1-1-2017

Convergence of Indigenous Science and Western Science Impacts Student's Interest in STEM and Identity as a Scientist

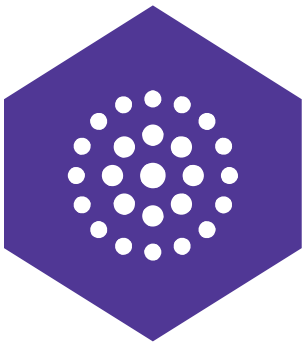
Sarah Omar Alkholy
Umm al-Qura University

Fidji Gendron
First Nations University of Canada, fgendron@fnuniv.ca

Betty McKenna
First Nations University of Canada

Tanya Dahms
University of Regina

Maria Pontes Ferreira
Wayne State University, ferreira@rowan.edu



VOLUME 10 ISSUE 1

Ubiquitous Learning

An International Journal

Convergence of Indigenous Science and Western Science Impacts Students' Interest in STEM and Identity as a Scientist

SARAH OMAR ALKHOLY, FIDJI GENDRON, BETTY MCKENNA, TANYA DAHMS, AND MARIA PONTES FERREIRA

COMMON GROUND

TECHANDSOC.COM

UBIQUITOUS LEARNING:
AN INTERNATIONAL JOURNAL
http://ubi-learn.com
ISSN: 1835-9795 (Print)
http://doi.org/10.18848/1835-9795/CGP (Journal)

First published by Common Ground Research Networks in 2017
University of Illinois Research Park
2001 South First Street, Suite 202
Champaign, IL 61820 USA
Ph: +1-217-328-0405
http://cgnetworks.org

Ubiquitous Learning: An International Journal
is a peer-reviewed, scholarly journal.

Common Ground Research Networks, a member of Crossref

Convergence of Indigenous Science and Western Science Impacts Students' Interest in STEM and Identity as a Scientist

Sarah Omar Alkholy, Umm al-Qura University, KSA
Fidji Gendron, First Nations University of Canada, Canada
Betty McKenna, First Nations University of Canada, Canada
Tanya Dahms, University of Regina, Canada
Maria Pontes Ferreira, Wayne State University, USA

Abstract: Within the context of North American Indigenous culture, certain Elders are respected gatekeepers to Indigenous science, also known as traditional knowledge. Yet, while North American born minorities such as Black Americans, Amerindians, and Latin Americans may hail from cultures with a similar appreciation of their own Indigenous science Elders, these minority groups are especially underrepresented in Western science, technology, engineering, and math (STEM)—both in academia and in the workforce. North American underrepresented minorities experience high attrition rates in academia generally, and in STEM specifically. Canada's Truth and Reconciliation Commission makes a call to action to Indigenize education to benefit all students. Herein lies an opportunity to investigate the impact of Indigenization of a Western science biochemistry course to assess the impact upon university students, both minority (non-White) and non-minority (White) in Anglophone North America (Canada and USA). The aim of the study is to investigate the impact of an Indigenized Western science online course upon student interest in STEM, student perception of the relevance of Elder co-instructors, and student identity as a scientist. A pedagogical quasi-experiment was conducted at North American tribal colleges and mainstream research-intensive universities, regarding an online science course taught either with or without Elder co-educators alongside PhD STEM-trained instructors. Student perceptions of the value of Elder co-educators did not differ across groups and remained unchanged after course delivery. Findings also show that after taking the course co-taught by Indigenous science Elder co-educators, students have significantly greater interest in STEM than those students not exposed to Elders' teachings. Non-White students reported significantly less self-identification as a scientist than did White students at pre-course, but reported similar identity as a scientist to White students post-course. We attribute these findings to the impact of culturally competent course content to minority students especially. This work establishes the relevance of using online technology to Indigenize a Western science course taught internationally, and suggests the need for more investigative work toward the convergence of Indigenous science and Western science in academia.

Keywords: Indigenous Science, Science Education, STEM, Online Pedagogy, Truth and Reconciliation Commission

Introduction

Aboriginal Elders are the wisdom-keepers of Indigenous science, also known as traditional knowledge (Ferreira, McKenna, and Gendron 2014), while PhD trained scientists are the gate-keepers of Western science, or science, technology, engineering, and mathematics (STEM), in North America. However, both may be key to attraction and retention of the next generation of scientists in STEM. While minorities are the most rapidly growing segment of the Anglophone North American (United States and Canada) populations today, they remain underrepresented in STEM. In the United States (USA) in 2010, minorities (Asian, Black, Latin, or Native American) (Humes, Jones, and Ramirez 2011) comprise approximately 30 percent of the population (Committee on Underrepresented Groups 2011), with rapid growth of the Native population by 39 percent since 2000 (Norris, Vines, and Hoeffel 2012). In Canada, the Aboriginal population in 2011 represented 4.3 percent of the total Canadian population (National Household Survey 2013).

Self-identification for indigenous people is important, and in the USA, the term Native American refers to Alaska Natives, Native Hawaiians, and American Indians, while in Canada,

Ubiquitous Learning: An International Journal
Volume 10, Issue 1, 2017, www.ubi-learn.com
 ISSN: 1835-9795 (Print)

COMMON GROUND

the term Aboriginal refers to the First Nations, Inuit, and Métis peoples. Native/Aboriginal will be used in this paper to describe indigenous North Americans (regardless of race), and Elder will be used to describe indigenous Elders who are respected authorities of traditional knowledge in their respective communities. Furthermore, in this paper, self-identification as Native American/Aboriginal or Hispanic/Latino refers to ethnicity regardless of race; whereas self-identification by race only (e.g., White, Asian, etc.) implies non-indigenous/non-Hispanic identity.

The demand for North American STEM professionals has been rising steadily; between 1995 and 2007, the STEM workforce increased by 36 percent in the US (Guterl 2014). While Whites and Asians are well represented in STEM, Black-, Latin-, and Native Americans are underrepresented minorities in STEM, and Native Americans are the least represented (Guterl 2014). Between the years 2002 and 2012, only 0.6 to 0.7 percent of bachelor degrees in science and engineering were attained by US Native students (Fiegener 2015). In Canada in 2006, 33 percent of Aboriginal adults aged twenty-five to fifty-four years had less than a high school education compared to only 13 percent of the non-Aboriginal population (Statistics Canada 2010).

Every culture has its own science (Ogawa 1995; Snively and Corsiglia 2001). Ogawa defines Indigenous science as "a culture-dependent collective rational perceiving of reality," where "collective" means held in sufficiently similar form by many persons to allow effective communication, but independent of any particular mind or set of minds (Ogawa 1995, 588). Indigenous science interprets how the local world works through a cultural lens (Snively and Corsiglia 2001). Indigenous science comprises the processes of knowledge acquisition that result from human experience in the natural world (Cajete 2000). It can be transmitted from generation to generation, especially orally, through daily social and cultural events (Ogawa 1995). Knowledge is passed from the giver to the receiver when there is a relationship between the two (Hatcher et al. 2009). A significant factor explaining the low retention of Native/Aboriginal students in STEM majors in North America is the apparent conflict between Western science and traditional knowledge (Tierney 1991), also known as Indigenous science (Snively and Corsiglia 2001). Native/Aboriginal students contend that much of STEM appears incompatible with their cultural ways of knowing and that their participation will lead to the loss of traditional values (Bissell 2004). This perception contributes to diminished involvement in Western science-related fields (Aikenhead 2006). The culture of Western science, which is science shared and authorized by the scientific community and treats the theoretical world, can create a chilly environment for Indigenous science (Ogawa 1995). Yet, it has been shown that the inclusion of cultural aspects in STEM courses can provide strong support for Native/Aboriginal students toward science self-efficacy and identity as (Western) scientists (Chemers et al. 2011).

A ten-year project at Cape Breton University demonstrates the successful delivery of courses integrating Indigenous and Western science to students in Canada (Hatcher et al. 2009). In this project, it was found that while Western science scrutinizes objects, Indigenous approaches focus upon subjects, and learning activities containing a cultural component develops student connection to nature rather than a separation from it (Hatcher et al. 2009). Thus, the integration of Indigenous values into STEM curricula facilitates a comprehensive cross-cultural, as well as multi-disciplinary approach, and highlights the multi-directional features of the different sciences (Hatcher et al. 2009). Science curricula linking science to culturally-relevant community work as citizen scientists has also been shown to increase Native/Aboriginal student success in STEM courses, which is attributed to their desire to contribute to their communities (Smith et al. 2014).

The concept of Aboriginal Elders as co-educators in Hatcher and colleagues' project plays a major role in the convergence between Indigenous (non-STEM) and Western (STEM) sciences. Elders can teach Indigenous science to all students (Native/Aboriginal or non-Native/Aboriginal) who pursue a Western education (Hatcher et al. 2009). Canada's Truth and Reconciliation Committee calls to action report (2015) includes specific points relevant to education including:

developing culturally appropriate curricula; recognizing the value of Aboriginal knowledge practices and Aboriginal/Indigenous Elders; understanding the United Nations Declaration on the Rights of Indigenous Peoples; building student capacity for intercultural understanding, empathy, and mutual respect; and utilizing Indigenous knowledge and teaching methods in classrooms. Indigenization of Western science education facilitates acknowledgement of the value of Indigenous science in the post-secondary environment generally, and in STEM specifically. Recent studies find that Native/Aboriginal students learn information about natural health products, such as medicinal plants, from traditional Elders and healers significantly more so than do non-Native/Aboriginal students (Alkholy et al. 2013; Craft et al. 2015). This research demonstrates the importance of Elders as a source of science-related information for Native/Aboriginal students, especially. In many indigenous communities, certain Elders are trusted Indigenous science practitioners, and when present in the post-secondary science education arena, they may play an important role as educators for students (Michell 2011). Thus, respected traditional knowledge keepers can bridge Indigenous science and STEM, and fill the cultural gap between non-Western and Western science (Bang and Medin 2010; Michell 2011). Current trends in education demonstrate the value of online education; this is especially true for minority students who are underrepresented in online programs and courses (Haynie 2014). Therefore, it will be increasingly important to respond to Canada's Truth and Reconciliation Commission call to action and thus Indigenize live and online course content to benefit all students, and to conduct research upon such pedagogy. The aim of the current research is to assess the impact of Aboriginal Elders and Indigenous science on students in an online health science course taught concurrently in the USA and Canada.

The current research builds upon a pilot study in which regional (USA vs. Canada) differences were examined among post-secondary students in an online health science course regarding perceptions of traditional Elders as STEM co-educators; interest in STEM; and self-identity as a scientist (Alkholy et al. 2015). However, the statistical power was low due to the limited sample size (n=11) in the published pilot study. No statistically significant results were reported, but some trends emerged. For example, Canadian students showed a stronger trend to believe that traditional Elders are appropriate as post-secondary science co-educators as compared to US students.

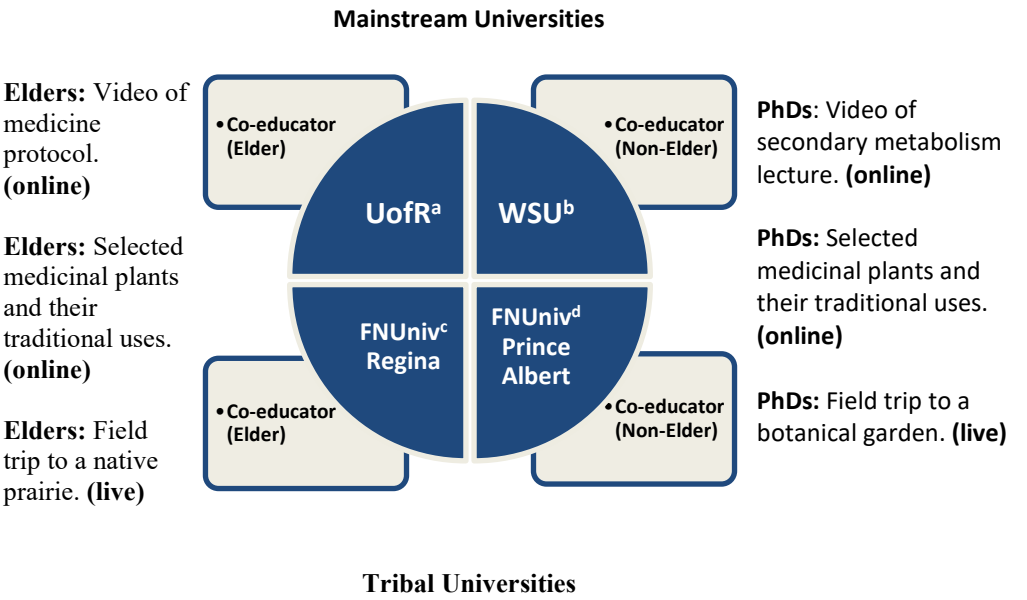
In the current pedagogical study reported here, the specific aim was to determine the impact of traditional Elder co-educators upon a larger sample of students taking an online science course at tribal and mainstream universities concurrently in the USA and Canada, in a quasi-experimental design. The impact of the intervention (Elders) upon the following variables was examined (across race and ethnicity but not gender): student perceptions of the role of Elders as Indigenous science educators; student interest in STEM; student self-identity as a scientist; and student learning outcomes. Therefore, this study explores the merit of Indigenization of a Western science online course for minority and non-minority students, across these dependent variables.

Methods

Study Design

A pedagogical quasi-experiment of 2 X 2 factorial design was conducted in the spring semester of 2014. A hybrid course entitled "Evidence-Based Ethnomedicine: Medicinal Plants and Culture" was offered at four universities (Figure 1). Two were tribal colleges and universities (TCUs): First Nations University of Canada (FNUniv), Regina, SK, Canada and FNUniv–Other, Prince Albert, SK, Canada. Two were mainstream research universities: University of Regina (UofR), Regina, SK, Canada and Wayne State University (WSU), Detroit, Michigan, USA. In the experimental group of institutions, non-PhD Indigenous Elders (Intervention) co-taught the

students live and online (e.g., medicine room workshop, prairie medicine walk, and presentation videos) at the UofR and FNUniv, Regina. In the control group of institutions, PhD-trained non-elders (Control) co-taught the students live and online (e.g., botanical garden tour, online lectures) at WSU and FNUniv–Other, Prince Albert. The *online* portion of the hybrid course taught at all participating institutions was otherwise the same in content and taught by the same three course instructors. Each instructor was specialized in a different discipline (Biology, Nutrition/Kinesiology, and Biochemistry) and provided a multi-ethnic perspective to course topics (e.g., western and/or colonist, indigenous, global perspectives). Elders (Intervention) or the PhD-trained non-elders (Control) were co-educators to the *hybrid and online* portions of the Ethnomedicine online course which was taught concurrently at all participating institutions. A mixed methods approach was adopted and in-depth interviews of participants were conducted to provide qualitative data. Those qualitative methods and data are not reported here but will be described in a future paper.



[a] University of Regina
[b] Wayne State University
[c] First Nations University of Canada, Regina
[d] First Nations University of Canada, Prince Albert

Figure 1: Study design diagram.

Participants

A total of twenty-eight students participated in the study: students from WSU (n=11), UofR (n=11), FNUniv–Regina (n=6), and from FNUniv–Other (n=0). Participating students (18 years or older) accessed the survey via SurveyMonkey. The project was approved by the UofR Research Ethics Board (FNUniv partnership with the UofR) and WSU Institutional Review Board.

The original goal was to determine the efficacy of Elders co-teaching a post-secondary STEM course to encompass Native/Aboriginal ethnic values, with a specific focus on effects upon Native/Aboriginal versus non-Native students. However, due to the small number of participants in the study, low number of students from FNUniv–Regina (n=6), and lack of students from FNUniv-other (n=0), we divided the institutions according to intervention (No Elders; USA versus Elders; Canada). The control "No Elders" institutions were WSU and FNUniv-Other (taught with non-Elder co-educators) and the intervention "Elders" institutions were the Regina, SK universities (UofR and FNUniv-Regina; taught with Elders co-educators). The pilot study indicates that the online science course (alone) delivered concurrently to these institutions is not associated with different outcomes (Alkholy et al. 2015). The pooled students were then grouped according to race and ethnicity, with White students (non-Native/Aboriginal; n=15) and non-White students (e.g., Native/Aboriginal (regardless of race), Black, Asian, and others; n=13).

Analyses were conducted to assess *a posteriori* hypotheses regarding intervention differences USA ("No Elders") versus Canada ("Elders") and racial/ethnic (White versus non-White) differences in post-secondary student learning outcomes as well as perceptions regarding these variables: role of traditional Elders as STEM co-educators, interest in STEM, and learners self-identifying as scientists.

Study Instrument

Pre- and post-course surveys were administered to participating students to assess student perceptions regarding: merit of traditional Elders as co-educators, interest in STEM, and self-identity as a scientist (Chemers et al. 2011). The survey contained five parts. The first part asked respondents about demographics (e.g., race/ethnicity, age, grade level, gender). For the demographics, students had the choice between "White," "Black," "First Nations/Métis/Inuit" or "American Indian/Alaska Native/Native Hawaiian," "Asian," "Hispanic or Latino," "other Pacific Islander," or "Other." In this study, White designates students who chose "White" on the survey and non-White designates those who chose any other options (e.g., Native/Aboriginal (regardless of race), Black, Asian, Hispanic/Latino (regardless of race), other Pacific Islander, or Other). The second section questioned students' perception of Elders' role in post-secondary STEM education. The third section surveyed participants about their interest in STEM fields and careers. The fourth section addressed participants' self-identification as scientists and the fifth section questioned their commitment to a science career (Chemers et al. 2011). Survey questions followed a 1- to 7-point Likert scale, modified from Chemers 5-point scale, for statistical analysis purposes. This online survey was administered to the students during the first week of the course, and the same online survey was administered via SurveyMonkey at the final week of the course. Learning outcomes were measured by weekly research quizzes, each with five multiple-choice questions based upon the topic of the week. These weekly research quizzes covered course content but did not contribute to students' final marks; rather, they comprised research data for "outcome measures." Course professors were not involved in data collection (e.g., survey and quizzes), which were collected and analyzed by a research assistant.

Technology

The hybrid Ethnomedicine classes, blending Indigenous science and Western science in a 200 level Biochemistry course, was taught concurrently in the USA and Canada in an asynchronous fashion during the seven-week-long spring semester. The online course was delivered to the USA participants on the Blackboard Learning Management System platform. In Canada, this same online course was delivered to the Canadian participants on the Moodle Learning Management System platform. This was in keeping with the technology platforms currently in use at the respective institutions, and use of the different delivery platforms did not contribute to any

differences in course content. The only differences in online course content were those specifically implemented in keeping with the study design (e.g., interventions or controls).

Statistical Analysis

ANOVA and ANCOVA models were used to provide a statistical analysis of significant difference in means for several groups and a student's *t*-test was used to determine if two sets of data were significantly different. The alpha level was set to less than or equal 0.05 to indicate statistical significance, and SPSS 21 software was used to analyze the data. Power analysis for this study determined 80 percent power with medium effect to calculate and estimate the total sample size (*N*) and number estimated in each group (n) in four groups (K) (*d*= .50, f = .25, and 80% power), (n=45) subjects per group for (K=4) groups (N=180 subjects total).

Results

Pooled Student Perception Pre- and Post-course

Pooled student responses did not show any significant differences indicating identical average perceptions (pre- and post-course) of students regarding: Elder co-educators, interest in STEM, and identity as scientists (Figure 2).

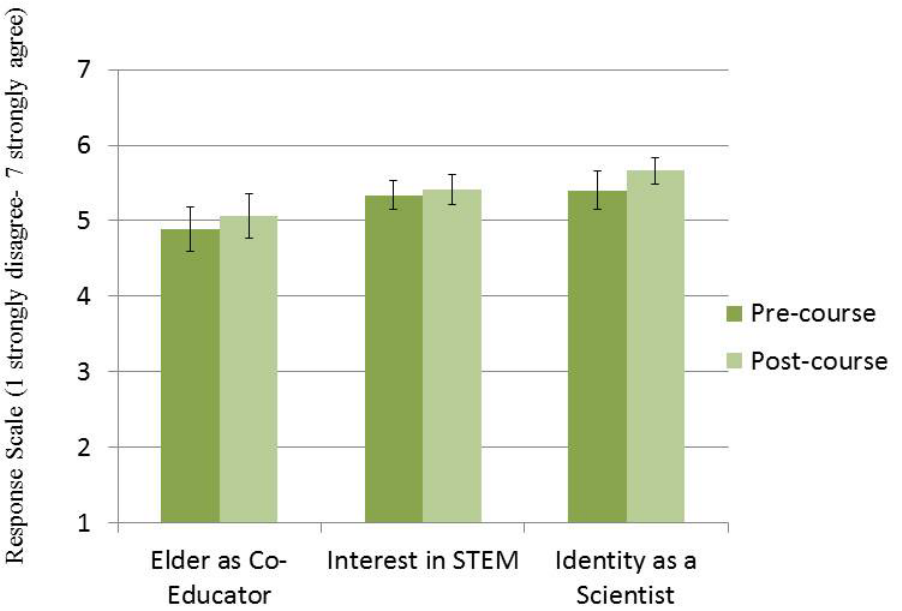


Figure 2: Pooled student perception differences: student perceptions regarding Elder co-educators, STEM interest, and self-identity as a scientist.

Intervention Differences Pre- and Post-course Survey

Figure 3 shows intervention differences between No Elders (USA) (n=11) and Elders (Canada) (n=17) pre-course (A) and post-course (B). We noted no significant differences between pre- and post-course opinions of participants in the context of "Elder as a co-educator" or "self-identity as a scientist." There was no statistically significant variation in STEM interest between students

taught an online STEM course without Elder co-educators (USA) or with Elder co-educators (Canada) pre-course. However, post-course students who were exposed to Indigenous science co-educators (Elders, Canada) reported significantly greater (p=0.021) interest in STEM than students lacking such exposure.

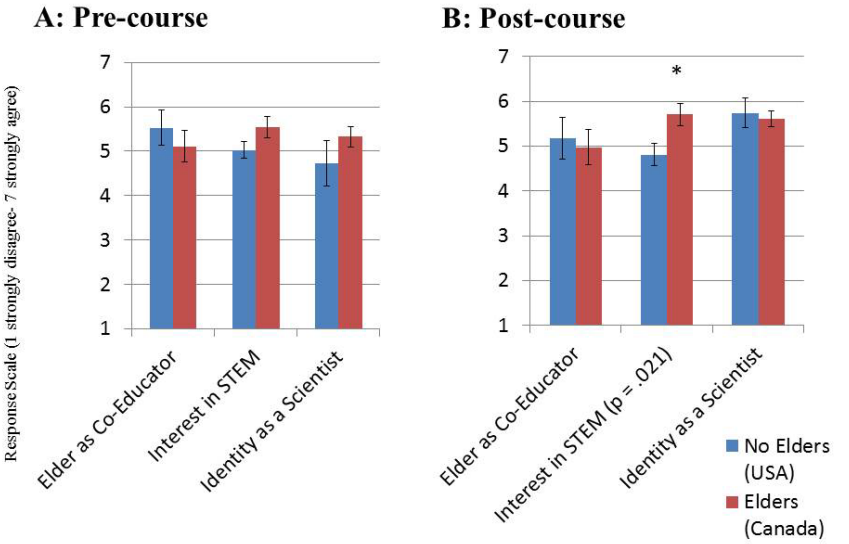


Figure 3. Intervention differences: student perceptions regarding Elder co-educators, STEM interest, and self-identity as a scientist without Elders (USA) and with Elders (Canada). *p < 0.05

Racial/Ethnic Differences Pre- and Post-course Survey

Figure 4 shows pooled US and Canadian participants in regards to racial/ethnic differences, designated White and non-White students, with no significant differences pre- (A) and post- (B) course in STEM interest and their opinion on the merit of Elders as co-educators. Examining how students identify themselves as scientists, we note a statistically significant difference between White and non-White students in the pre-class survey (p=0.016). White students initially identified more strongly as scientists, but after taking the online Ethnomedicine course blending Indigenous and Western science, regardless of exposure to Elder co-educators, both student pools reported similar self-identity as a scientist, since more non-White students agreed with this affirmation after the course than before the course.

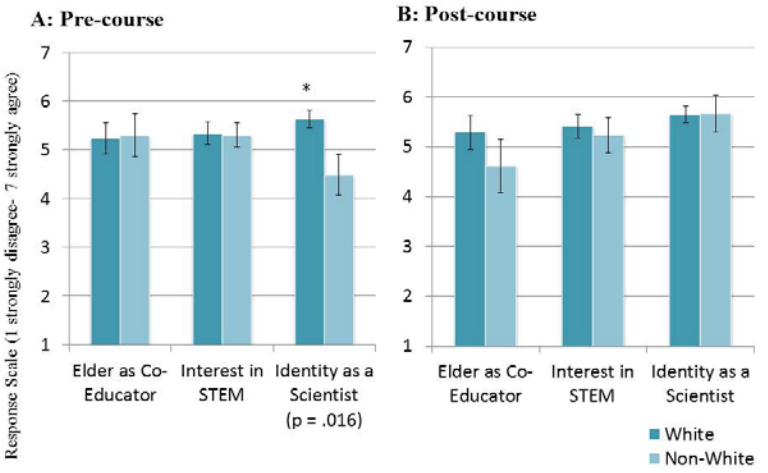


Figure 4. Racial/Ethnic differences: pooled student perceptions regarding Elder co-educators, STEM interest, and self-identity as a scientist for White and non-White students. *p < 0.05

Learning Outcomes

Figure 5 shows learning outcomes (quiz results) as a function of average weekly quiz scores, with no significant differences between students regarding (A) exposure to Elder knowledge (intervention differences) or (B) their ethnicities (racial/ethnic differences).

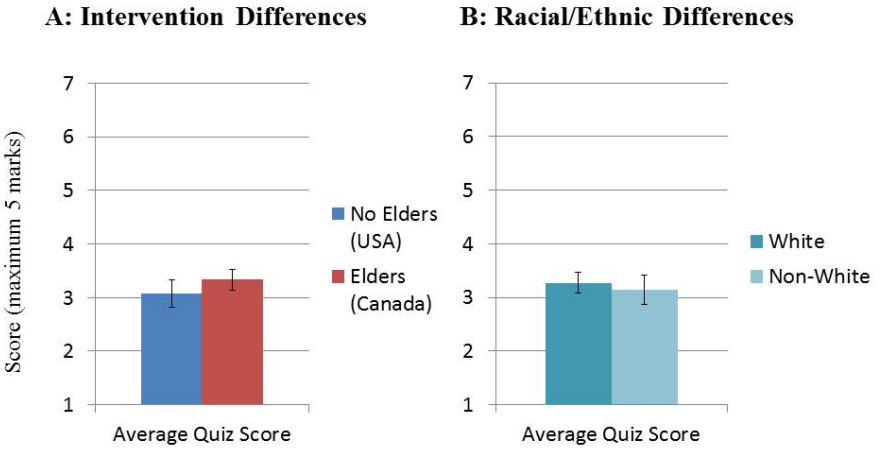


Figure 5: Average quiz scores as a function of intervention differences (without Elders in the United States and with Elders in Canada) and racial/ethnic differences (White and non-White students).

Discussion

The findings of the pilot study (a longitudinal pilot study conducted one year prior to this quasi-experimental study) plausibly established that when the same online health science course without intervention is delivered concurrently to students in the USA and Canada, there are no

statistical differences across countries for the dependent variables measured (Alkholy et al. 2015). Building upon this, we introduced an intervention (Elders or Control) to the same online course delivered concurrently in the USA and Canada. The findings of this current quasi-experiment (same online course and same institutions as the pilot, delivered now with intervention or control) show significant association between the presence of Indigenous science educators and post-secondary science students' interest in science. Upon completion of the hybrid Ethnomedicine course with Indigenous science Elders as co-educators (Canada), students report considerably greater interest in STEM than those without (USA), affirming the important role Indigenous science Elders can play toward improving interest in STEM, regardless of student ethnicity. Minority or non-White students reported significantly less self-identification as scientists than White students before taking the blended Indigenous and Western science class, but then report a similar self-identification afterwards, regardless of exposure to Elders in both cases. This finding is interpreted to represent a positive association between the Indigenization of the Ethnomedicine health science course and minority student identity as a scientist.

Our findings support the work of Bang and Medin (Bang and Medin 2010) on community-based summer science programs designed to support students through multiple ways of knowing, including teachings delivered by Elders and mainstream educators. After taking a culturally competent program, students stated that they learn science from conventional sources (e.g., textbooks and school teachers) and from Elders; whereas before the program they indicated that they learn science only from conventional sources. Thus, science learning environments that are designed to be supportive of cultured meanings of science benefit minority students (Bang and Medin 2010).

While we show the positive impact of Elders upon all students' interest in STEM, we also demonstrate that the convergence of Indigenous science and Western science in an online STEM course can have a positive impact upon minority students' identity as a scientist, irrespective of the presence of Elder co-educators. However, despite our efforts to vastly improve participation rates since the pilot study, there was only a marginal improvement and few Native/Aboriginal participants (n=6). The latter precluded statistical analysis of the course impact specifically upon Native/Aboriginal students. Consider this an urgent call for greater participation both by Tribal Colleges and Universities and participation of Native/Aboriginal students in such studies in the future, for full representation and impact on studies that hope to promote Indigenization in online courses. Greater participation by Native/Aboriginal students in such future research is needed, to improve the generalizability of research findings to this group in particular.

These findings support the notion of exposing post-secondary STEM students to Indigenous science, which could either be direct, with the presence of Indigenous science Elder co-educators, or indirect, through course design incorporating mindfulness of science culture(s) (Ferreira, McKenna, and Gendron 2014; Lederman 2007). Empowerment theory espoused by renowned educator Paulo Freire posits that student centered pedagogy increases critical thinking by equalizing all voices and increasing exposure to multiple points of view to recreate knowledge (Freire 1970). Competency in "science culture" entails acknowledgement that science is a human endeavor, thus science is a cultural construct and therefore, Indigenous science and Western science are both science. We define science as the human endeavor to systematically explore and explain the natural world, through inquiry and pedagogy. Since certain Elders are the gatekeepers to Indigenous science, they can act as Indigenous scientists to all students. Thus, we encourage all science students to be exposed to Traditional knowledge/Indigenous science and engage in a dialogue regarding the accepted definition of "science."

Increasing numbers of mainstream and tribal colleges and universities utilize Elders' services as educators and co-educators in their courses (Hatcher et al. 2009; Michell 2011). This practice has been successfully implemented with Native/Aboriginal students, and demonstrates the importance of Elders as a source of science knowledge for these students (Aikenhead 2001; Bang and Medin 2010; Michell 2011). Elders play myriad roles at the interface of Indigenous

and Western science such as: course curriculum design, teaching, and research. Elders can bring traditional knowledge to the classroom and set it on equal footing with Western science. This has a several-fold impact: 1) it clarifies the need for operational definitions of "science," 2) it creates a more inviting classroom experience for minorities because it gives students culturally relevant scientific role-models and course content, and 3) it provides validation of Indigenous science/traditional knowledge. Above all, the presence of these respected professionals in the post-secondary education environment adds an invaluable sense of community and overall integrity to Native/Aboriginal students, and provides benefits to all students as we show. A less colonized, more Indigenized curriculum enriches science education and allows students to explore another human view of the natural world, whether they are Native/Aboriginal students or not (Battiste 2004). At the 2014 American Association for the Advancement of Science presidential address, the convergence of scientific fields was described as an important means to achieve advancements in discovery and innovation with both social and scientific value (Sharp 2014). It would be desirable to thus have students braid both sciences together using the strengths of Western and Indigenous science for such advancements (Hatcher et al 2009). However, recognizing the value of exchange at the interface of Indigenous and Western science remains a challenge, underscoring the need for more research, both quantitative (Alkholy et al 2015) and qualitative (Bang and Medin 2010).

Study Limitations

This study has several shortcomings, which should be noted. First, the study could be criticized for not adequately addressing the anticipated low participation rates, given the pilot study participation. While the researchers used mixed methods (qualitative interviews of study participants conducted) the qualitative data will be analyzed in a future study and reported in an upcoming paper. Next, the Chemers' instrument was modified from the original 5-point Likert scale (to a 7-point). This makes it more difficult to compare our findings to studies that used the original instrument by Chemers. Next, the authors attempted to decolonize a Western STEM course by Indigenizing it. For example, Elders provided guided medicine walks to discuss native plants of the prairies. Novel filming of Elders and the inclusion of such produced videos (e.g., Elders discuss protocols for medicinal plant collection and usage) provided online accessibility for university students to North American Indigenous science. Students were then engaged in online forum discussions upon viewing the videos. Exam questions assessed student knowledge of both Indigenous science and Western science for plants covered in the course. Reports written by students on native plants described not only plant biology and bioactive components but also their traditional uses. However, such efforts at Indigenization of a primarily Western science course can only be a work in progress at best, likely never meeting a shifting standard of what "Indigenization" should entail. Similarly, the social constructs of race, ethnicity, and "science" are a moving target, but must have clear operational definitions in this convergent field of study. Finally, the merging of students at North American universities from two different countries appears to be a bold *a posteriori* analytic move to salvage a quantitative study plagued by low power. The pilot study demonstrated that the online course offered concurrently at all four institutions (across the two countries) did not yield different results across the studied dependent variables. The USA and Canada are more similar than dissimilar, in regards to Northern American post-secondary educational systems and Northern American indigenous populations, as compared to systems and populations in Africa, Asia, or Latin America, for example. Therefore, despite these shortcomings, the authors are confident the findings of the study merit being shared with scholars across disciplines to catalyze a discussion regarding the Indigenization of science and science education in both the online and live environment.

Conclusion and Implications for Future Directions

These findings demonstrate that student perceptions of the value of Aboriginal Elder co-educators did not differ across racial categories and time points (pre- and post-course). Further, a post-secondary online Western science course taught with Elder co-educators is associated with an increase in North American university students' interest in STEM and the blending of Indigenous science and Western science is associated with modification of minority students' self-identity as a scientist. While White students identified more as a scientist at the beginning of the international online course (as compared to non-White), upon completion of the course, there was no difference between White and non-White students' identity as a scientist. These findings suggest that there is value in exposing post-secondary STEM students to Indigenous science through culturally competent course design and content delivered by Indigenous science educators alongside STEM trained PhDs promulgating Indigenous science in a primarily Western science course. Thus, we demonstrate the positive impact that Elders may have upon university students' interest in STEM and the potential impact of exposure to Indigenous science upon minority students' identity as a scientist. Future directions for inquiry should include an exploration of the myriad ways that Elders may contribute to science curriculum design, pedagogy, and science education research in the online environment. Indigenization of science education is a call to action.

REFERENCES

Aikenhead, Glen. 2001. "Integrating Western and Aboriginal Sciences: Cross-Cultural Science Teaching." *Research in Science Education* 31: 337–55.

———. 2006. *Science Education for Everyday Life: Evidence-Based Practice*. New York: Althouse Press.

Alkholy, Sarah O., Samiah N. Alqahtani, Audrey Cochrane, Maria Pontes Ferreira, and Fidji Gendron. 2013. "Aboriginal and Non-Aboriginal Students Learn About Natural Health Products from Different Sources." *Pimatisiwin: A Journal of Aboriginal and Indigenous Community Health* 11 (1): 99–112.

Alkholy, Sarah O., Fidji Gendron, Tanya Dahms, and Maria Pontes Ferreira. 2015. "Assessing Student Perceptions of Indigenous Science Co-Educators, Interest in STEM, and Identity as a Scientist: A Pilot Study." *Ubiquitous Learning: An International Journal* 7 (3–4): 41–51.

Bang, Megan, and Douglas Medin. 2010. "Cultural Processes in Science Education: Supporting the Navigation of Multiple Epistemologies." *Science Education* 94 (6): 1008–26.

Battiste, Marie. 2004. "Respecting Postcolonial Standards of Indigenous Knowledge: Toward a Shared and Sustainable Future." *Journal of Aboriginal Economic Development* 4 (1): 59–67.

Bissell, Therese. 2004. "The Digital Divide Dilemma: Preserving Native American Culture While Increasing Access To Information Technology On Reservations." *Journal of Law, Technology and Policy* 1: 129–50.

Cajete, Gregory. 2000. *Native Science: Natural Laws of Interdependence*. Santa Fe: Clear Light Publishers.

Chemers, Martin M., Eileen L. Zurbriggen, Moin Syed, Barbara K. Goza, and Steve Bearman. 2011. "The Role of Efficacy and Identity in Science Career Commitment among Underrepresented Minority Students." *Journal of Social Issues* 67 (3): 469–91.

Committee on Underrepresented Groups and the Expansion of the Science and Engineering Workforce Pipeline. 2011. *Expanding Underrepresented Minority Participation:*

America's Science and Technology Talent at the Crossroads. Washington, DC: The National Academies Press.

Craft, Rachel, Katrina McClure, Steve Corbett, Maria Pontes Ferreira, Ashley Stiffarm, and Kelly Kindscher. 2015. "Ethnic Differences in Medicinal Plant Use Among University Students: A Cross-Sectional Survey of Self-Reported Medicinal Plant Use at Two Midwest Universities". *BMC Complementary and Alternative Medicine* 15:192.

Ferreira, Maria Pontes, Betty McKenna, and Fidji Gendron. 2014. "Traditional Elders in Post-Secondary STEM Education." *The International Journal of Health, Wellness, and Society* 3: 1–11.

Freire, Paulo. 1970. *Pedagogio do Oprimido*. Rio de Janeiro, Brasil: Paze Terra.

Fiegener, Mark K. 2015. *Science and Engineering Degrees, by Race/Ethnicity of Recipients: 20022012*. Virginia: National Science Foundation.

Guterl, Fred. 2014. "Diversity in Science: Where are the Data?" *Scientific American.* Accessed May 16, 2016. http://www.scientificamerican.com/article/diversity-in-science-where-are-the-data/.

Hatcher, Annamarie, Cheryl Bartlett, Albert Marshall, and Murdena Marshall. 2009. "Two-Eyed Seeing in the Classroom Environment: Concepts, Approaches, and Challenges." *Canadian Journal of Science, Mathematics and Technology Education* 9 (3): 141–53.

Haynie, Devan. 2014. "U.S. News Data: Online Programs Attract Fewer Minority Undergrads." *USNews*, October 29. http://www.usnews.com/education/online-education/articles/2014/10/29/us-news-data-online-programs-attract-more-minority-undergrads.

Humes, Karen R., Nicholas A. Jones, and Roberto R. Ramirez. 2011. "Overview of Race and Hispanic Origin: 2010." In *United States Census Bureau*, 1–23.

Lederman, Norman G. 2007. "Nature of Science: Past, Present, and Future." In *Handbook of Research on Science Education*, edited by Sandra K. Abell and Norman G. Lederman, 831–80. Mahway: Lawrence Erlbaum Associates, Inc.

Michell, Herman. 2011. *Working with Elders and Indigenous Knowledge Systems: A Reader and Guide for Places of Higher Learning.* Vernon: JCharlton Publishing Ltd.

National Household Survey. 2013. "2011 National Household Survey: Immigration, Place of Birth, Citizenship, Ethnic Origin, Visible Minorities, Language and Religion." *Statistics Canada*. Accessed May 16, 2016. http://www.statcan.gc.ca/daily-quotidien/130508/dq130508b-eng.htm.

Norris, Tina, Paula L. Vines, and Elizabeth M. Hoeffel. 2012. "The American Indian and Alaska Native Population: 2010." In *United States Census Bureau*, 1–21.

Ogawa, Masakata. 1995. "Science Education in a Multiscience Perspective." *Science Education* 79 (5): 583–93.

Sharp, Phillip A. 2014. "Meeting Global Challenges: Discovery and Innovation through Convergence." *Science* 346: 1468–71.

Smith, Jessi L., Erin Cech, Anneke Metz, Meghan Huntoon, and Christina Moyer. 2014. "Giving Back or Giving Up: Native American Student Experiences in Science and Engineering." *Cultural Diversity and Ethnic Minority Psychology* 20 (3): 413–29.

Snively, Gloria, and John Corsiglia. 2001. "Discovering Indigenous Science: Implications for Science Education." *Science Education* 85 (1): 6–34.

Statistics Canada. 2010. "Education: Aboriginal People are more Likely to Have Trades and College Certificates." Accessed May 16, 2016. http://www.statcan.gc.ca/pub/89-645-x/2010001/education-eng.htm.

Tierney, William G. 1991. "Native Voices in Academe: Strategies for Empowerment." *Change: The Magazine of Higher Learning* 23 (2): 36–9.

Truth and Reconciliation Commission. 2015. *Calls to Action Report*. Accessed April 20, 2016. www.trc.ca

ABOUT THE AUTHORS

Sarah Omar Alkholy: Lecturer, Umm al-Qura University, Mecca, KSA

Fidji Gendron: Associate Professor, Department of Science, First Nations University of Canada, Regina, Saskatchewan, Canada

Betty McKenna: Elder in Residence, First Nations University of Canada, Regina, Saskatchewan, Canada

Tanya Dahms: Professor, Department of Chemistry and Biochemistry, University of Regina, Regina, Saskatchewan, Canada

Maria Pontes Ferreira: Assistant Professor, Department of Nutrition and Food Science, Wayne State University, Detroit, Michigan, USA

Ubiquitous Learning: An International Journal is one of the five thematically focused journals that comprise the Technology Collection and support the Technology, Knowledge, and Society knowledge community—its journals, book series, and online community.

The journal sets out to define an emerging field. Ubiquitous learning is a new educational paradigm made possible in part by the affordances of digital media.

Ubiquitous Learning is a counterpart to the concept "ubiquitous computing", but one which seeks to put the needs and dynamics of learning ahead of the technologies that may support learning. The arrival of new technologies does not mean that learning has to change. Learning should only change for learning's sake. The key perspective of the journal is that our changing learning needs can be served by ubiquitous computing. In this spirit, the journal investigates the affordances for learning in the digital media, in school, and throughout everyday life.

Ubiquitous Learning: An International Journal is a peer-reviewed scholarly journal.

ISSN 1835-9795