Original Paper

Native Perspectives about Coupling Indigenous Traditional Knowledge with Western Science in Geoscience Education from a Focus Group Study

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Abstract

Traditional Knowledge (TK) from Native American/Alaska Native (NA/AN) communities is often met with dismissive attitudes due to its perceived qualitative nature, however, careful examination of what TK represents, and how it formed, leads to the realization that TK is a mixture of qualitative, quantitive, and spiritual knowledge utilizing the same rigor as western science. TK represents knowledge about place, historical insight, and spiritual beliefs with a longstanding and tested understanding about terrestrial and aquatic systems. Theoretical positioning of this study supports the ideology that providing NA/AN students with culturally aligned educational opportunities creates equitable and inclusive learning environments, thereby increasing sense of identity and belonging. We present focus group data collected from two national conferences focused on success of NA/AN students in geoscience. Using a small discussion group format respondents were asked to consider: (1) How do you define science?, (2) How do you define TK?, and (3) What does coupling TK and science mean to you? Our findings revealed a holistic definition of science using typical (e.g., biology, geology, etc.) and atypical (e.g., social science, cultural identity, equity) descriptors. These findings emphasize the importance of developing culturally

aligned curriculum across all education levels to support NA/AN students.

1. Introduction

This study examines, through a focus group format, the perspectives of Native students, Native and non-Native mentors, faculty, and professionals in geoscience research and education, about their opinions of how or if TK and western science knowledge systems are interrelated and complimentary. A review of current literature makes a strong argument for the benefits of using both knowledge systems for all students—while also addressing the difficulties encountered in blending these two distinct systems into geoscience research and education (Chatterjee, 2019; Ragavan, 2001). To better elucidate perspectives, we conducted two focus groups (n=50) at two national conferences that focused on Native student success across all western science or Science, Technology, Engineering, and Math (STEM) disciplines. To gain a better understanding of the perspectives of Natives, from various tribal nations, on the importance of providing culturally aligned and ethical geoscience education, and the impacts respondents thought coupling these knowledge systems would have on their self-efficacy as a Native scientist. Research questions discussed in focus groups were: (1) How do you define science? (2) How do you define TK? and (3) What does coupling TK and science mean to you?

This study is grounded in the theory that providing students with opportunities to couple TK and STEM will lead to positive outcomes in self-identity as a scientist and increase the pursuit of and retention of Native students in geoscience disciplines. Native students' values and beliefs about themselves, in relation to their culture and community, span a spectrum of diversity within the classroom. Hence, post-secondary institutions often struggle to create equitable and inclusive spaces that meet the needs of each of these diverse students. Historically, academic institutions have failed to acknowledge that Native students come with unique life and cultural experiences and self-perceptions about their culture that influence and define their world view. This can lead to Native students struggling to reconcile these two worldviews (Guillory & Wolverton, 2016), making it difficult to connect STEM to their cultural identities, and resulting in decreased self-efficacy and failed retention rates. The belief that western science is universal knowledge, accepted by all, is a longstanding obstacle for Native students with higher educational aspirations, especially due to the dismissive perception that undermines TK (Bressan, 2017).

2. Traditional Knowledge

TK varies at the community level by virtue that there are 573 federally recognized and 66 state recognized tribes, with each community having distinct protocols, histories, and broader community cultural practices. The idea of combining the identities and realities of individuals from unique communities into a single understanding of TK is neglectful and harmful. In fact, it is more reasonable

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to assume there will be a spectrum of beliefs, values, and perceptions of what constitutes TK. Generally, TK refers to local and/or regional knowledge embedded in cultural traditions by Native peoples, in one or more forms of collective abstracts, intuited, and diverse understanding, including, but not limited to, language, art, dance, music, names, medicines and remedies (Berkes et al., 2000; CEMA, 2015; Downes, 2000; Hoagland, 2017; Ragavan, 2001).

TK encompasses multiple disciplines from geoscience, social science, spirituality, and health into a single body of knowledge. This ideology is in stark contrast to typical STEM ideologies, where information is seemingly compartmentalized and disconnected (Berkes et al., 2000; Durie, 2004; Iaccarino, 2003; Martin, 2012). The way in which TK is practiced between communities inform lifestyles and environmentalism from a specific community context. The root difference between TK and STEM is that STEM is grounded in a western perspective, and is disconnected from the values, culture, and perspectives that inform TK. This difference makes it difficult for mainstream society to understand and value TK. When the significance of TK is understood and perceived as equal in value to western science, only then will we realize the power of coupling these two knowledge systems as an innovative tool providing powerful solutions to complex scientific problems by creating a hybridized and holistic STEM education experience (Aikenhead & Ogawa, 2007; Hoagland, 2017; Smythe et al., 2017). The coupling of these two knowledge systems is challenging, due to the difference in evaluation procedures, difference in ways of knowing, and in the understanding of what constitutes intellectual property and the required protocol of obtaining permissions to discuss and share TK. Coupling of these two knowledge systems presents great potential to create a new means for STEM research and education with an increase in diversity and innovation (Durie, 2004). Native students who have been exposed to both knowledge systems have an advantage in developing critical thinking skills with the ability to contemplate multiple knowledge systems as possessing value (Cobern & Loving, 2001). Robin Kimmerer (2002) provides a descriptive definition of TK, where he states that TK is the:

"knowledge, practice, and belief concerning the relationships of living beings to one another and to the physical environment… born of long intimacy and attentiveness to a homeland and arise wherever people are materially and spiritually with their landscape".

2.1 Literature Review

Here we distinguish between the cultural identity of Native students as numerous distinct cultures bound together and their TK systems, which represent more than a way of life or body of knowledge that cannot be fragmented into discrete ideologies (Weaver, 2001). Historically, TK has been manipulated and taken out of context to coincide with western concepts thereby misinterpreting its intended purpose and cultural meaning. Cobern and Loving (2001) contend that if TK were to be incorporated into western science, it risks being assimilated by the "dominate" science discourse, thus misconstruing the intended purpose. Menzies and Butler (2006) caution that using TK as a tool to enhance western science may result in scientists inferring that TK is less valuable and lacks the rigor of western science. This does not mean that TK and western science are incompatible but emphasizes the

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benefit of using both knowledge systems to enhance our understanding of the world through STEM education.

Barnhardt and Kawagley (2005) proposed a call to action to enhance Native students' understanding of STEM by developing a hybridized TK-STEM research and science education model. One challenge was the preservation of TK, culture, and language while providing STEM instruction. By implementing a hybridized educational model that incorporates cultural and western perspectives, Native students would be more successful in pursuing STEM disciplines than when taught from only a western perspective. Coupling TK and western science and infusing traditional ways of knowing into western pedagogy is an effective strategy to engage Native students in STEM disciplines, an area in which Native students have historically had little success compared to their non-Native counterparts (Price et al., 2008). In addition, teachers with an understanding of TK especially from the community where they teach, will allow them to have a better understanding of the worldview of their students, and thus allowing them to engage with their students on subjects such as science in an meaningful way, as they adopt a culturally relevant science pedagogy (Kawagley et al., 1998).

According to Snively and Corsiglia (2001), only 3% of students enroll in STEM programs, as they view science as "inaccessible and culturally irrelevant". Native students may find science content inaccessible if TK does not co-exist with STEM in their classrooms (Aikenhead, 2002), and students cannot engage in meaningful science learning until conflicts between what is taught and their cultural experiences are resolved (McKinley & Gan, 2014). Using a *both/and* approach in teaching rather than an *either/or* approach enables students to become fluent in multiple ways of knowing and thinking (Abrams & Hogg, 2004; Aikenhead & Jegede, 1999) better preparing them to become Native scientists and leaders. Despite the benefits, ontological differences between TK and STEM can challenge efforts to bring the two knowledge systems together (Mazzocchi, 2006), as there is a fundamental disconnect between the TK and STEM with regard to: 1) ways of knowing, 2) protocol for collecting and using TK, 3) interpretation of knowledge, and 4) the ethics of using and sharing TK (Chatterjee, 2019; Ragavan, 2001). This disconnect is often reflected in the history of the U.S. which has extracted from TK for science instruction, where few educators understand Native worldviews and its effect on student learning (Snively & Corsiglia, 2001; Kawagley et al., 1998). To this end, it has been suggested that western science may be functionally distinct from TK and these distinctions could contribute to the disconnect between Native worldviews and western science (Durie, 2004), resulting in western scientists being skeptical as to the value of TK because western science is considered objective and generalizable focusing heavily on technical skills, experimental design, and explanatory power of the data, whereas these attributes are not the focus of TK which is grounded in a particular culture (Abrams & Hogg, 2004). Despite ontological differences, these two worldviews possess similarities in that they both involve making observations and inferences about natural systems of understanding of the natural world (Hoagland, 2017; Martin, 2012).

2.2 Methods

This case study was conducted using a dual moderator focus group format, in which moderator one posed discussion questions, and moderator two recorded all responses and ensured that all discussion questions were addressed by the group. We applied the Indigenous Traditional Knowledge Framework (ITKF) guidelines when posing questions, recoding, and analyzing data. ITKF emphasizes respect, protection, and the ethical use of TK systems, by reducing environmental, social, and cultural risk associated with the development of resources, by improving relationships, and strengthening public trust in environmental decisions driven by policy. ITKF is based on the following guiding principles for TK such that; TK is an important body of knowledge providing insight of the natural environment and is unique to the communities bearing the knowledge, that it is valuable and should be considered and acknowledged alongside western science; that TK belongs to the Native community who bears the knowledge and is under the authority and control of the community; that permission is required to collect, analyze, and disseminate knowledge; and TK will be discussed in a constructive manner building an atmosphere of mutual respect between stakeholders (CEMA, 2015).

2.3 Study Structure and Focus Group Questions

This is a collective case study of two focus groups from two STEM conferences focused on Native students and scholars. The focus group A took place at Conference A, a three-day gathering of tribal mentors, college students, faculty, research centers, elders, and tribal community members. The mission of the conference was to promote participation of Native students in the applied science disciplines with the purpose of encouraging students from largely two-year institutions such as community or tribal colleges, to consider transitions to four-year institutions while build peer and mentor networks. Additionally, Conference A focused on supporting Native students on developing their identities as Native scientists. Conference B, while similar to Conference A, focused on increasing representation of Native students, scientists, and professionals in STEM disciplines. Conference B brought together Native college students, pre-college students, faculty, professionals, and industry partners working in STEM disciplines. Students who attended Conference B were primarily from 4-year universities and graduate programs with fewer tribal college students and faculty represented. Conference B provided professional development opportunities for students by providing mentors and resources for resume writing, onsite job interviews, information for academic scholarships, and providing students an opportunity to present research in a culturally aware welcoming environment.

For this study, convenience sampling was used as respondents (n=50) self-selected to participate in the focus groups as advertised at both conference programs as an opportunity to discuss their perspectives on the relationships (if any) between STEM and TK. The composition of respondents covered a broad range of professions, undergraduate through postdoc, faculty, cultural practitioners, and elders, and thus a broad age range, 18 to 64 years reported. Gender composition was skewed towards females (66%) over males (34%). The structure of the study was a series of open-ended questions designed to maximize the opportunity for respondents to discuss the questions among their peers. Questions

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discussed were: (1) How do you define STEM? (2) How do you define TK? and (3) What does coupling TK and STEM mean to you? Focus groups were divided into small groups of five to ten, to ensure that each participant had an opportunity to participate in the discussion questions and ensured respondents remained engaged.

2.4 Data Sources and Analysis

Qualitative data for this study was collected from focus group responses to a series of three discussion questions (Wilkinson, 2004). Namely, each group was provided with materials with which to record both individual and group responses as data sources (Duggleby, 2005). Data collected was used to construct an open coding schema organized into a matrix that was organized according to each question and conference (A or B). Constant comparison method (Glaser, 1965) was used to analyze the focus group responses from the matrix. The first round of coding consisted of open coding as described by Saldana (2013). Next, axial coding was used to sort data into sub-category topics within the context of each question. Finally, line-by-line coding was used to develop themes. The frequency of each theme was determined by tabulating the of responses falling within each theme (Glaser, 1978, 1992; Glaser & Strauss, 1967; Strauss, 1987).

3. Results and Discussion

Through our coding schema, we developed a matrix to address the manner in which focus groups made sense of discussion questions (Onwuegbuzie et al., 2009). The first discussion question examined how respondents defined science (Table 1). Responses to question one (*How do you define science?*) were provided by 82% of respondents. These respondents described science using both traditional disciplines (e.g., biology, geology, chemistry, etc.) in addition to disciplines and concepts not typically considered when describing science, such as social justice, equity, social science, politics, and cultural identity, resulting in a more holistic definition of science (Barnhardt & Kawagley, 2005; Hart, 2010).

Responses demonstrate the importance of community cultural practices and knowledges to defining STEM. Focus group respondents from Conference B appeared to utilize expected discipline specific (e.g., biology, geology, etc.) terms to describe STEM. A number of respondents from both conferences described STEM through social science disciplines (e.g., sociology, public health, political science and education), discussing STEM through the lens of social justice and equity. Respondents from Conference B interpreted question one through the lens of STEM work impacting tribal sovereignty in positive ways. Additionally, responses from Conference B also included coupling of TK with STEM. This illustrates that a subset of respondents viewed a relationship between TK and STEM knowledge systems. The responses to define what science is and/or means display interdisciplinary notions across science and social science.

Table 1. Categories and Definitions of STEM Illustrating Themes Present in the Data and the Frequency of the Cited Themes across Conferences A and B

Question #1—What does STEM mean to you?		A	B
Category	*Definition*		
STEM Disciplines	Refers to STEM being defined as different STEM disciplines	14	27
Social Science Disciplines	Refers to social sciences	7	7
Social Justice/Equity	Refers to social justice activist issues and actions related to Native American/Alaska Native communities' wellbeing, capacity building, and positive outcomes	3	6
Tribal Politics, Governance, Policy	Refers to tribal sovereignty, exercising tribal sovereignty or the impacts of external policy on tribal communities	0	3
Native American/Alaska Native Cultural Identities and Practices.	Refers to the Native American/Alaska Native histories, beliefs, practices, customs, values, and knowledges	0	5

Responses to question two (*How do you define TK?*) were provided by 82% of respondents, in which a majority of respondents from both conferences (A and B) discussed a definition of TK as related to practices, beliefs, histories, customs and values of their community, as it relates to individual identity (Table 2). There were a number of respondents from conference B that discussed knowledge sharing as important to defining TK. It is somewhat unexpected that the concept of sharing knowledges outside of the community would be part of this defining (Brush, 1993; Coombe, 1998; Iseke-Barnes, 2006). Responses from Conference A did not discuss sharing TK across communities, with only one participant discussing sharing knowledge. This difference in the opinion of exchange of and assimilation of TK with STEM may be attributed to life experiences and alterations in worldview of participants from each conference. Keeping in mind that respondents from conference A were from 2-year tribal colleges, cultural practitioners, and tribal members and likely to have had limited experiences in mainstream culture, relative to respondents from Conference B who were from 4-year university, postdoctoral researchers, faculty, and STEM professionals who spend more time in mainstream culture. The other significant theme that emerged from question two was the role of collaboration to couple TK with STEM education. The desire to couple TK with STEM was present across both conferences. Conference B respondents are trying to reconcile their two worldviews into a coupled knowledge system that allows them to utilize two distinctive and equally important knowledge systems.

Table 2. Definitions of TK Outlines the Different Ways Focus Group Respondents Thought about How to Define TK and the Frequency of the Cited Themes across Conferences A and B

Question #2—What does TK mean to you?		A	B
Category	*Definition*		
Cultural Identities and Identity Practices	Refers to the Native American/Alaska Native histories, beliefs, practices, customs, values, and knowledge that contribute to individual identity.	19	22
Community Knowledge Sharing	Refers to the practice of sharing Native American/Alaska Native cultures, beliefs, knowledges, etc. with another group and/or community.	1	19
Efforts and/or Perspectives to Bridge TK with STEM	Collaborations, meetings, workshops, classes, curriculum to couple TK with STEM.	6	10

Finally, responses to question three (*What does coupling TK and science mean to you?*) were provided by 44% of respondents (Table 3). The significant decline in response was notable and suggests a variety of reasons as to why respondents chose not to respond. Respondents may not have been comfortable coupling knowledge systems due to fear of knowledge being misinterpreted, theft of intellectual property, or loss or engulfment of knowledge to mainstream ideologies, or respondents simply never considered coupling TK and STEM knowledge systems and may have needed more time to consider the question (Barnhardt & Kawagley, 2005; Brush, 1993; Cobern & Loving, 2001; Coombe, 1998; Iseke-Barnes, 2006; Menzies & Butler, 2006). However, of those who did respond, we noted positive views on the importance of coupling TK and STEM knowledge systems in which respondents viewed TK as equal to STEM, without the typically imposed hierarchy. However, there were notable differences between Conference A and B between the number of respondents highlighting this theme, again this may be due to life experience and alterations in worldview. A second major theme identified was in the desire for youth to reclaim TK to support their identity and leadership in STEM disciplines, and respondents discussed the importance of sharing TK with others, as found from question two.

Table 3. Views on Coupling TK and STEM Outlines the Themes and the Frequency of the Cited Themes across Conferences A and B

Question #3—What does coupling TK and STEM mean to you?		A	B
Category	*Definition*		
View TK as Equal to STEM	Refers to (1) recognizing the benefits of bringing the two knowledge systems together; (2) viewing TK as a valid and valuable knowledge system in the same way as STEM	6	14
Collective Understanding and/or Communication	Refers to communicating and sharing knowledge with others	3	4
Becoming a Change Agent	Refers to power structures at play, or desire to reclaim power to ignite change. How respondents view themselves as taking a stand, sharing their ability to be change agents, how to claim and maintain TK power statements. Self-identity and leadership. Surviving standing in two worlds	16	7

Analysis of focus group responses revealed several findings and themes around the perceived interdisciplinary potential of geosciences education, the potential impact of western science on Native communities, and the need to share knowledge across cultural groups and communities to support the betterment of education for all. Themes represented here highlight the interconnected nature of STEM identities to cultural identities. Respondents highlighted the differences in worldviews seen between these two cultures, where TK was described as observations of the natural world and learning how to adapt for survival, and where STEM was described as a field that was an addition to what was already known by elders in the community. The acknowledgment that TK and STEM are relevant knowledge systems and necessary to survive was a theme that repeatedly emerged.

Respondents from both conferences (A and B) stated that they felt their TK was marginalized in academia and agreed that coupling of these two knowledge systems would be positive for Native students, with the idea that integration would result in increased pre-college graduation rates, and an increase in post-secondary degree completion in STEM disciplines (Dee & Penner, 2017). Brayboy and Castagno (2009) have shown how a culturally responsive education model is successful in improving student self-efficacy, as "culturally responsive education recognizes, respects, and uses students' identities and backgrounds as meaningful sources for creating optimal learning environments". When the importance of TK is understood and weighted as possessing value, STEM education can create a learning community that is supportive of Native students and valuing of two knowledge systems which are truly innovative, problem solvers capable of providing powerful solutions to complex scientific problems through the creation of a hybridized and holistic STEM education experience (Hoagland, 2017; Smythe et al., 2017).

4. Conclusion

This study conducted with two focus groups (n=50) at two national research conferences focused on supporting Native student success in geosciences fields. Our study examined how respondents defined science and TK, and the potential of coupling TK with geoscience research and education. We found that respondents across the two conferences defined science through traditional science disciplines (e.g., biology, geology, etc.) but also through nontraditional disciplines such as social science. Definitions of science also included strong social justice, equity, and community-centered themes. In regard to definitions of TK, respondents focused on concepts of knowledge sharing across culture and communities, cultural identity, and sense of belonging with in geoscience. There was a strong desire expressed to couple TK and western science knowledge systems to foster the betterment of tribal communities and NA/AN students. Finding of this focus group study presents us with a snapshot of perspectives of NA/AN students, mentors, and geoscience professionals. While this is a small study which cannot be broadly generalized, the findings are valuable and suggest a need for additional research. For example, the differences identified between the responses from participants at the two conferences related to sharing TK across communities indicate a need to further explore this areas. In particular, it will be important to explore how the life experiences of these different respondents contribute to their views on sharing TK across communities.

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