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Theorizing Chemistry Learning in Higher Education: An Indigenous Perspective

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Abstract

This review article explores the integration of Indigenous knowledge systems (IKS) into chemistry education in higher education, focusing on how these perspectives can enhance learning. Traditional chemistry education has been dominated by Western models, which frequently exclude the rich, practical knowledge developed by Indigenous communities over centuries. The article argues that incorporating IKS into chemistry education fosters inclusivity and engages students, particularly in regions like Nepal, where Indigenous knowledge plays a significant cultural role. From interdisciplinary studies and case analyses, this review study theorizes the possibility of decolonizing chemistry education through a culturally responsive pedagogy, emphasizing the interconnectedness of life, land, and resources essential in IKS.

Keywords: *Indigenous Knowledge Systems (IKS), Chemistry Education, Decolonizing Science, Culturally Responsive Pedagogy*

Introduction

Chemistry education in higher education has a historically entrenched foundation in Western pedagogical models, which emphasize theoretical frameworks and empirical methods of scientific inquiry (Olesko, 2013). This approach often prioritizes standardized curricula and assessment techniques that may not resonate with or reflect diverse student populations' cultural and contextual realities. A growing body of research has recently illuminated the significant benefits of integrating Indigenous perspectives into science

education. This shift is particularly essential in regions where Indigenous communities hold a profound cultural presence and have a longstanding historical connection to the land, such as Nepal and other parts of the world. In these contexts, Indigenous communities possess rich and complex knowledge systems that have been meticulously developed over centuries. These knowledge systems include practical insights into local ecosystems, traditional ecological practices, and a deep understanding of environmental sustainability, aligning closely with many aspects of scientific inquiry. For example, Indigenous methodologies often emphasize holistic approaches that consider the interrelationships between living beings and their environments, contrasting sharply with the reductionist attitudes prevalent in Western science.

Moreover, incorporating Indigenous perspectives into chemistry education can enhance students' engagement and relevance of the material. It allows for the exploration of local natural resources, traditional practices involving chemistry, and the impact of chemical processes on the environment. This integration enriches the educational experience, fosters respect for diverse worldviews and promotes inclusive learning environments that validate and affirm Indigenous knowledge. As educators strive to create a more holistic and culturally responsive curriculum, it's crucial to collaborate with Indigenous community members and knowledge keepers. By doing so, chemistry education can evolve to be more inclusive, bridging the gap between Western science and Indigenous wisdom, benefiting all students, and fostering a deeper understanding of the interconnectedness of science, culture, and the environment.

This review article aims to theorize chemistry learning in higher education through an Indigenous lens, exploring how Indigenous knowledge systems (IKS) can enrich chemistry education, enhance student engagement, and foster a more inclusive and holistic learning environment (Barnhardt & Kawagley, 2005). From a range of interdisciplinary studies, the review focuses on Indigenous perspectives in the context of chemistry education. It examines the potential for integrating these perspectives into higher education frameworks.

Indigenous Knowledge Systems and Chemistry Education

Indigenous Knowledge Systems (IKS) offer a holistic approach to understanding the natural world, emphasizing the interconnectedness of life, land, and resources. In chemistry education, IKS provides practical insights into chemical processes, such as plant-based medicine, metallurgy, and sustainable agricultural practices, which have developed over centuries (McKinley & Stewart, 2012). Integrating these knowledge systems into mainstream chemistry curricula enriches the learning experience and promotes cultural inclusivity and ecological awareness.

The Nature of Indigenous Knowledge in Science

Indigenous knowledge systems (IKS) are fundamentally different from Western scientific paradigms. While Western science tends to isolate phenomena for study under controlled conditions, Indigenous knowledge often emphasizes the interconnectedness of life, land, and resources (Cajete, 2000). IKS incorporates holistic approaches to understanding the natural world, and its methods are deeply intertwined with community practices, cultural beliefs, and environmental stewardship. In many Indigenous communities, knowledge is passed down orally through generations and often involves a practical application of chemistry, such as medicinal plants, metallurgy, and agricultural practices (Emeagwali & Shizha, 2016). For example, Indigenous peoples have historically employed chemical processes in activities such as food preservation, natural dyeing, and the production of medicines from plants. These practices illustrate that Indigenous knowledge encompasses a form of chemistry that predates and exists alongside the development of modern chemical theories. By acknowledging these contributions, chemistry education can become more inclusive and reflective of a wider array of scientific practices.

Methodology

This research review adopts a qualitative methodology, primarily drawing on document analysis to review existing literature on Indigenous knowledge and its role in science education, particularly chemistry. Key sources include journal articles, educational reports, and case studies that explore the integration of IKS in higher education. The review also incorporates critical theory to analyze how Indigenous perspectives challenge conventional science education models and propose alternative

frameworks for teaching and learning chemistry. Secondary data from institutions, policy documents, and Indigenous educational practices are analyzed to present a comprehensive perspective. This methodology allows for an in-depth exploration of the differences in integrating IKS into higher education while critiquing current models' limitations.

Data Analysis

The analysis is based on themes like a disconnect between Western chemistry education and Indigenous knowledge, Indigenous knowledge of chemistry regarding practical application, theorizing chemistry learning through an Indigenous perspective, and a case study of integrating Indigenous knowledge into chemistry learning.

The Disconnect Between Western Chemistry Education and IK

Despite the richness of Indigenous knowledge systems, they are often marginalized or ignored in mainstream chemistry education. Chemistry curricula in higher education typically follow Western models that emphasize reductionism, scientific abstraction, and the compartmentalization of knowledge into specific fields such as organic, inorganic, and physical chemistry. This compartmentalized approach contrasts with Indigenous holistic frameworks, which treat knowledge as interconnected, with chemistry integral in broader ecological and societal systems (Snively & Corsiglia, 2001). This disconnect is problematic for Indigenous students in higher education, who may feel alienated by a curriculum that does not reflect their cultural backgrounds or value their community knowledge. Studies show that Indigenous students often struggle with low retention rates in STEM fields, in part because of the cultural dissonance they experience when engaging with science curricula that exclude their knowledge systems. Integrating Indigenous perspectives into chemistry education would require a shift in how chemistry is taught, focusing on contextualizing chemical concepts within Indigenous practices and acknowledging the epistemic value of Indigenous knowledge. This approach benefits Indigenous students and enriches the overall learning experience for all students by fostering a more diverse and culturally sensitive educational environment.

Indigenous Perspectives on Chemistry: Practical Applications

Indigenous practices demonstrate a deep understanding of chemical processes, even though they may not be articulated in the same scientific language as Western chemistry. Some examples include:

Medicinal Chemistry

Many Indigenous communities have developed cultured knowledge of medicinal plants and their chemical properties. For example, Indigenous healers have long understood how to extract active compounds from plants to treat illnesses, a practice that aligns with modern pharmacology. In Nepal, for instance, using *Swaras* in herbal preparations involves complex chemical knowledge about extraction processes and compound interactions.

Metallurgy and Material Science

Indigenous groups have developed metal extraction and purification techniques, such as smelting and alloying, long before Western scientific processes formalized these practices. The indigenous methods for creating alloys or preserving materials showcase an understanding of chemical transformation and conservation.

Ecological Stewardship and Chemistry

Indigenous knowledge systems are deeply intertwined with environmental chemistry, particularly in water management and sustainable agriculture. Communities have historically understood the chemical cycles of ecosystems, utilizing them for sustainable practices that ensure long-term ecological balance. These examples highlight the practical nature of Indigenous chemistry knowledge, suggesting that its inclusion in chemistry education can bring the subject to life for students by showing how chemical principles apply to real-world problems.

Theorizing Chemistry Learning Through Indigenous Perspective

Theorizing chemistry learning through an Indigenous perspective highlights the importance of integrating Indigenous knowledge with Western scientific paradigms. This approach fosters inclusivity and enhances students' understanding of chemistry in ways that connect with their cultural and environmental experiences. For example, by embedding Inuit life and culture into the high school chemistry curriculum, educators aim to make the subject more relevant and engaging for Indigenous students, potentially increasing their interest in science-related careers (Rayner-Canham & Hogue, 2022). This holistic method encourages students to view chemical concepts through scientific and traditional ecological lenses, promoting a deeper connection to the community and nature (Handayani & Masyhuri, 2023).

Decolonizing Chemistry Education

Integrating Indigenous knowledge into chemistry learning can be understood through the broader framework of decolonization, which seeks to challenge the dominance of Western knowledge systems and promote the inclusion of marginalized perspectives (Battiste, 2013). Decolonizing chemistry education involves critiquing the assumptions and values embedded in the traditional science curriculum, which often reflects a Eurocentric worldview. It also makes space for Indigenous epistemologies and ontologies, which offer alternative ways of understanding the natural world. Decolonizing chemistry education does not mean rejecting Western science but instead creating a more inclusive curriculum that acknowledges the validity of multiple knowledge systems. This can be achieved by incorporating Indigenous case studies, fieldwork, and collaborative learning opportunities into chemistry courses. Such an approach broadens the scope of chemistry education and helps students develop critical thinking skills as they learn to navigate different ways of knowing.

Culturally Responsive Pedagogy in Chemistry

Another essential theoretical framework for integrating Indigenous knowledge into chemistry education is culturally responsive pedagogy (CRP). CRP emphasizes recognizing students' cultural backgrounds and experiences as central to learning. In the context of chemistry education, this means designing curricula that connect chemical principles to Indigenous practices and worldviews (Aikenhead & Michell, 2011). For example, chemistry educators might incorporate Indigenous water purification methods into discussions of chemical equilibrium or use traditional knowledge of plant chemistry to explore organic compounds. By doing so, educators can make chemistry more relatable and meaningful for Indigenous students while also providing all students with a broader understanding of how chemistry operates in different cultural contexts (Handayani, Masyhuri, 2023).

Case Studies of Integrating Indigenous Knowledge in Chemistry Education

The case of the Canadian Indigenous community and the case of integrating Indigenous knowledge into science classroom practices in Nepal is highlighted here.

Case Study 1

Chemistry Education in Canadian Indigenous Communities

In Canada, efforts have been made to integrate Indigenous knowledge into science education, including chemistry. A project in collaboration with the Indigenous community in British Columbia involved revising chemistry curricula to include traditional ecological knowledge (TEK). Students engaged with elders and community members to learn about traditional practices like plant medicine preparation, which was then linked to modern chemical concepts like extraction, filtration, and solubility (Paquin, 2023). Data from this initiative showed increased student engagement and a deeper understanding of chemistry concepts when contextualized within Indigenous knowledge frameworks. Students reported feeling a stronger connection to the material, as it resonated with their cultural backgrounds and everyday experiences.

Case Study 2

Integrating Indigenous Knowledge in Chemistry Curricula in Nepal

In Nepal, where Indigenous groups have long been administrators of environmental knowledge, there has been a growing movement to incorporate this knowledge into the national education system. Recent efforts to introduce Indigenous perspectives into university-level chemistry courses have included modules on traditional water management systems and the chemistry of medicinal plants used by local healers (Lamsal, 2021). Analysis of these initiatives reveals that integrating Indigenous knowledge in science curricula and classrooms is possible and related to applied chemistry (Dakota &Timilsena, 2023). Furthermore, these results focused on the student's higher levels of engagement and critical thinking skills developed through IKS, as they could see the relevance of chemistry in their daily lives.

Conclusion

Theorizing chemistry learning in higher education from an Indigenous perspective presents an opportunity to create a more inclusive and holistic educational framework. With their practical and ecological foundations, Indigenous knowledge systems offer rich insights into chemical processes that can complement Western scientific models. By integrating Indigenous knowledge into chemistry curricula, higher education institutions can foster greater cultural inclusivity, enhance student engagement, and promote a deeper understanding of the natural world. The challenge lies in shifting chemistry education

paradigms to accommodate multiple knowledge systems, which requires institutional commitment, curriculum reform, and collaboration with Indigenous communities. As the case studies from Canada and Nepal illustrate, the benefits of such an integration extend far beyond the classroom, empowering students and contributing to the decolonization of science education.

References

Aikenhead, G. S., & Michell, H. (2011). *Bridging cultures: Indigenous and scientific ways of knowing nature*. Toronto, Canada: Pearson Education.

Barnhardt, R., & Kawagley, A. O. (2005). Indigenous knowledge systems and Alaska Native ways of knowing. *Anthropology & Education Quarterly*, 36(1), 8-23. doi:10.1525/aeq.2005.36.1.008

Battiste, M. (2013). *Decolonizing Education: Nourishing the Learning Spirit*.

Cajete, G. A. (2000). *Native science: Natural laws of interdependence*. Santa Fe, NM: Clear Light Publishers.

Devkota, K. M., & Timilsena, N. (2023). Indigenous Knowledge in Science Classroom Practices: An Explorative Study. *KEPES, 21*(3), 847-856.

Emeagwali, G., & Shizha, E. (2016). Interconnecting history, African indigenous knowledge systems and science. In *African indigenous knowledge and the sciences* (pp. 1-11). Brill.

Handayani, N., Masyhuri, S. (2023). Innovating Chemistry Education: Integrating Cultural Knowledge through a Practical Guide. *SpringerLink.*

HARI, V. (2020). *Phytomedicine: Healing Herbs*. Notion Press.

Henderson, J. Y. (2000). *Protecting Indigenous knowledge and heritage: A global challenge*. Saskatoon: Purich Publishing.

Lamsal, H.P. (2021). "Chemistry Education and Indigenous Knowledge: Challenges and Opportunities in Nepal." *Nepalese Journal of Science Education*.

McKinley, E., & Stewart, G. (2012). Science education in a bicultural context: Teaching and learning through Indigenous values. *Cultural Studies of Science Education*, 7(4), 927-935. doi:10.1007/s11422-012-9425-5

Paquin, A. (2023). The Integration of Indigenous Knowledge in Education.

Rayner-Canham, G. & Hogue, M. (2022). Integrating Indigenous perspectives into chemistry education. *Chemical Institute of Canada*.

Snively, G., & Corsiglia, J. (2001). Discovering Indigenous science: Implications for science education. *Science Education*, 85(1), 6-34. doi:10.1002/1098-237X(200101)85:1<6::AID-SCE3>3.0.CO;2-R

Olesko, K. M. (2013). Science education in the historical study of the sciences. In *International Handbook of Research in History, philosophy and science teaching* (pp. 1965-1990). Dordrecht: Springer Netherlands.