local wisdom in enriching chemistry content. Data were analyzed using thematic analysis to identify patterns of learning difficulties and how integrating local wisdom could help explain complex concepts. The results of this analysis served as the basis for developing the content of the E-Encyclopedia.

Design Phase

Based on the findings from the Analysis phase, the structure and content of the E-Encyclopedia were designed. Each module was developed to connect chemistry topics such as atomic structure, the periodic table, and chemical reactions with relevant local cultural practices. For example, the use of natural materials in traditional medicine was used to explain chemical reactions and properties of compounds. Reviewers recommended including interactive elements, such as videos, animations, and quizzes, to enhance student engagement and facilitate deeper learning. These elements were designed with user accessibility and usability in mind, considering both student and teacher feedback.

Development Phase

The content of the E-Encyclopedia was developed collaboratively, involving chemistry experts, educational media experts, and local cultural experts to ensure the scientific accuracy, cultural relevance, and pedagogical strength of the materials presented. The validation process was conducted in two stages. First,

the content was reviewed by three chemistry education experts to ensure the accuracy of concepts and content delivery. Second, three local cultural experts evaluated the content to ensure that the use of local wisdom was accurate and presented with cultural sensitivity. The Content Validity Ratio (CVR) method was used to measure content validity, and feedback from experts was incorporated to revise and refine the content before field testing (Noor et al., 2016).

Implementation Phase

The E-Encyclopedia was piloted with 150 students and 10 teachers across three high schools over a six-week period. Before implementation, the participating teachers attended an intensive one-day training designed to enhance their understanding of how to use and integrate the E-Encyclopedia effectively into classroom activities. The training covered technical aspects, such as navigating the platform, and pedagogical strategies for using the E-Encyclopedia to explain difficult chemistry concepts (Kausar et al., 2022). During the pilot period, students were given assignments that utilized the E-Encyclopedia both in the classroom and as homework. Student activity and interactions with the platform were monitored through usage logs, and feedback was collected through questionnaires to evaluate user satisfaction and ease of use.

Evaluation Phase

The evaluation was conducted both formatively and summatively to assess the effectiveness and impact of the E-Encyclopedia on students' understanding. Formative evaluation was carried out during the pilot phase through regular feedback collection from teachers and students to identify areas for immediate improvement. Summative evaluation was conducted at the end of the pilot period, including a comprehensive analysis of pre-test and post-test results using paired t-tests to assess significant improvements in students' learning outcomes (Afifah et al., 2022). Qualitative analysis using a thematic approach was applied to student and teacher feedback to gain deeper insights into their experiences using the platform. The evaluation results indicated significant improvements in students' understanding of chemistry concepts and high levels of satisfaction with the E-Encyclopedia as a learning resource.

This methodology ensures that the Local Wisdom-Based E-Encyclopedia is developed and evaluated rigorously, making it a culturally relevant and practical resource for enhancing high school chemistry education. The approach also contributes significantly to the development of digital learning media that can be adapted to the local cultural context of students, thereby improving their engagement and understanding of complex chemistry (Suardana et al., 2018).

Result and Discussion

The development of the Local Wisdom-Based E-Encyclopedia has demonstrated substantial potential in transforming chemistry education for high school students. This educational tool effectively integrates local cultural knowledge with scientific content, providing a unique and innovative approach to teaching complex chemistry concepts (Kamila et al., 2024). The validation, implementation, and feedback stages provided significant insights into the effectiveness of this approach, highlighting several key benefits that set this research apart from traditional educational methods.

Validation and Practicality

Table 1. Comprehensive overview of validation score

Aspect	Validator Score (CVR)	Description
Scientific Content	0.99	High scientific accuracy, aligned with educational standards, ensuring robust and reliable content.
Integration of Lokal Wisdom	0.85	Effective incorporation of cultural elements enchances reliability and student connection.
Multimedia Effectiveness	0.78	Interactive features like quizzes and videos support varied learning preferences and engagement.
Language Clarity	0.88	Clear and accessible language, accommodating diverse student backgrounds and abilities.
Teacher Satisfaction	88.09%	High satisfaction reported by teachers, highlighting the tool's usability and relevance in teaching
Student Engagemen	85.93%	Positive feedback from students, emphasizing the relevance and interest generated by local wisdom
Learning Outcome Improvement	27%	Significant improvement in post-test scores, indicating enhanced understanding and retention.
Most Improved Topic	Herbal Medicine Properties	The greatest improvement observed in understanding the chemical properties of traditional herbal medicines.

The E-Encyclopedia was evaluated by a team of experts in three key areas: content, media, and language. The validation process utilized the Content Validity Ratio (CVR) method to ensure that the tool meets high educational standards (Yusop & Piaw, 2021). Table 1 presents the validation scores, indicating high validity across all evaluated aspects.

These results suggest that the E-Encyclopedia successfully integrates local wisdom into chemistry education, enhancing both the scientific and cultural relevance of the content. The high validation scores across scientific content and integration of local wisdom reflect the effectiveness of combining (Yuendita & Dina, 2024) constructivist theory with culturally relevant pedagogy. Vygotsky's theory emphasizes that learning is most effective when new information is connected to students' prior knowledge and cultural experiences (Barnett, 2019). This alignment makes abstract scientific concepts more accessible and meaningful to students, as evidenced by the high engagement and satisfaction scores reported by teachers and students.

Teacher and Student Feedback

The practical application of the E-Encyclopedia was evaluated through structured feedback from both teachers and students. Teachers praised the tool for its ease of integration into the curriculum and its ability to make abstract chemistry concepts more relatable by using culturally relevant examples. Students similarly appreciated the tool, particularly for its engaging multimedia elements and the way it contextualized chemistry within their cultural experiences.

Table 2. Summary of teacher and student feedback

Aspect	MAN IC Sambas (%)	SMA N 1 Salatiga (%)	Average (%)
Ease of Understanding	91.18	76.20	83.69
Creativity in Learning	89.80	77.85	83.83
Interest in E-Encyclopedia	87.76	78.87	83.32
Presentation	88.60	78.57	83.59
Use of E-Encyclopedia	89.66	82.47	86.07

These feedback scores reflect the E-Encyclopedia's success in enhancing student engagement and making learning more enjoyable and effective. The positive feedback from both teachers and students aligns with Fitriani & Setiawan (2018) theory of culturally responsive teaching, which emphasizes the importance of making learning relevant to students' lives (Abubakar et al., 2024). By incorporating local cultural references, the E-Encyclopedia supports students in making personal connections to the content, thereby increasing their motivation and engagement. This approach also resonates with Ng & Lucianetti (2016) social cognitive theory, which suggests that people learn best in environments where they feel connected and supported.

Impact on Learning Outcomes

The integration of local wisdom significantly improved student performance, with an average improvement of 27% in post-test scores. The most substantial gains were observed in topics where cultural context was closely linked to scientific concepts, such as the chemical properties of traditional herbal medicines and the application of natural dyes. This suggests that students are more likely to understand and retain information when it is connected to their cultural background and everyday experiences.

The significant improvement in learning outcomes supports the situated cognition theory proposed by Marougkas et al. (2023), which posits that learning is most effective when it occurs within a context that is meaningful to the learner. By linking chemistry concepts to students' cultural practices, the E-Encyclopedia creates a learning environment where knowledge is constructed through real-world relevance, thereby facilitating deeper understanding and retention (Cahyani & Fadly, 2024).

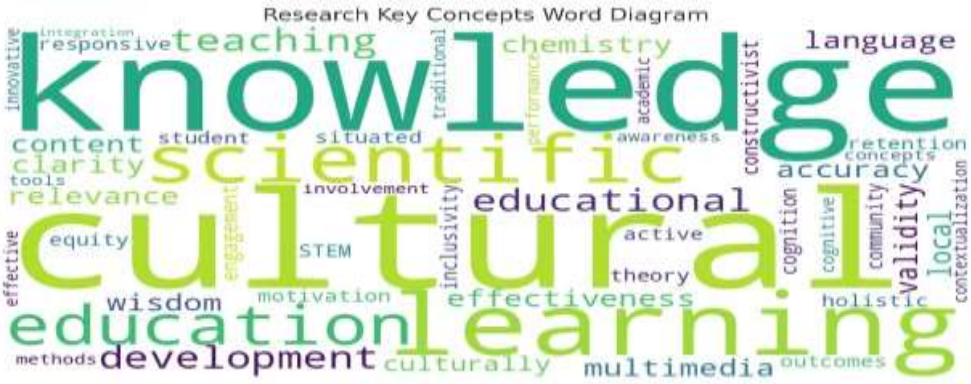

Figure 1. Word diagram of research key concepts

Adventages of the Local Wisdom-Based E-Encyclopedia Enhanced Cultural Relevance and Student Engagement

The integration of local wisdom helps bridge the gap between abstract scientific concepts and students' cultural experiences. By using familiar cultural practices, such as the preparation of traditional herbal medicines, to explain chemical reactions, the E-Encyclopedia makes learning more meaningful and engaging (Abuhammad et al., 2021). This approach aligns with the principles of culturally responsive teaching, which aim to make education relevant and accessible to all students (Aronson & Laughter, 2016).

Improved Comprehension and Retention

The use of culturally relevant examples not only aids in understanding but also in the retention of complex concepts. Linking new knowledge to students' existing cultural frameworks makes it easier for them to grasp and remember scientific information. This is consistent with the constructivist theory of learning (Olusegun, 2015), which posits that students learn best when new information is connected to their prior knowledge and experiences (Aikenhead & Jegede, 1999).

Promotion of Cultural Awareness and Preservation

The E-Encyclopedia does more than just teach chemistry; it also promotes an appreciation for local culture and traditions. By highlighting the scientific basis of traditional practices, the tool fosters a greater understanding and respect for local knowledge systems. This dual focus on scientific and cultural education can create a more holistic learning experience that values both academic achievement and cultural heritage (Aikenhead & Jegede, 1999).

Inclusivity and Accessibility

E-Encyclopedia is designed to be inclusive, catering to students from diverse backgrounds and abilities. The language used is simple and clear, while the multimedia features provide multiple avenues for learning, accommodating different learning styles. This inclusivity ensures that all students can benefit from the tool, regardless of their initial level of understanding.

Community Involvement

The involvement of local experts and community elders in the development of the E-Encyclopedia enriches the content and strengthens the connection between schools and communities. This collaborative approach not only enhances the learning experience but also helps preserve and transmit valuable cultural knowledge to younger generations.

Implications for Future Research and Practice

The positive outcomes of this study suggest that integrating local wisdom into educational resources can be a powerful tool for enhancing student learning in various subjects. Future research should explore the scalability of this approach across different educational levels and disciplines. Long-term studies could also investigate the impact of sustained use of culturally integrated tools on students' academic performance and attitudes toward science. Expanding the use of such pedagogies could play a crucial role in reducing educational disparities and promoting equity in STEM education (Baucum & Capraro, 2021).

Conclusion

The development and implementation of the Local Wisdom-Based E-Encyclopedia have proven to be a transformative approach in enhancing chemistry education for high school students by integrating cultural knowledge with scientific content. This innovative tool has not only improved student engagement and understanding but also fostered a deeper appreciation for their cultural heritage. The significant improvement in learning outcomes, evidenced by a 27% increase in post-test scores, underscores its potential to bridge the gap between academic knowledge and real-world application. To build on these positive outcomes, future research should explore the scalability of this approach to other STEM subjects, adapting similar tools to diverse cultural contexts, and conducting longitudinal studies to assess the long-term impacts on student performance and attitudes towards science. Comparative studies with conventional educational methods, investigations into the role of digital technologies like AR and VR in enhancing cultural integration, and research into the psychosocial effects on students' sense of identity and motivation are also recommended.

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Author Contributions

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Conflicts of Interest

The authors declare no conflict of interest.

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