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# Needs Analysis of Innovative Chemistry Teaching Materials Integrated with Ethnopedagogy Oriented to 21st Century Learning

Siswanto Siswanto[1]*, Anjany Tasya Surabika Tarigan[2], Ramlan Silaban[3], and Manihar Situmorang[4]

[1,2,3,4]*Chemistry Education Study Program, Universitas Negeri Medan, Medan*

**Email*: siswanto.8246141005@mhs.unimed.ac.id

***Abstract***: *21st-century education emphasizes six core competencies: critical thinking, creativity, collaboration, communication, character, and citizenship. However, the PISA 2022 results indicate that Indonesia's performance remains relatively low, highlighting the need for improvement in developing students' essential skills. This study aims to analyze the needs for innovative chemistry teaching materials that are integrated with ethnopedagogy and oriented toward 21st-century learning as an effort to enhance students' 21st-century competencies. This research employed a descriptive qualitative approach conducted at SMP Negeri 1 Sei Bingai, Langkat Regency, using interviews, observations, and document analysis. The data were analyzed through four stages: data collection, data reduction, data presentation, and conclusion drawing. The results showed that the current science textbooks do not adequately support the development of 21st-century skills, and teachers reported that students' competencies in this area remain low. All science teachers expressed the need for teaching materials integrated with ethnopedagogical. Furthermore, 74% of students indicated a need for innovative learning materials, 90% desired the integration of ethnopedagogy, and 94% supported the implementation of 21st-century learning approaches. These findings highlight the need for innovative, contextual, and culturally based chemistry materials to enhance students' 21st-century skills and learning experiences.*

***Keywords***: *21st-century skills; instructional material development; ethnopedagogy; educational innovation*

## INTRODUCTION

In facing the challenges of the 21st-century, education is required to prepare learners who excel not only in academic knowledge but also possess skills relevant to real-life contexts. The learning process is no longer limited to the mastery of concepts but also encourages the development of creativity, the utilization of technology, and students' readiness to adapt to social and professional dynamics in the future (Inganah et al., 2023).

However, various studies have shown that Indonesian students' 21st-century skills remain relatively low, particularly in science subjects that involve abstract concepts (Pardosi & Situmorang, 2024). Many students struggle to solve problems and formulate logical conclusions, which are key indicators of critical thinking ability. Data from the 2022

Programme for International Student Assessment (PISA) also reveal that Indonesia continues to rank among the lower-performing countries in literacy, numeracy, and critical thinking. This condition indicates the urgent need to enhance the quality of learning to make it more meaningful and contextually relevant (Bilad et al., 2024).

In the context of secondary education, efforts to enhance 21st-century skills should begin with a comprehensive needs analysis of the teaching materials and instructional approaches being used. One promising strategy is the integration of ethnopedagogy, an educational approach that incorporates cultural values and local wisdom as learning resources. This approach not only enriches the learning content but also fosters students' sense of identity and connection to their environment, helping to cultivate positive character traits such as honesty and responsibility. At the same time, it strengthens the relevance of learning to students' real-life experiences (Adinugraha & Ratnapuri, 2020; Haryati & Suciptaningsih, 2020).

In line with these needs, this study aims to analyze the requirements for developing innovative chemistry teaching materials integrated with ethnopedagogy and oriented toward 21st-century skills. The findings are expected to serve as both a conceptual and empirical foundation for the development of chemistry teaching materials that not only strengthen students' scientific understanding but also foster critical thinking, creativity, cultural awareness, and social responsibility in addressing global challenges sustainably.

## LITERATURE REVIEW

21st-century skills play a crucial role in modern education, particularly in response to the evolving demands of the global workforce and society. In this context, six core competencies, commonly referred to as the 6Cs, critical thinking, creativity, collaboration, communication, character, and citizenship, serve as the foundational framework for shaping learners who are adaptive, innovative, and globally competitive (Fullan & Langworthy, 2014).

Critical thinking skills have become one of the main focuses of 21st-century education, as they play a pivotal role in preparing learners to navigate complex information and decision-making processes. This ability encompasses the processes of analyzing information, making evidence-based decisions, and solving problems reflectively. Aslamiah et al. (2021) emphasized the importance of education in fostering critical thinking skills so that students can recognize and respond effectively to challenges that arise both in daily life and in broader social contexts. Therefore, critical thinking serves as a key competency for students to adapt and remain competitive in the fast-changing and dynamic landscape of the 21st-century workforce.

To effectively develop 21st-century skills, learning models that encourage students' active engagement and participation in solving real-world problems are essential. One approach that has proven to be highly relevant is Problem-Based Learning (PBL) (Azizah & Purba, 2025; Panggabean et al., 2023). This model guides students to actively engage in critical thinking, collaborate within groups, communicate effectively, and generate creative ideas to address contextual issues. Several studies have shown that the implementation of PBL can enhance conceptual understanding while simultaneously improving students' higher-order thinking skills (Agmita et al., 2021; Rosyid & Mubin, 2024; Susino et al., 2023).

In addition to problem-based approaches, 21st-century learning also requires cultural contextualization to make the learning experience more meaningful for students. In this regard, ethnopedagogy emerges as a promising approach to be integrated into the learning process. The term ethnopedagogy derives from two words: ethno, which refers to a community and its culture, and pedagogy, which means the science of education. Thus, ethnopedagogy

can be defined as a learning approach that integrates local values, wisdom, and culture into the educational process, thereby making learning activities more contextual, relevant, and meaningful (Hidayat et al., 2023; Silaban, Hutasoit, et al., 2025).

Ethnopedagogy positions local wisdom as an integral part of the learning process. By linking learning materials to local cultural values, teachers can create more engaging and contextually relevant learning experiences for students. Silaban (2025) demonstrated that ethnopedagogy-based learning enhances students' engagement and motivation, as they can recognize the direct connection between classroom lessons and their own cultural realities. This approach not only enriches the learning content but also contributes to the development of students' character, identity, and social responsibility.

The integration of ethnopedagogy with 21st-century learning models is believed to create a more holistic and meaningful learning experience. The collaboration between these two approaches not only emphasizes the mastery of scientific concepts but also fosters cultural awareness, social empathy, and reflective thinking skills. Purba et al. (2024) revealed that learning which integrates local cultural contexts with 21st century competencies can enhance students' conceptual understanding while simultaneously strengthening their character and sense of national identity. Such integration positions chemistry learning not merely as a process of knowledge transmission but also as a means of cultivating cultural identity and global awareness concurrently.

A needs analysis study on ethnopedagogical teaching materials conducted by Merliza (2023) revealed that 65% of students expressed the need for learning resources that could connect mathematical theories with their daily lives, particularly those incorporating local cultural aspects. Furthermore, research by Yusnita and Astriani (2022) found that among 233 teacher and student respondents, the majority (37%) preferred a Problem-Based Learning (PBL) model for Biology instruction. Similarly, 80% of respondents agreed that developing ethnopedagogy-based teaching materials for Indonesian language learning is essential to enhance students' critical thinking skills (Suryanto et al., 2025).

In another study, a needs analysis of local wisdom-based electronic student worksheets in Islamic elementary schools in Palangkaraya revealed that 72% of students required such materials (Supriatin et al., 2022). Additionally, a study analyzing the integration of local culture in learning conducted on Sitaro Island obtained a mean response score of 3.99 on a 5-point Likert scale, indicating a highly positive perception toward culturally integrated learning (Purba et al., 2024).

To date, studies that specifically examine the need for developing innovative chemistry teaching materials based on ethnopedagogy and oriented toward 21st-century skills remain very limited, particularly at the junior high school level. In fact, chemistry learning holds great potential to connect scientific concepts with local wisdom while simultaneously fostering critical thinking, creativity, and collaboration. This condition highlights a clear research gap in the development of teaching materials that integrate cultural values with the orientation of 21st-century learning.

This study seeks to address that gap by providing both empirical and conceptual insights as a foundation for developing chemistry teaching materials that are relevant, contextual, and culturally grounded. Through a needs analysis of innovative chemistry teaching materials integrated with ethnopedagogy, this research aims to generate comprehensive information to design holistic, meaningful learning experiences that strengthen students' 21st-century competencies

## METHODS

1. Research Location and Time

This research was conducted at SMP Negeri 1 Sei Bingai, located at Jalan Pendidikan No. 5, Namu Ukur Selatan, Sei Bingai District, Langkat Regency, North Sumatra Province, Indonesia. The study took place from July 8 to July 24, 2025, during the first semester of the 2025/2026 academic year.

2. Research Participants and Sampling Technique

This study employed a purposive sampling technique, in which participants were deliberately selected based on specific criteria relevant to the research objectives. The research subjects consisted of 31 students from Class IX-1 of SMP Negeri 1 Sei Bingai, chosen from among seven classes because they represented the school's average academic characteristics and possessed relevant learning experience in chemistry. In addition, four science teachers and one vice principal for curriculum affairs were included as informants to provide insights from the perspectives of instructional practices and curriculum policy. The selection of participants was based on the consideration that these respondents have substantial experience and knowledge regarding science learning processes, the use of teaching materials, and the potential integration of ethnopedagogical values and 21st-century skills in chemistry education (Sugiono, 2019).

3. Data Collection Techniques

This study employed a descriptive qualitative approach during the needs analysis stage of the ADDIE development model (Analysis, Design, Development, Implementation, Evaluation). The needs analysis stage was designed to obtain comprehensive data necessary for subsequent development phases (Akmalia et al., 2025; Purwanto et al., 2025; Zhang et al., 2024). The primary focus of this research was to gain an in-depth understanding of the current conditions, challenges, and needs related to the development of innovative chemistry teaching materials based on ethnopedagogy and oriented toward 21st-century skills. The study was conducted at SMP Negeri 1 Sei Bingai, Langkat Regency, which was considered representative of junior high schools in the region.

Data were collected through in-depth interviews, direct observations, and document analysis. The interviews were conducted with the vice principal for curriculum affairs, four science teachers, and 31 students to explore their perspectives on the effectiveness of existing teaching materials, learning needs, and the relevance of local cultural values. The observations focused on classroom chemistry instruction, particularly examining teacher–student interactions, the use of instructional media, and the implementation of 21st-century learning skills. Meanwhile, the document analysis involved reviewing syllabi, lesson plans, and teaching materials used in connection with curriculum development and the integration of local wisdom.

The research instruments consisted of interview guides containing semi-structured questions for teachers and an online Google Form questionnaire for students to collect detailed information regarding the needs for teaching materials, ethnopedagogical integration, and 21st-century learning practices. Observation sheets were used to assess school facilities, student characteristics, and the classroom environment, while document analysis forms were designed to evaluate the feasibility and relevance of the existing teaching materials.

The research instruments consisted of three main components. First, interview guides containing semi-structured questions were developed for teachers, along with an online Google Form questionnaire for students, to obtain comprehensive information regarding teaching material

needs, the integration of ethnopedagogical values, and the implementation of 21st-century learning. Second, observation sheets were utilized to examine school facilities, student characteristics, and the learning environment during chemistry instruction. Third, document analysis forms were employed to assess the feasibility, content quality, and contextual relevance of the existing teaching materials used in the classroom.

4. Data Validation

The validity and trustworthiness of the data were ensured through several validation techniques. First, source and technique triangulation was applied by comparing and cross-verifying the results obtained from interviews, observations, and document analyses involving multiple informants. This process helped to enhance the consistency and credibility of the findings. Second, a feasibility study instrument standardized by the National Education Standards Agency (BNSP) was utilized to ensure that the evaluation of teaching materials met nationally recognized quality criteria.

5. Data Analysis Techniques

Data analysis was carried out following the model proposed by Miles and Huberman, as cited in Sugiyono (2021), which consists of four main stages: (1) data collection, (2) data reduction, (3) data display, and (4) conclusion drawing and verification. In accordance with this model, the analysis process began with data collection through interviews, observations, and document studies. The collected data were then reduced by categorizing and organizing them according to key themes such as the need for teaching materials, the potential integration of ethnopedagogical values, and the implementation of 21st century learning skills. Subsequently, the data display stage involved presenting the reduced data in the form of tables and descriptive summaries to facilitate interpretation. Finally, conclusions were drawn and verified based on patterns and insights that emerged from the field findings to ensure the accuracy and validity of the interpretations.

The interview data were analyzed using a descriptive qualitative approach to gain an in-depth understanding of participants' perspectives and experiences. Meanwhile, the responses from questionnaires and the results of the feasibility assessments were converted into percentages using a predetermined formula to support the qualitative findings. The percentage was calculated using the following equation:

$$P = \frac{F}{N} \text{ x } 100\ \% \qquad (1)$$

Where P represents the percentage, F is the total score obtained, and N is the maximum possible score (Abdullah S et al., 2022).

The results of the interviews and questionnaires regarding the need for innovative teaching materials integrated with ethnopedagogy and based on 21st-century learning were interpreted according to the perception criteria presented in Table 1.

**Table 1.** Criteria for Interpretation of Teachers' and Students' Perceptions (Riduwan, 2011).

| Percentage Range | Interpretation |
|---|---|
| 10–25% | Poor |
| 26–50% | fair |
| 51–75% | Good |
| 76–100% | very good |

The results of these calculations were then interpreted based on the feasibility criteria established by the National Education Standards Agency (Badan Nasional Standar Pendidikan – BNSP), as presented in Table 2.

**Table 2.** Criteria for Assessing the Feasibility of Teaching Materials

| Percentage Range | Feasibility Category |
|---|---|
| 0–39% | Highly Infeasible |
| 40–54% | Infeasible |
| 55–64% | Feasible |
| 65–84% | Highly Feasible |

Source: National Education Standards Agency (BNSP) and Center for Books, 2014, in Abdullah, Susilo, & Mulawarman (2022).

## RESULT AND DISCUSSION

Based on the data presented in Table 3, all teachers reported that they had implemented the Kurikulum Merdeka in classroom instruction. However, several challenges were still identified in the teaching of science, particularly in chemistry topics. The findings revealed that students' 21st-century skills remain relatively low, with an achievement level of only 25%. This indicates that the current learning process has not yet fully promoted the development of the six core 21st-century competencies: critical thinking, creativity, communication, collaboration, character, and citizenship (6C).

These results are consistent with the findings of Silaban et al. (2025), who emphasized that critical thinking ability is a key element for understanding chemistry concepts, which are often abstract and complex in nature. The condition further suggests that the teaching materials currently used have not been able to effectively stimulate reflective thinking or encourage active student engagement in the learning process.

From the perspective of teaching materials, the results indicate that teachers still rely heavily on main textbooks (100%) and teaching modules (100%), while the use of supplementary books (25%) and student worksheets (50%) remains limited. All respondents agreed that the current teaching materials are not yet innovative and do not incorporate elements of local wisdom. This condition signifies that the available materials have not adequately supported contextual learning, namely learning that connects scientific concepts to students' everyday lives and their cultural environments.

In terms of ethnopedagogy, only a small proportion of teachers (34%) have attempted to integrate local cultural values into the learning process. However, all respondents (100%) acknowledged the importance of integrating ethnopedagogical principles into chemistry learning. This finding indicates a collective awareness among teachers of the strategic value of local wisdom in strengthening the relevance of subject matter, fostering positive character development, and enhancing students' cultural identity. Consistent with the findings of Sulastri et al. (2025), the development of teaching materials integrated with ethnopedagogy is deemed highly necessary. Therefore, the application of ethnopedagogy is viewed as an effective approach to making science learning more socially and culturally meaningful.

Meanwhile, in the context of 21st-century learning, only half of the teachers (50%) reported that they had implemented it in their teaching materials, although all respondents (100%) agreed that the application of 21st-century learning models is highly necessary. This condition highlights a discrepancy between teachers' conceptual understanding of the importance of 21st-century learning approaches and their actual implementation in classroom practice (Az-Zahra & Darmana, 2024).

**Table 3.** Tabulation of Teachers' Responses Regarding the Need for Innovative, Ethnopedagogy-Based Instructional Materials Integrated with 21st-Century Learning

| Aspect | Indicator | Percentage |
|---|---|---|
| Curriculum | Implementation of "Kurikulum Merdeka" | 100 % |
| | Constraints in science teaching, specifically chemistry | 100 % |
| | Students' 21st century skills (critical thinking, creativity, collaboration, communication, character, citizenship) | 25 % |
| Teaching Materials | Instructional materials used in science (chemistry):<br>(1) Main textbook<br>(2) Companion textbook<br>(3) Teaching module<br>(4) Student worksheets | (1) 100%<br>(2) 25 %<br>(3) 100 %<br>(4) 50 % |

| | | |
|---|---|---|
| | Instructional materials are not innovative | 100 % |
| | Instructional materials do not incorporate local wisdom | 100 % |
| Integration of Ethnopedagogy | Incorporating ethnopedagogy into learning | 34 % |
| | Need for integrating ethnopedagogy in science (chemistry) | 100 % |
| 21st-century learning | Implementation of 21st-century learning in instructional materials | 50 % |
| | Need to apply 21st-century learning models | 100 % |

The results of in-depth interviews with teachers provided more comprehensive information regarding the need for innovative chemistry teaching materials integrated with ethnopedagogy and oriented toward 21st-century learning, as presented in Table 4.

**Table 4**. Teachers' needs analysis for innovative, ethnopedagogy-based instructional materials integrated with 21st-century learning.

| Aspect | findings |
|---|---|
| curriculum | The limited availability of learning resources, incomplete laboratory facilities, and time constraints have made it difficult for teachers to effectively deliver science instruction, particularly in the field of chemistry. |
| Teaching Materials | The lack of supplementary textbooks that can assist students in understanding the abstract concepts of science, particularly chemistry, poses an additional challenge in the learning process. |
| Integration of Ethnopedagogy | The integration of ethnopedagogy is particularly relevant for teaching topics such as elements, compounds, and mixtures, by incorporating local wisdom examples like traditional herbal products made from Curcuma xanthorrhiza (temulawak), sembur, and param. |
| 21st-century learning | Students need to be equipped with 21st-century skills through appropriate learning approaches so that they can adapt effectively to the demands of a rapidly changing era. |

Overall, the findings of this study reveal that teachers possess a high level of awareness and commitment toward the need for innovative teaching materials and the integration of ethnopedagogy in chemistry learning. However, they still face significant limitations in terms of the availability of appropriate learning resources. Therefore, it is essential to develop chemistry teaching materials that not only contain accurate scientific content but also incorporate local cultural values and 21st-century learning principles. The needs analysis conducted in this study serves as an important initial step toward producing innovative, contextual, and culturally grounded teaching materials, which can enhance the quality of learning while meaningfully preparing students to face global challenges.

The students' needs for innovative chemistry teaching materials integrated with ethnopedagogy and oriented toward 21st-century learning are presented in Figure 1.

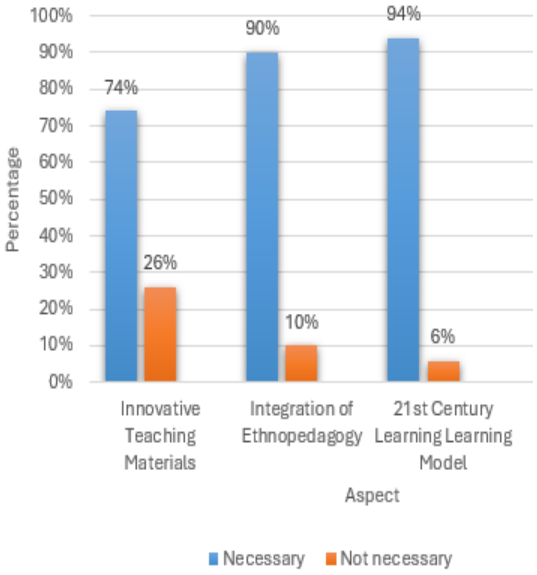


**Figure 1.** Students' needs for innovative instructional materials that integrate ethnopedagogy and are aligned with 21st-century learning

Based on Figure 1, the findings indicate that students require innovative chemistry teaching materials that are interactive and accessible through digital devices such as smartphones or laptops, allowing for greater flexibility in use. This finding aligns with the study by Sinuhaji and

Silaban (2025), which highlights the importance of developing innovative, contextual, and technology-friendly science teaching materials to support effective and engaging learning experiences.

Approximately 90% of students expressed their desire for teaching materials that are integrated with ethnopedagogical values. According to Silaban et al. (2025), the implementation of ethnopedagogy can create more contextual and relevant learning experiences, as it bridges scientific knowledge with students' cultural values and lived experiences. Therefore, the integration of local wisdom in chemistry learning not only deepens students' understanding of abstract scientific concepts but also fosters awareness and appreciation of their cultural identity.

Furthermore, 94% of students indicated their preference for learning that incorporates 21st-century skills. This finding underscores the need for developing more interactive, contextual, and student-centered teaching materials and learning strategies, which can strengthen students' 21st-century competencies while simultaneously instilling meaningful local cultural values (Ambarita & Situmorang, 2023; Silaban et al., 2020).

The results of the observations related to school facilities and infrastructure, student characteristics and environment, as well as ethnic diversity and students' parental occupations are presented in table 5.

**Table 5.** Observation Data on School Facilities, Ethnic Diversity, and Students' Parents' Occupations

| Component | Description |
|---|---|
| Number of study groups | 20 classes |
| Interactive digital screens | 2 units |
| Projectors | 20 units |
| Laptops | 20 units |
| Internet facilities | Indihome Wi-Fi |
| Ethnic Diversity | The majority of students are from the Karo ethnic group, followed by Javanese, with a small proportion from other ethnic groups. |
| The majority occupation of parents | Farmers |

Based on Table 5, it can be seen that facilities and infrastructure, such as internet connectivity and multimedia equipment, greatly support the implementation of innovative chemistry teaching materials. This finding is consistent with the study by Situmorang et al. (2024), which emphasized the importance of virtual-based instructional media in the development of teaching materials. The use of images and videos featuring local wisdom can facilitate students' understanding of chemistry concepts by providing more concrete and contextual learning experiences. Furthermore, the integration of ethnopedagogy related to Curcuma xanthorrhiza (temulawak) is highly relevant in science learning, particularly in chemistry, as it allows students to recognize chemical compounds in alignment with the ethnic and cultural diversity of their local community (Adlar et al., 2025).

The results of the document analysis on textbook feasibility were conducted to evaluate the appropriateness of the main science textbook for Grade VIII, published by the Ministry of Education, Culture, Research, and Technology of the Republic of Indonesia, as a foundation for developing innovative chemistry teaching materials integrated with ethnopedagogy and oriented toward 21st-century learning, as presented in Table 6.

**Table 6.** Distribution of Textbook Feasibility According to BNSP (2014)

| Aspect | Percentage | Category | Notes and Suggestions |
|---|---|---|---|
| Content Feasibility | 73% | Feasible | There is no integration of local wisdom or 21st-century learning. It is recommended to include explanations or examples that encourage students to practice problem-solving. |
| Language Feasibility | 83% | Feasible | The language used should be more closely related to students' daily lives and developmental stages. |

| | | | |
|---|---|---|---|
| Presentation Feasibility | 78% | Feasible | Innovation is needed by embedding learning video links, adding summaries, and assessments. |
| Graphic Feasibility | 73% | Feasible | The book cover needs more attractive illustrations and should feature authentic images. |

Based on the feasibility study of the main science textbook, all evaluated aspects were categorized as feasible; however, several important notes and recommendations were identified as the basis for developing improved teaching materials. First, it is essential to incorporate local wisdom content and apply 21st-century learning principles to enhance student engagement in the learning process. This can be achieved by providing explanations or examples that encourage students to practice contextual problem solving. In addition, the language used in the learning materials should be more closely aligned with students' daily experiences and developmental stages, as this helps them better understand the content being taught.

Innovation is also necessary, such as including links to instructional videos to enrich students' learning experiences. Furthermore, the addition of summaries and assessment components will assist students in reviewing and consolidating the material they have learned. Lastly, attention should be given to the physical design of the textbook; attractive illustrations and the use of authentic images on the cover can increase students' interest and motivation to engage with the learning materials. By implementing these improvements, the learning process is expected to become more effective, engaging, and meaningful for students.

## CONCLUSION

Based on the results of the needs analysis from both teachers and students, several key conclusions can be drawn: (1) The current junior high school science (chemistry) teaching materials do not yet fully support 21st-century learning and are not integrated with local wisdom. (2) Teachers face time constraints and limited learning resources, and they perceive that students' 21st-century competencies remain low. (3) Students experience difficulties in understanding the material, although they still demonstrate interest in the existing teaching resources. (4) Both teachers and students express a desire for more contextual, interactive, and life-related learning experiences. (5) Teachers believe that the integration of local cultural elements, such as the use of traditional medicinal plants like Curcuma xanthorrhiza (temulawak), turmeric, and ginger, can enhance students' understanding of chemical compounds in science learning. (6) Students require more engaging teaching materials that include visual media, simple experiments, and digital accessibility to support flexible and meaningful learning.

The identified needs for innovative chemistry teaching materials are expected to support students' understanding of scientific concepts, strengthen local cultural values, and foster 21st-century skills. Future studies should focus on the design and implementation stages of the developed teaching materials to evaluate their effectiveness in improving students' scientific literacy and 21st-century competencies.

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