From Culture to Science: Development and Validation of the CHEMazing Lab Ethnochemistry Learning Packet

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ABSTRACT

Chemistry is often perceived as a difficult subject because of its abstract concepts, scientific terminologies, and limited connection to learners' real-life experiences. This study aimed to develop and validate the CHEMazing Lab Ethnochemistry Learning Packet as a contextualized instructional material integrating Indigenous Cultural Knowledge and Practices (ICKP) and Filipino food preservation practices in teaching selected Chemistry concepts. Specifically, the study determined the need for ethnochemistry integration and evaluated the validity, acceptability, usability, learner engagement, and impact on learners' performance of the developed learning packet among Grade 11 learners.

The study employed a quantitative developmental research design utilizing the ADDIE Model. Participants included 90 Grade 11 learners, 30 Science teachers, 6 expert evaluators, and 32 Grade 11 learners who participated in the tryout implementation. Data were gathered using needs assessment questionnaires, evaluation rating sheets, usability and learner engagement questionnaires, and pretest-posttest assessments.

Findings revealed that ethnochemistry was only sometimes integrated into Chemistry instruction, highlighting the need for contextualized instructional materials. The developed learning packet obtained an overall expert evaluation mean of 3.54, interpreted as Highly Acceptable. Usability and learner engagement results yielded mean scores of 3.62 and 3.63, respectively, both interpreted as Highly Evident. The Wilcoxon Signed-Rank Test revealed a significant difference between pretest and posttest scores ($Z = -3.82$, $p < .001$), resulting in the rejection of the null hypothesis with a large effect size ($r = 0.68$).

The findings suggest that the learning packet may serve as an effective contextualized instructional material for improving Chemistry learning experiences.

Keywords: Chemistry education, Ethnochemistry, Indigenous Cultural Knowledge and Practices (ICKP)

INTRODUCTION

Chemistry remains one of the most challenging disciplines for many learners because of its abstract concepts, scientific terminologies, mathematical demands, and difficulties in relating scientific concepts to real-life situations. Learners often encounter difficulties in conceptual understanding when scientific principles are presented in isolated and theoretical contexts. These concerns are reflected in recent international assessments, wherein Filipino learners continued to perform below the global average in scientific literacy and science achievement (OECD, 2019; OECD, 2023). Such findings highlight the need for instructional approaches and materials that can make Chemistry learning more meaningful and relevant to learners.

Contextualization has been identified as an instructional approach that promotes meaningful learning by linking scientific concepts with familiar experiences, community practices, and cultural knowledge. Studies have shown that contextualized science instruction improves learner engagement, conceptual understanding, and scientific literacy by connecting academic content with authentic experiences (Picardal & Sanchez, 2022). In the

Philippine setting, contextualized instructional approaches have likewise been found to improve learner participation and acquisition of Chemistry concepts through the integration of locally relevant examples and experiences (Gecolea & Amon, 2022).

Ethnochemistry has emerged as a culturally responsive approach that integrates Indigenous Cultural Knowledge and Practices (ICKP) with Chemistry instruction. Ethnochemistry recognizes that community-based practices embody scientific principles that may serve as meaningful contexts for learning. Previous studies reported that ethnochemistry-based learning positively influences learner engagement and understanding by connecting scientific concepts with familiar cultural experiences (Rahmawati et al., 2019; Wahyudiati, 2024). In the Philippine context, contextualized Chemistry learning materials such as those developed by Matrido and Salazar (2025) and Salamat (2024) demonstrated positive effects on learners' engagement and conceptual understanding.

Despite increasing emphasis on contextualized and culturally responsive instruction, the integration of Indigenous Cultural Knowledge and Practices into Chemistry learning materials remains limited. Existing instructional resources continue to rely heavily on generalized and textbook-centered examples that may not sufficiently reflect learners' cultural backgrounds and lived experiences. Consequently, there remains a need for localized instructional materials that bridge scientific concepts with learners' everyday experiences and cultural practices.

Thus, this study developed and validated the CHEMazing Lab Ethnochemistry Learning Packet, a contextualized instructional material integrating food preservation practices and Indigenous Cultural Knowledge and Practices with selected Chemistry concepts. Specifically, the study aimed to determine the acceptability, usability, learner engagement, and effectiveness of the developed learning packet among Grade 11 learners.

Objectives of the Study

This study aimed to develop and validate the CHEMazing Lab Ethnochemistry Learning Packet as a contextualized instructional material in Chemistry education. Specifically, it sought to:

1. develop an ethnochemistry-based learning packet that integrates Indigenous Cultural Knowledge and Practices (ICKP) and Filipino food preservation practices in teaching Chemistry concepts;
2. determine the validity and acceptability of the developed learning packet based on the evaluation of experts and Grade 11 learners; and
3. determine the usability and learner engagement of the developed learning packet through pilot testing among Grade 11 students.

Hypothesis of the Study

H_0: There is no significant difference between the pretest and posttest scores of Grade 11 learners after utilizing the CHEMazing Lab Ethnochemistry Learning Packet.

METHODOLOGY

Research Design

This study employed a quantitative developmental research design utilizing the ADDIE Model in the development and validation of the CHEMazing Lab Ethnochemistry Learning Packet. The ADDIE framework, consisting of the Analysis, Design, Development, Implementation, and Evaluation phases, guided the systematic process of developing, validating, implementing, and refining the instructional material.

Quantitative methods were utilized to determine the validity, acceptability, usability, learner engagement, and learner performance associated with the developed learning packet through structured evaluation instruments and assessment results. Pretest and posttest scores were analyzed to determine learners' performance following the utilization of the learning packet during tryout implementation.

Qualitative feedback obtained through comments and suggestions from pilot testing participants and expert evaluators was also utilized to support the quantitative findings and provide additional insights for the refinement of the instructional material.

The developmental research design was considered appropriate because the study focused on the systematic development and evaluation of a contextualized and culturally responsive instructional material integrating ethnochemistry concepts and Indigenous Cultural Knowledge and Practices (ICKP) into Chemistry instruction.

Research Setting and Participants

The study was conducted in a private secondary school offering Senior High School education in the Division of Iligan City. The school offers General Chemistry under the Senior High School curriculum and provided an appropriate setting for the implementation and evaluation of the CHEMazing Lab Ethnochemistry Learning Packet.

The participants included Grade 11 students, Science teachers, and expert evaluators involved in different phases of the study. During the needs assessment phase, ninety (90) Grade 11 students and thirty (30) Science teachers participated in identifying instructional needs related to ethnochemistry integration in Chemistry instruction. Pilot testing involved five (5) Grade 11 students who evaluated the clarity, organization, readability, and usability of the developed learning packet. Their comments, suggestions, and feedback were utilized to refine and enhance the instructional material prior to its implementation.

Following the revisions, tryout testing was conducted among one Grade 11 class consisting of thirty-two (32) students. The primary purpose of the tryout was to determine the usability and learner engagement promoted by the CHEMazing Lab Ethnochemistry Learning Packet in an actual classroom setting and to gather preliminary evidence regarding learners' performance after utilizing the material. Participants were selected through convenience sampling based on their availability and willingness to participate during the conduct of the study.

For expert validation, purposive sampling was employed to select six (6) qualified evaluators with expertise in science education and instructional material evaluation. The panel consisted of one Master Teacher I, one Principal II, two Chemistry Instructors, one Science Department Head, and one Senior High School Science Teacher. The evaluators assessed the developed learning packet in terms of content quality, instructional effectiveness, contextualization, and cultural appropriateness.

Research Instrument

Several research instruments were utilized to gather data for the development and validation of the CHEMazing Lab Ethnochemistry Learning Packet. Researcher-made needs assessment questionnaires for teachers and learners were used during the analysis phase to identify instructional needs, learner experiences, and existing practices related to the integration of traditional food preservation practices in Chemistry instruction. The questionnaires included close-ended items measured using a four-point Likert scale and open-ended questions intended to obtain additional insights regarding experiences and challenges encountered in Chemistry learning and instruction.

The CHEMazing Lab Ethnochemistry Learning Packet served as the primary instructional material developed in the study. The learning packet consisted of contextualized lessons, guided activities, illustrations, exercises, and assessments integrating Indigenous Cultural Knowledge and Practices (ICKP) and Filipino food preservation practices with selected Chemistry concepts.

An adapted and modified evaluation rating sheet was utilized for expert validation to determine the validity and acceptability of the learning packet in terms of content, technical quality, presentation and organization, accuracy, instructional effectiveness, assessment, integration of Indigenous Cultural Knowledge and Practices, and time appropriateness.

A usability and learner engagement questionnaire was administered during pilot and tryout testing to determine learners' perceptions regarding the clarity, organization, ease of use, attractiveness, and engagement promoted by the learning packet. Qualitative comments and suggestions were also collected to support the quantitative findings and guide material refinement.

A researcher-made pretest and posttest assessment aligned with the selected Chemistry competencies was utilized to determine learners' performance after utilizing the learning packet. The scores obtained were used to examine changes in learner performance during tryout implementation.

Data Collection Procedure

The data gathering procedure followed the ADDIE Model, consisting of the Analysis, Design, Development, Implementation, and Evaluation phases. During the analysis phase, permission to conduct the study was obtained from the school administration, after which teacher and learner needs assessment questionnaires were administered to identify instructional needs and determine relevant cultural contexts for the development of the instructional material.

Based on the results of the needs assessment, the CHEMazing Lab Ethnochemistry Learning Packet was designed and developed by integrating Indigenous Cultural Knowledge and Practices (ICKP), Filipino food preservation practices, and selected Chemistry concepts. The developed material underwent expert validation, and the comments and recommendations provided by the evaluators were utilized for revision and refinement.

Following expert validation, pilot testing was conducted among five Grade 11 students to determine the clarity, organization, and usability of the learning packet. Revisions based on participant feedback were incorporated prior to tryout implementation. The finalized learning packet was then implemented among thirty-two Grade 11 learners. A pretest was administered prior to implementation to determine learners' prior knowledge of the selected Chemistry concepts. After utilizing the learning packet, participants completed the posttest and usability and learner engagement questionnaires.

The data gathered from the needs assessment, evaluation rating sheets, questionnaires, pretest and posttest assessments, and qualitative feedback were subsequently organized and analyzed to determine the validity, acceptability, usability, learner engagement, and effectiveness of the developed instructional material.

Ethical Consideration

The researchers strictly observed ethical principles throughout the conduct of the study. Prior to the implementation and pilot testing of the learning packet, permission was formally secured from the school administration. The participants were informed regarding the purpose, procedures, and academic nature of the study, and participation was entirely voluntary. Informed consent was obtained from the participants prior to their involvement in the pilot testing process.

Confidentiality and anonymity of the participants and evaluators were maintained at all times. The information and responses gathered during the study were treated with utmost confidentiality and were utilized solely for academic and research purposes. The researchers also ensured that the instructional material and activities were culturally respectful, age-appropriate, and aligned with ethical standards in educational research.

RESULTS AND DISCUSSION

Needs Assessment Results

The needs assessment was conducted to determine existing instructional practices and identify the need for contextualized and ethnochemistry-based instructional materials in Chemistry education.

Table 1. Needs Assessment Results on the Integration of Ethnochemistry

Respondents	Mean	Interpretation
Teachers (n = 30)	2.36	Sometimes
Learners (n = 90)	2.27	Sometimes

Table 1 presents the needs assessment results regarding the integration of ethnochemistry in Chemistry instruction. Teachers obtained an overall mean score of 2.36, while learners obtained a mean score of 2.27, both interpreted as Sometimes.

The findings suggest that ethnochemistry and culturally responsive approaches remain inconsistently implemented in Chemistry instruction. Although contextual examples are occasionally utilized, these practices are often limited to introductory discussions and are not systematically integrated throughout instructional activities and assessment processes. Similar findings were reported by Sayre et al. (2025), who identified gaps in Chemistry competency mastery among Grade 11 learners and emphasized the importance of instructional interventions that address specific learning needs. Likewise, Melitante et al. (2025) highlighted that identifying least-mastered competencies provides an empirical basis for designing targeted and responsive instructional materials that address learners' difficulties. Gilbert (2006) further explained that meaningful understanding develops when scientific knowledge is presented within authentic contexts rather than as isolated information. Similarly, Chibuye and Singh (2024) emphasized that integrating local and indigenous knowledge systems into Chemistry instruction enables learners to connect scientific concepts with familiar experiences, thereby strengthening understanding and relevance.

The findings further support the need for a structured instructional material integrating Indigenous Cultural Knowledge and Practices (ICKP) with Chemistry concepts. Such integration may provide learners with opportunities to engage in culturally meaningful learning experiences that facilitate conceptual understanding and strengthen the relationship between scientific knowledge and real-life situations, consistent with the contextualization framework discussed by Picardal and Sanchez (2022).

Development and Validation Results

The development phase involved determining the readability and learner-centeredness of the learning packet, followed by expert validation to establish the quality and acceptability of the instructional material.

Table 2. Readability and Student Involvement Results of the CHEMazing Lab Ethnochemistry Learning Packet

Measure	Result	Interpretation
Fry Readability Level	Grade 11–12	Appropriate for target learners
Student Involvement Index	1.24	High learner involvement

Table 2 presents the readability and student involvement results of the CHEMazing Lab Ethnochemistry Learning Packet. The readability findings indicate that the material was appropriate for the target learners, while the Student Involvement Index demonstrated that the learning packet emphasized learner-centered activities.

Appropriate readability is important in Chemistry instruction because scientific concepts often involve abstract ideas and specialized terminology that may affect learners' comprehension. Johnstone (1991) explained that difficulties in learning science frequently arise when learners experience cognitive overload due to the complexity of concepts and information presented. Likewise, Sevian and Talanquer (2014) emphasized that meaningful Chemistry learning requires instructional approaches that align with learners' cognitive development and facilitate understanding of scientific ideas. The readability findings therefore suggest that the learning packet employed language and content appropriate for the developmental level of Senior High School learners.

The Student Involvement Index findings further indicate that the learning packet promoted active participation through learner-centered and contextualized activities. Similar findings were reported by Salamat (2024), who

found that contextualized Chemistry instructional materials enhanced learners' engagement and conceptual understanding by increasing interaction with lesson content. Likewise, Matrido and Salazar (2025) reported that contextualized learning packets improved learner participation and engagement through culturally relevant and authentic learning experiences. The results also support the contextual learning framework discussed by Bennett et al. (2007), which emphasized that instructional materials grounded in meaningful contexts encourage greater learner participation and active knowledge construction.

Table 3. Expert Validation Results of the CHEMazing Lab Ethnochemistry Learning Packet

Criteria	**Mean**	**Interpretation**
Content	3.67	Highly Acceptable
Technical Quality	3.00	Acceptable
Presentation and Organization	3.17	Acceptable
Accuracy	4.00	Highly Acceptable
Instructional Effectiveness	3.67	Highly Acceptable
Assessment	3.50	Highly Acceptable
Integration of ICKP	4.00	Highly Acceptable
Time Appropriateness	3.33	Acceptable
Overall Mean	**3.54**	**Highly Acceptable**

Table 3 presents the expert validation results of the CHEMazing Lab Ethnochemistry Learning Packet. The overall findings indicate that the learning packet achieved satisfactory instructional quality and cultural relevance, obtaining a Highly Acceptable rating from the expert evaluators. High ratings for Accuracy and Integration of Indigenous Cultural Knowledge and Practices (ICKP) suggest that the material successfully incorporated scientifically accurate content while maintaining cultural authenticity and relevance. This indicates that the developed learning packet effectively aligned Chemistry concepts with culturally familiar contexts, making the material appropriate for learner-centered and contextualized instruction.

The findings are consistent with previous studies emphasizing the value of contextualized and culturally responsive instructional materials in improving learning relevance and instructional effectiveness. Rahmawati et al. (2019) reported that ethnochemistry-based learning materials facilitate meaningful learning by enabling learners to connect scientific concepts with familiar cultural experiences. Similarly, Chibuye and Singh (2024) emphasized that integrating local knowledge systems into Chemistry instruction strengthens the relevance of scientific content and improves learners' understanding of concepts through authentic contexts. In addition, Mamintal (2024) and Medina and Baraquia (2023) reported that instructional materials that undergo systematic development and validation processes demonstrate high levels of acceptability and instructional effectiveness. These findings support the validity and acceptability of the CHEMazing Lab Ethnochemistry Learning Packet as a culturally responsive instructional material for Chemistry education.

Usability and Learner Engagement Results

Following implementation, learners evaluated the usability and learner engagement promoted by the instructional material.

Table 4. Usability and Learner Engagement Results

Indicators	**Mean**	**Interpretation**
Usability	3.62	Highly Evident
Learner Engagement	3.63	Highly Evident

The findings revealed high levels of usability (M = 3.62) and learner engagement (M = 3.63), both interpreted as Highly Evident. These results indicate that the CHEMazing Lab Ethnochemistry Learning Packet effectively supported learners' interaction with instructional content and promoted active participation during the learning

process. The contextualized and culturally relevant features integrated within the learning packet may have contributed to learners' positive learning experiences and increased involvement in Chemistry learning activities.

Similar findings were reported by Salamat (2024), who found that contextualized Chemistry instructional materials improved learner engagement and conceptual understanding through meaningful learning experiences. Likewise, Matrido and Salazar (2025) reported that contextualized learning packets increased learner participation and interest through authentic and culturally familiar activities. Rahmawati et al. (2019) further emphasized that ethnochemistry-based learning enhances learner engagement by enabling students to connect scientific concepts with familiar cultural experiences.

Learners' Performance After Utilizing the CHEMazing Lab Ethnochemistry Learning Packet

To determine the effectiveness of the learning packet, learners' performance before and after implementation was analyzed.

Table 5. Learners' Performance and Wilcoxon Signed-Rank Test Results (n = 32

Measure	Value	Interpretation
Pretest Mean (SD)	11.47 (2.91)	—
Posttest Mean (SD)	17.84 (2.33)	—
Z-value	−3.82	Significant
p-value	< .001	Reject H_0
Effect Size (*r*)	0.68	Large Effect

The findings showed an increase in learners' performance, with the posttest mean score (M = 17.84, SD = 2.33) exceeding the pretest mean score (M = 11.47, SD = 2.91). Furthermore, the Wilcoxon Signed-Rank Test revealed a statistically significant difference between the pretest and posttest scores ($Z = -3.82$, $p < .001$), resulting in the rejection of the null hypothesis. The computed effect size ($r = 0.68$) further indicated a large practical effect, suggesting that the CHEMazing Lab Ethnochemistry Learning Packet produced a meaningful impact on learners' performance.

The improvement in learners' performance may be attributed to the integration of contextualized and ethnochemistry-based learning experiences that enabled learners to relate scientific concepts to familiar cultural practices. Similar findings were reported by Wahyudiati (2024), who found that ethnochemistry-based instruction improved learners' problem-solving abilities and learning experiences. Likewise, Sayre and Nabua (2026) emphasized that contextualized learning experiences contribute positively to learners' performance by strengthening the connection between scientific concepts and authentic situations. Matrido and Salazar (2025) similarly reported improved conceptual understanding among learners exposed to contextualized instructional materials grounded in familiar cultural contexts.

CONCLUSION

This study successfully developed and validated the CHEMazing Lab Ethnochemistry Learning Packet as a contextualized instructional material integrating Indigenous Cultural Knowledge and Practices (ICKP) and Filipino food preservation practices with selected Chemistry concepts. The needs assessment findings revealed limited and inconsistent integration of ethnochemistry in Chemistry instruction, highlighting the need for culturally relevant instructional resources that connect scientific concepts with learners' experiences and local practices.

The developed learning packet demonstrated satisfactory instructional quality and learner-centered characteristics. The readability assessment showed that the material was developmentally appropriate for Grade 11 learners, while the Student Involvement Index indicated that the learning packet promoted active learner participation and engagement. Furthermore, expert evaluation established the validity and acceptability of the developed material, obtaining an overall rating of Highly Acceptable, which suggests that the learning packet

met instructional standards in terms of content quality, contextual relevance, and integration of Indigenous Cultural Knowledge and Practices.

The findings likewise revealed that the learning packet promoted high levels of usability and learner engagement, indicating that learners positively responded to the contextualized and culturally responsive features incorporated within the material. Learners also demonstrated improved performance after utilizing the learning packet, as evidenced by higher posttest scores compared to pretest scores. Moreover, the Wilcoxon Signed-Rank Test revealed a statistically significant difference between learners' pretest and posttest scores, resulting in the rejection of the null hypothesis. The computed effect size further indicated that the learning packet produced a meaningful educational impact on learners' performance.

Collectively, the findings demonstrate that the CHEMazing Lab Ethnochemistry Learning Packet may serve as an effective contextualized instructional material capable of improving learner engagement, supporting conceptual understanding, and promoting culturally meaningful learning experiences in Chemistry education. The integration of ethnochemistry and Indigenous Cultural Knowledge and Practices may therefore provide a relevant and learner-centered approach that enhances both the quality and meaningfulness of Chemistry instruction.

RECOMMENDATION

The CHEMazing Lab Ethnochemistry Learning Packet may be utilized as a supplementary instructional material in Chemistry instruction to support contextualized and culturally responsive teaching practices. Integrating Indigenous Cultural Knowledge and Practices (ICKP) and familiar cultural contexts into instructional materials may enhance learner engagement and strengthen conceptual understanding of Chemistry concepts.

Future studies may examine the implementation of ethnochemistry-based learning materials among larger and more diverse learner populations across different schools and cultural settings to establish broader evidence of effectiveness and improve the generalizability of the findings. Additional investigations may also explore the application of similar instructional materials across other Chemistry topics and educational levels.

Future researchers may incorporate qualitative approaches such as interviews, focus group discussions, and classroom observations to gain deeper insights into learners' experiences, perceptions, and cultural engagement while using ethnochemistry-based instructional materials. Furthermore, longitudinal studies may be conducted to examine learners' knowledge retention and long-term attitudes toward Chemistry following exposure to contextualized and culturally responsive learning interventions.

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