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Bridging Culture and Chemistry: Assessing Grade 9 Learners' Cultural awareness and Conceptual Understanding for an Ethno Chemical Learning Module

Mary-Ann Viduya-Galo[1, 2*], Edna B. Nabua[2]

[1] Central Mindanao University, Musuan, Maramag, Bukidnon, Philippines

[1,2] Mindanao State University – Iligan Institute of Technology, Iligan City, Philippines

ABSTRACT

This study investigated the cultural awareness and conceptual understanding of chemistry among Grade 9 learners as a foundational basis for developing an ethnochemical learning module. Specifically, it aimed to (1) assess learners' cultural awareness, (2) evaluate their conceptual understanding of selected chemistry concepts, (3) identify the least mastered topics in chemistry, and (4) examine the relationship between learners' conceptual understanding and their level of cultural awareness. A quantitative, non-experimental descriptive–correlational research design was employed. Participants consisted of Grade 9 learners purposively selected from Sitio Tandacol Integrated School in Valencia City, Bukidnon. Data were collected using a researcher-constructed cultural awareness survey and a conceptual understanding test in chemistry. The findings revealed that learners' cultural awareness was generally limited and fragmented, particularly with respect to traditional beliefs and tapay-making practices. Similarly, learners' conceptual understanding of chemistry was low to average, with the poorest performance observed in abstract topics such as the electronic structure of matter, chemical bonding, the periodic table, the mole concept, and varieties of carbon compounds. Spearman's Rank Correlation analysis indicated no significant relationship between learners' conceptual understanding and cultural awareness, likely reflecting the baseline nature of the data collection conducted prior to the implementation of a culturally integrated ethnochemical module. Collectively, these results underscore the necessity for culturally grounded instructional materials and suggest that learners' existing cultural awareness and conceptual understanding may serve as critical inputs for the design of an ethnochemical learning module anchored on the Talaandig tapay-making process.

Keywords: Conceptual Understanding, Ethnochemistry, Indigenous Knowledge, Chemistry Education.

1. INTRODUCTION

Science education in the Philippines, particularly in chemistry, continues to face persistent systemic challenges that significantly influence students' learning experiences and academic achievement. Many science teachers encounter limitations related to insufficient preparation for specialized subject matter, restricted access to laboratory facilities, and shortages of instructional resources, all of which constrain effective classroom instruction. These structural inadequacies are reflected in learners' outcomes, as a substantial proportion of students demonstrate low mastery levels and persistent misconceptions across foundational chemistry concepts. Such patterns suggest that prevailing instructional conditions remain insufficient to support deep and meaningful science learning. These challenges are further exacerbated in rural contexts, where the lack of functional laboratory equipment and the continued use of outdated apparatus severely limit opportunities for hands-on experimentation and inquiry-based learning. Similar conditions have been reported globally, as rural schools frequently contend with limited funding, scarce instructional materials, and minimal opportunities for science-focused professional development, thereby narrowing both pedagogical approaches and students' access to authentic scientific practices.

Beyond resource-related constraints, learners commonly experience difficulty in relating abstract scientific concepts to their everyday experiences and cultural practices, resulting in diminished engagement and interest in science learning. When scientific knowledge is presented in decontextualized forms, students often struggle to perceive its relevance to their lived realities. In contrast, culturally responsive and context-based instructional approaches have been shown to enhance learner engagement, foster a sense of belonging, and strengthen conceptual understanding by situating learning within familiar cultural frameworks. These approaches therefore offer promising avenues for improving science learning outcomes, particularly in culturally diverse and Indigenous learning communities.

In recent years, the integration of local and Indigenous Knowledge (IK) into science education has gained increasing scholarly attention as a means of contextualizing instruction while simultaneously preserving cultural heritage. Within chemistry education, ethnochemistry has emerged as a pedagogical framework that connects cultural practices with chemical principles, enabling learners to comprehend abstract concepts through culturally familiar processes. Empirical studies consistently indicate that ethnochemistry-based instruction can improve conceptual understanding, chemical literacy, and student engagement, while also affirming learners' cultural identity and epistemological agency.

One Indigenous practice with strong relevance to organic chemistry is the traditional rice fermentation process known as tapay, practiced by the Talaandig people of Sitio Tandacol, Valencia City, Bukidnon. The tapay-making process involves complex biochemical and chemical transformations associated with fermentation, enzymatic activity, and the formation of organic compounds such as alcohols, carboxylic acids, and esters. Traditional fermentation practices constitute a specialized field of study that examines microbial interactions and chemical transformations underlying Indigenous food and beverage production. Despite its cultural and scientific significance, knowledge transmission related to tapay production and other Talaandig traditions has declined among younger generations due to social change, modernization, and limited representation within formal education.

The declining familiarity with Indigenous practices, coupled with persistent conceptual difficulties in chemistry, underscores the need for culturally grounded instructional materials. Research indicates that Indigenous learners often experience challenges in science learning when instruction is disconnected from their cultural contexts, particularly when culturally appropriate learning resources are scarce. Teachers working in Indigenous settings have likewise reported that the absence of contextualized and culturally responsive instructional materials constrains their ability to deliver meaningful science instruction, despite curricular policies that acknowledge Indigenous knowledge systems.

Nevertheless, chemistry curricula remain largely dominated by Western scientific paradigms, often marginalizing Indigenous ways of knowing and resulting in learning experiences that are perceived as less relevant by Indigenous learners. Although Indigenous knowledge offers rich and authentic contexts for explaining chemical phenomena, its integration into secondary-level chemistry instruction remains limited and underdeveloped. Existing ethnochemistry initiatives demonstrate clear pedagogical value; however, many are broad in scope and have not been systematically translated into structured, grade-level learning modules aligned with specific curricular competencies. Prior studies emphasize that culturally grounded instructional approaches enable learners to bridge cultural experiences and disciplinary understanding, thereby strengthening both conceptual learning and cultural relevance in science education.

At present, there is a notable lack of ethnochemical learning modules that integrate Talaandig Indigenous knowledge with Grade 9 chemistry concepts. Addressing this gap, the present study seeks to develop an ethnochemical learning module grounded in the Talaandig tapay-making process, with the aim of enhancing learners' cultural awareness and conceptual understanding of selected organic chemistry concepts, particularly alcohols, carboxylic acids, and esters.

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This study examined the levels of cultural awareness and conceptual understanding of chemistry among Grade 9 learners as a basis for the development of an ethnochemical learning module. Specifically, the study aimed to assess the level of learners' cultural awareness related to Talaandig Indigenous practices; to evaluate learners' conceptual understanding of selected organic chemistry concepts; to identify the least mastered chemistry topics among Grade 9 learners; and to analyze the relationship between learners' cultural awareness and their conceptual understanding of chemistry.

2. METHODOLOGY

2.1 Research Design

This study employed a quantitative, non-experimental descriptive–correlational research design to determine the levels of cultural awareness and conceptual understanding of chemistry among Grade 9 learners. The design was appropriate given that the investigation aimed to describe existing conditions and examine the relationship between the identified variables without the introduction of any instructional intervention or experimental treatment. Data were collected at a single point in time through standardized instruments, namely a structured cultural awareness survey questionnaire and a researcher-constructed chemistry conceptual understanding test. The scope of the study did not include the development, validation, implementation, or evaluation of an ethnochemical learning module. Rather, the findings generated served as baseline evidence to inform subsequent research initiatives focused on the design of culturally grounded or ethnochemical instructional materials.

2.2 Participants and Locale of the Study

The participants comprised all Grade 9 learners enrolled at Sitio Tandacol Integrated School, situated within the Talaandig Indigenous community of Sitio Tandacol, Lilingayon, Valencia City, Bukidnon. Given the relatively small population size of 20 learners, total enumeration was employed to ensure complete representation of the target group and to eliminate potential sampling bias. The research locale was purposefully selected due to its strong cultural context and close association with Indigenous practices relevant to ethnochemistry, particularly traditional fermentation processes and ethnomedicinal knowledge.

2.3 Research Instruments

Two researcher-developed instruments were utilized for data collection. The first instrument, the Cultural Awareness Survey Questionnaire, was designed to measure learners' awareness of Indigenous practices, including ethnomedicinal plant use, cultural consciousness, tapay-making processes, and traditional Talaandig beliefs. Responses were recorded using a four-point Likert scale ranging from 1 (Not Aware) to 4 (Highly Aware). Survey items were developed based on documented narratives and statements provided by Talaandig elders and community leaders. The instrument underwent expert validation by a panel of specialists in science education and Indigenous studies. Although a reliability analysis was not conducted due to the context-specific nature of the instrument and the limited sample size, expert evaluation yielded a Content Validity Index (CVI) of 3.99 out of 4.00, indicating excellent content validity.

The second instrument, the Conceptual Understanding Questionnaire, consisted of 100 multiple-choice items covering chemistry topics from Grades 7 to 10 in alignment with Department of Education curriculum competencies. A table of specifications was used to ensure balanced representation across content areas and cognitive levels. The instrument was pilot-tested with 134 senior high school students, resulting in a Cronbach's alpha coefficient of 0.900, which reflects excellent internal consistency. The test scores were used to determine learners' levels of conceptual understanding and to identify least mastered chemistry topics.

2.4 Data Gathering Procedure

Data collection was conducted upon securing ethical clearance and obtaining informed consent from both parents and participating learners. The Cultural Awareness Survey Questionnaire and the Conceptual Understanding Questionnaire were administered to all Grade 9 learners during regular school hours in a controlled classroom setting.

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Participation was strictly voluntary, and learners were informed of their right to decline or withdraw at any point without penalty. Confidentiality of responses was assured throughout the data-gathering process. No instructional intervention or treatment was introduced during data collection.

2.5 Data Analysis

Descriptive statistical measures, including frequency counts, percentages, means, standard deviations, and Mean Percentage Scores (MPS), were computed to describe learners' levels of cultural awareness and conceptual understanding of chemistry. Mastery levels were interpreted using the Department of Education's prescribed descriptors. To determine the relationship between learners' cultural awareness and conceptual understanding, Spearman's Rank-Order Correlation Coefficient was employed at a 0.05 level of significance, given the ordinal nature of the data and the non-normal distribution of scores.

2.6 Ethical Considerations

Strict adherence to ethical research standards was observed throughout the study. Participation was voluntary, and learners were afforded the right to withdraw from the study at any time. Informed consent was obtained from parents or guardians prior to data collection. Participants' anonymity and confidentiality were maintained by assigning coded identifiers and restricting access to the data to the researcher alone. All data were securely stored, and no physical, emotional, or psychological harm was inflicted on the participants during the conduct of the study.

3. RESULTS AND DISCUSSION

3.1 Learners' Cultural Awareness

The Awareness Survey examined learners' awareness of ethnomedicinal plants, cultural consciousness, tapay-making practices, and traditional beliefs, revealing varying levels of awareness across the assessed indicators. As illustrated in Figure 1, learners demonstrated the highest level of awareness in relation to ethnomedicinal plants. Notably, several plant species, such as *Psidium guajava* (bayabas), were recognized by all respondents, suggesting sustained exposure through routine household and community use. In contrast, markedly high levels of unawareness were observed for *Psychotria pendens* (sibuli) and *Homalantus populneus* (salimbaga), indicating a potential erosion in the intergenerational transmission of ethnobotanical knowledge within the community. These findings underscore uneven retention of Indigenous medicinal knowledge among learners and point to the need for culturally responsive instructional strategies that deliberately integrate lesser-known traditional practices into formal science education.

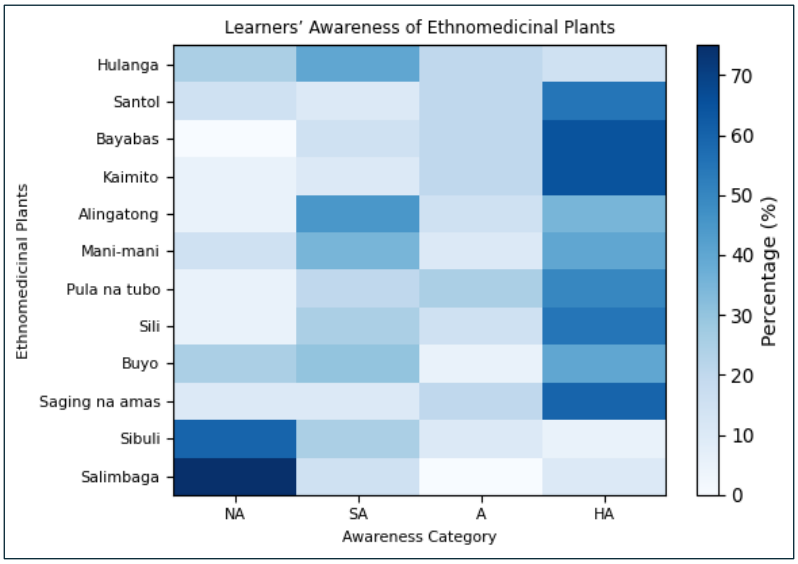

Figure 1. Heat map illustrating learners' awareness levels of selected ethnomedicinal plants.

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Awareness across the cultural indicators—namely cultural significance, healing applications, associated myths, identity formation, and protective functions—remained fragmented, with a substantial proportion of learners reporting only limited or superficial awareness. This pattern suggests that while certain cultural elements persist at a functional level, deeper symbolic meanings and traditional knowledge systems are not fully internalized by many learners, reflecting gaps in cultural transmission and contextual understanding.

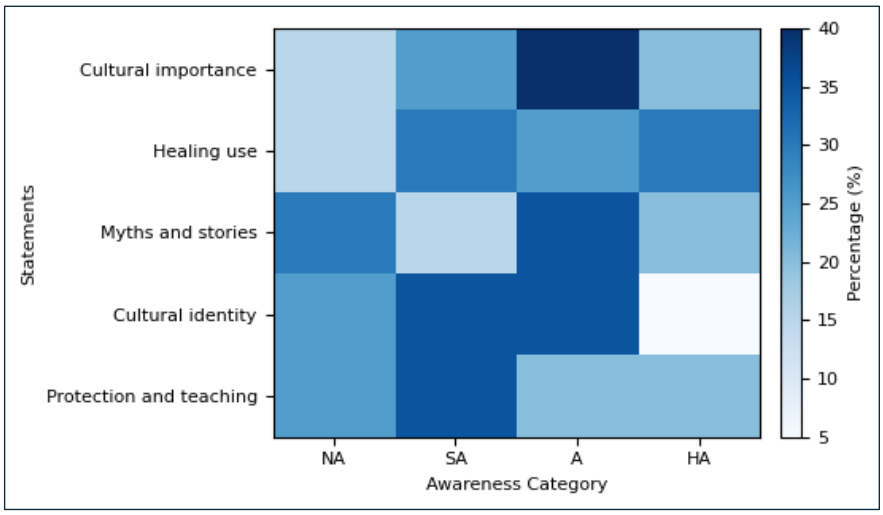

Figure 2. Heat map illustrating learners' awareness levels of culturally important ethnomedicinal plants across five indicators.

Learners' awareness of tapay-making practices was generally low, as illustrated in Figure 3. The majority of respondents indicated limited familiarity with the preparation process, cultural protocols, medicinal significance, and ritual functions associated with tapay. This finding points to a weakening intergenerational transmission of Indigenous knowledge related to traditional fermentation practices, despite their continued cultural relevance within the community.

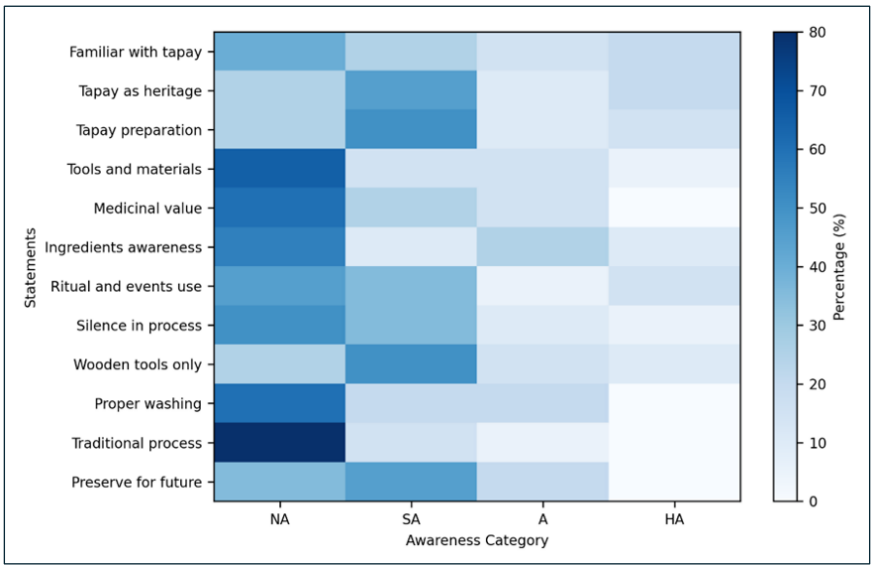

Figure 7. Heat map illustrating learners' levels of awareness of culturally significant tapay across twelve indicators

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Similarly, learners' awareness of Talaandig traditional beliefs and practices was largely concentrated within the Not Aware and Slightly Aware categories, as shown in Figure 4. This distribution indicates limited exposure to ancestral values, customary rituals, and belief systems, suggesting a gradual erosion of cultural knowledge and practices among younger members of the community.

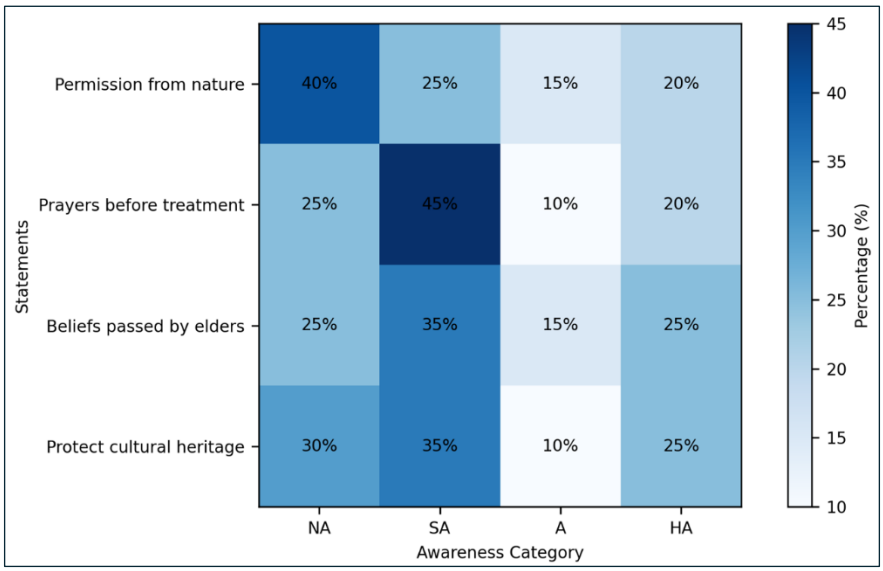

Figure 4. Heat map illustrating learners' levels of awareness of Talaandig traditional beliefs.

Overall, as presented in Figure 5, ethnomedicinal plant awareness was the only domain that reached the Aware level, whereas cultural consciousness, tapay-making practices, and traditional beliefs remained within the Slightly Aware category. This pattern underscores the uneven retention of Indigenous knowledge among learners, with practical, household-based knowledge being more readily preserved than culturally embedded practices and belief systems.

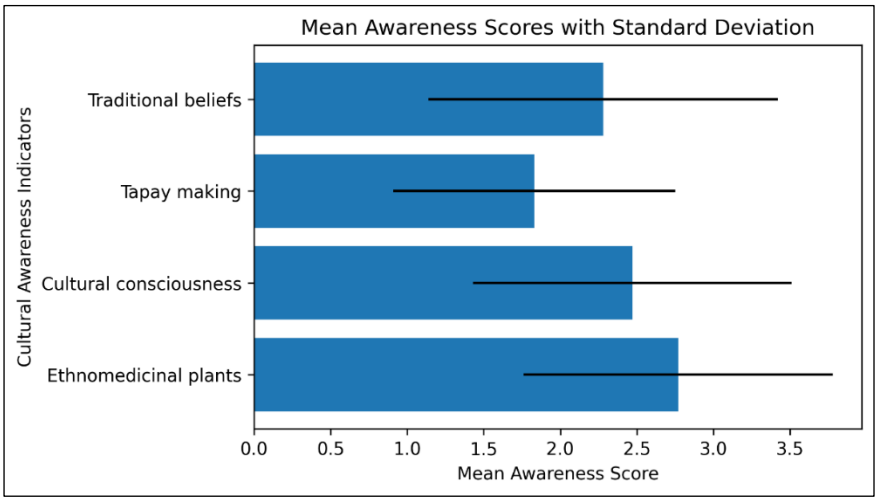

Figure 5. Mean (± SD) levels of learners' cultural awareness across four indicators.

3.2 Learners' Conceptual Understanding of Chemistry

Learners' conceptual understanding, as measured by a 100-item chemistry test, revealed generally low to average levels of mastery across the assessed topics. As illustrated in Figure 6, the least mastered areas included the electronic structure of matter, chemical bonding, the periodic table of elements, the mole concept, and varieties of carbon compounds. These topics are largely abstract and symbolic in nature, requiring multilevel representational understanding. In contrast, relatively higher mastery levels were observed in topics involving observable or procedural

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concepts, such as solutions, gases, chemical reactions, and scientific investigations, which are more readily accessible through direct experience and hands-on activities.

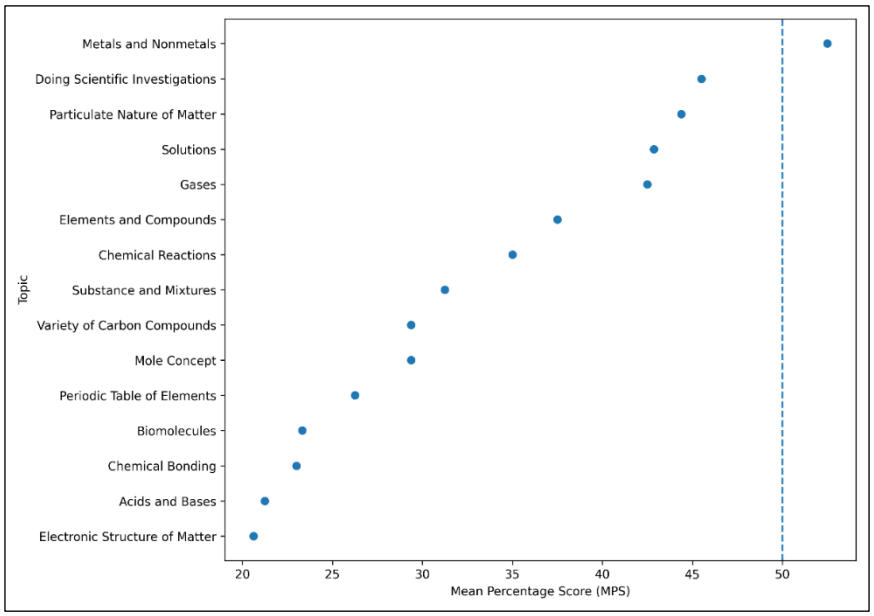

Figure 6. Horizontal dot plot showing the mean percentage scores (MPS) of students across chemistry conceptual understanding topics

3.3 Relationship between Cultural Awareness and Conceptual Understanding

Figure 7 presents the results of Spearman's Rank Correlation analysis, which revealed no statistically significant relationship between learners' cultural awareness and their conceptual understanding of chemistry. This finding indicates that higher levels of cultural awareness did not correspond to higher achievement in chemistry, suggesting that cultural knowledge alone does not automatically translate into improved conceptual understanding in the absence of explicit instructional integration..

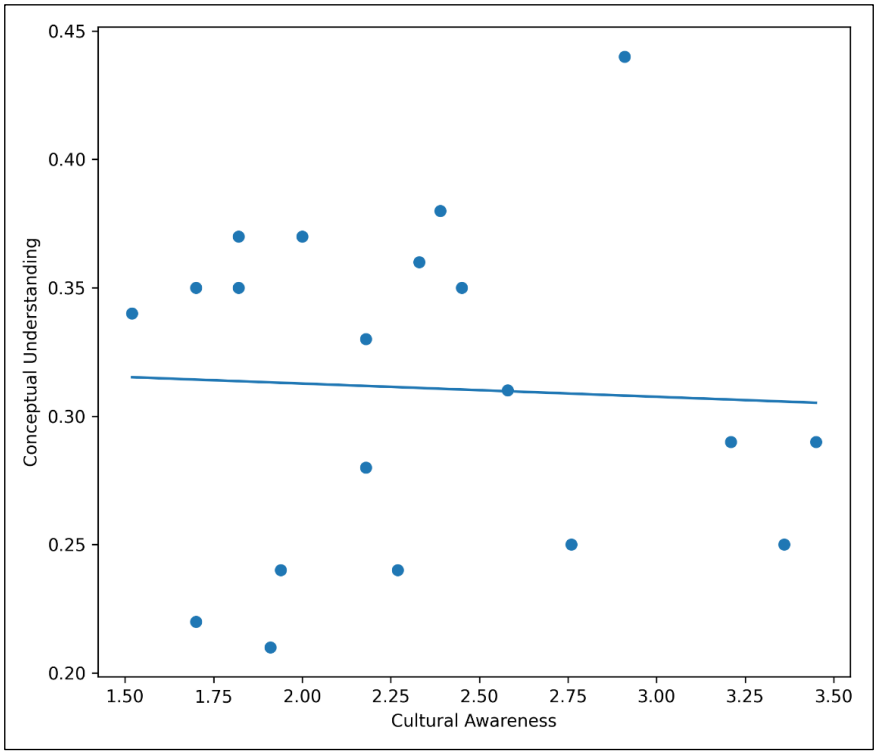

Figure 7. Scatter plot of learners' cultural awareness and conceptual understanding.

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This study explored the baseline cultural awareness and conceptual understanding of chemistry among Grade 9 learners to inform the development of an ethnochemical learning module grounded in Talaandig Indigenous knowledge. The primary aim was to assess how well students understood key chemistry concepts and the extent to which they were aware of their own culture and traditional practices. Three major findings emerged: first, learners' cultural awareness was generally low and inconsistent; second, learners demonstrated low to average conceptual understanding, with identifiable gaps in abstract topics; and third, no statistically significant relationship was found between cultural awareness and chemistry achievement at baseline. These findings resonate with broader literature on the marginalization of Indigenous knowledge (IK) in science education, the integration of cultural knowledge into disciplinary content, and the value of culturally responsive and ethnochemistry-based pedagogies.

Analysis revealed uneven cultural awareness across indicators. Learners demonstrated relatively higher familiarity with commonly used ethnomedicinal plants but exhibited markedly lower awareness of tapay-making processes, traditional beliefs, and other customary practices. This pattern reflects a broader cultural gap in science education, wherein Indigenous knowledge is gradually eroded due to limited intergenerational transmission and insufficient integration into formal curricula [10, 17]. Similar trends have been reported in other Indigenous contexts, where learners retain practical knowledge yet lack deeper understanding of the symbolic, procedural, and scientific dimensions of their cultural heritage [19, 25].

The low awareness of tapay-making is particularly significant given that fermentation is a culturally embedded practice encompassing complex chemical processes and principles. Prior research emphasizes that when Indigenous practices are not deliberately embedded into instruction, learners tend to perceive them as mere cultural traditions rather than as legitimate knowledge systems with scientific relevance [23, 27]. The present findings thus corroborate the literature asserting that IK, despite its pedagogical potential, remains peripheral in formal science curricula due to limited teacher preparation, insufficient resources, and a lack of culturally appropriate instructional materials [18, 24].

Learners' conceptual understanding was similarly uneven. The least mastered topics included the electronic structure of matter, chemical bonding, the periodic table, the mole concept, and varieties of carbon compounds. These areas are highly abstract and symbolic, demanding conceptual reasoning that is often difficult for learners when instruction is disconnected from real-world experiences [46, 47]. In contrast, learners demonstrated higher mastery in topics involving observable or procedural phenomena, such as solutions, gases, chemical reactions, and scientific investigations, supporting the assertion that contextualization and experiential learning enhance comprehension [36, 37]. These results align with prior research indicating that decontextualized, Western-centric chemistry instruction disproportionately disadvantages learners from Indigenous and rural communities [6, 12], resulting in superficial understanding and low retention [48]. Linking abstract chemistry concepts to familiar cultural practices, such as fermentation, food preparation, and natural product utilization, has been shown to promote more meaningful learning [16, 41].

The absence of a significant correlation between cultural awareness and conceptual understanding suggests that cultural familiarity alone does not automatically improve academic performance. This finding aligns with Meyer and Crawford's (23) assertion that science learning must be framed as a negotiated interaction between cultural knowledge and disciplinary content, rather than as mere exposure to cultural elements. In the present study, cultural awareness and chemistry learning coexisted without deliberate instructional alignment, reflecting baseline conditions prior to the implementation of an ethnochemical intervention. Similar observations have been documented in other pre-intervention studies, where Indigenous learners' cultural familiarity did not significantly predict achievement until culturally responsive pedagogical approaches were explicitly applied [26, 27]. Collectively, the literature underscores the importance of pedagogical mediation—through ethnoscience, ethnochemistry, and culturally responsive teaching—to transform cultural knowledge into meaningful conceptual understanding [31, 35]. Accordingly, the lack of correlation in this study should not be interpreted as evidence against cultural integration but rather as confirmation of the need for structured, intentional, and well-designed ethnochemical learning materials.

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Taken together, these findings strongly justify the development of an ethnochemical learning module centered on the Talaandig tapay-making process. Ethnochemistry has been widely recognized as an effective strategy for bridging culture and chemistry by linking traditional practices with scientific principles, including fermentation, enzymatic activity, alcohol formation, and organic functional group transformations [12, 35, 49]. Research consistently demonstrates that ethnochemistry-based instructional modules enhance chemical literacy, motivation, conceptual retention, and higher-order thinking skills by situating learning within culturally meaningful contexts [13, 14, 49]. The present study provides empirical support for the creation of culturally grounded chemistry instructional materials that leverage Indigenous practices to improve learning outcomes while affirming cultural identity.

5. CONCLUSION AND RECOMMENDATION

Based on the findings of this study, several conclusions can be drawn:

- Limited Cultural Awareness – Grade 9 learners exhibit restricted cultural awareness, particularly regarding Talaandig traditional beliefs and tapay-making practices. This finding suggests a declining transmission of Indigenous knowledge among younger generations.
- Low to Average Conceptual Understanding – Learners demonstrate low to average mastery of core chemistry concepts, with pronounced difficulties in abstract topics that are challenging to comprehend when instruction lacks meaningful cultural or contextual connections.
- Cultural Awareness Does Not Automatically Translate to Learning Gains – The absence of a statistically significant relationship between cultural awareness and conceptual understanding indicates that exposure to cultural knowledge alone does not inherently improve chemistry learning unless it is purposefully integrated into instructional design.
- Need for Contextualized Instructional Materials – The observed gaps in both cultural awareness and conceptual understanding underscore the necessity of culturally responsive and contextually grounded instructional materials to facilitate meaningful chemistry learning.
- Foundational Basis for Ethnochemical Module Development – The study validates that learners' baseline cultural awareness and conceptual understanding can serve as critical inputs for designing an ethnochemical learning module. Anchoring instruction on the Talaandig tapay-making process provides a culturally authentic framework to contextualize organic chemistry concepts such as fermentation, enzymatic reactions, and the formation of alcohols, carboxylic acids, and esters.

Based on the conclusions of this study, the following recommendations are proposed:

1. Development of an Ethnochemical Learning Module – An instructional module grounded in the Talaandig tapay-making process may be developed to contextualize abstract chemistry concepts. This module should link Indigenous practices with scientific principles such as fermentation, enzymatic activity, and the chemistry of organic compounds to enhance learners' conceptual understanding.
2. Integration of Indigenous Knowledge in Chemistry Instruction – Chemistry educators are encouraged to deliberately incorporate Indigenous knowledge and local cultural practices into lesson planning to improve learning relevance, engagement, and conceptual comprehension.
3. Emphasis on Least Mastered Chemistry Topics – Instructional interventions may prioritize topics identified as least mastered in this study, particularly those abstract and symbolic concepts that require experiential and contextually grounded teaching approaches.
4. Professional Development for Culturally Responsive Teaching – Teacher training programs may equip educators with strategies for ethnochemistry-based instruction and culturally responsive pedagogy, enabling them to bridge traditional practices with scientific concepts effectively.
5. Future Research Directions – Subsequent studies should implement and evaluate the proposed ethnochemical learning module to determine its effectiveness in enhancing learners' conceptual understanding and cultural awareness. Research may also be expanded to include other Indigenous communities and larger sample populations to improve generalizability and refine ethnochemistry-based instructional frameworks.

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