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Investigating Teacher Candidates' Understandings and Experiences of First Nations Science

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Purpose of the Research Project

First Nations peoples in Saskatchewan are currently underrepresented in programs and careers associated with education in the sciences. One explanation that has been proposed to explain First Nations students' lack of engagement with the sciences is the limited compatibility between First Nations culture and teaching and learning frameworks commonly used in science education. But what of science teachers' understandings of First Nations culture and the teaching and learning frameworks commonly used in science education? How do science educators perceive the teaching and learning of science education, and more specifically, how do they engage all students in First Nations and Métis culture and knowledge? The answers to these questions also play a role in the puzzle to why First Nation peoples are underrepresented in science related fields. Therefore, this project sort to investigate the understandings and experiences concerning First Nations Science knowledge and implementation held by preservice science teachers at the Faculty of Education, University of Regina; the Department of Indian Education, First Nations University; and the Saskatchewan Urban Native Teacher Education Program (SUNTEP).

This background of this research was situated in science education research literature that proposes science teachers' instructional practices are more closely aligned with, and influenced by, general beliefs about teaching and learning than by understandings of the nature of science teaching (Abell & Smith, 1994; Aguirre, Haggerty & Linder, 1990; Laplante, 1997; Lederman, 1992; Yerrick, Pedersen & Arnason, 1998). A review of science education research showed that much of the research into science pedagogy had focused on the content and strategies of science education rather than on investigating the beliefs science teachers have about the nature and role of education, or how these understandings affect what they teach, or on how they believe science is most effectively taught (Lederman, 1992, Southerland, Gess-Newsome & Johnson, 2003). This research proposed to clarify the relationship between science educators' generic understandings of teaching and learning and their beliefs and actions regarding First Nations Science education. An in-depth exploration of this relationship is particularly important as First Nations Science necessitates systemic and individual transformations within the teaching and learning of Western orientations of science. Without more clarity about how teachers' broader educational beliefs influence their science practice, the complexities of integrating First Nations Science will not be fully realized.

The aim of this research was to explore the boundaries of preservice science teachers' beliefs about First Nations Science. It sort to explore how future science teachers attempt to negotiate Western Science and First Nations Science in culturally sensitive ways in order to inform future research by providing much needed background research into the assumptions preservice science teachers have about First Nations Science. The social construction of

what is deemed to be appropriate to include in the teaching and learning of science education necessitates an exploration of how teachers at the beginning stages of their careers make sense of the world of school science and the inclusion of First Nations Science. Questions in this research explored preservice science students' understandings and potential practices of teaching science education, the importance these students place on First Nations Science, their beliefs about what First Nations Science involves, and the possibilities and challenges they assume they would have including First Nations Science.

Literature Review

Contemporary science education

In a general sense, postmodern science calls into question, if not completely rejects, most of the cultural certainties that we have come to rely on living in the dominant cultures in North America (Weaver, 2001). Particularly under postmodern interrogation are science and scientific knowledge, and the privileging and construction of cultures by science. What is being critiqued is the plethora of assumptions that enable science to breath life: who historically and contemporarily has been able to 'give voice' to knowledge, who has been excluded, and what assumptions and expectations have been associated with the methods of knowledge production and the resultant models that are used to 'describe the world'. Further, there is a critique of how these assumptions and larger infrastructures are in service of the dominant socio-cultural, economic, political perspectives that work to maintain and reproduce the status quo.

Postmodern science education is more than just a negotiation of postmodern philosophies and science. Evolving within pedagogical frames that encompass the complexities of how people navigate meaning, and the teaching of this meaning, these fundamentally different perspectives reluctantly join and merge towards what Weaver (2001) describes as a democratic approach to science education. The goal of postmodern science education is public education for the participation in decisions relating to scientific policy. Weaver (2001) maintains that postmodern science education is "not only about the teaching of science but the complexity of knowledge (in spite of simplistic scientific models) and life and the importance of making sound public policy decisions that are not done for ideologically or profit motives but the sustaining of a quality life" (p. 17). Rather than teaching (modern) science (education) that revolves around universal, generalizable, and timeless theories that are broken down into simplistic, seemingly regurgitable pieces for the students to learn, this perspective highlights the socio-cultural, political aspects of science concepts, by exploring their models, their development, their developers and assumptions that links this knowledge into a bigger picture that perpetuates a particular cultural narrative. Postmodern science education does not just 'investigate' the content of science education but also how we come to know this information.

The process of teaching postmodern science education is also significant in postmodern science education, for I agree with Ellsworth (2005), how we come to know something influences what we know about it. To think uncritically of science education is to perpetuate the power relations of domination and to continue to exclude many peoples (and much useful knowledge) from the mainstream of those societies (Barton, 1997; Barton & Osborne, 2001). The recognition that science education is interconnected within a web of complex socio-cultural interactions sparked contemporary calls for science education to move beyond teaching traditional Western science perspectives and skills, and engage in the philosophies and activities that encompass a more multicultural view of, and knowledge about, science (Aikenhead, 1997; Rodriquez, 1998; Sammel, 2003). Further too is the recognition that students engage with science education by drawing on their own cultural knowledge and perspectives (Barton & Osborne, 2001). These theoretical movements in science education align with the cultural diversity of Canadian societies and highlights critical issues that need to be faced within the practical reality of science education in Canada.

Contemporary science education is beginning to acknowledge that Western science represents only one way of understanding the world (Aikenhead, 1997; Atwater, 1996; Brickhouse, 1994; Cajete, 2000; Gill & Levidow, 1989; Helms, 1998; Hodson, 1999; Rodriquez, 1998; Sammel, 2003). Incredibility privileged, Western science is historically situated within powerful socio-economic positions within global societies that tend to view it as objective, neutral and free from culture, race or gender bias. But science can no longer viewed as a method of finding 'reality' somewhere 'out there'. Contemporary science education highlights that what constitutes 'science' comprises of locally constructed knowledge that interconnects with political, social, economic and cultural forces to generate answers to questions with as much precision as is presently reasonable to hope for. However, understandings of science as political (Kyle, 2001) are usually absent in the practical cultural stories educators tell and in the majority of contemporary classroom teachings. The reshaping of science education to include political and social understandings must include the telling of science from multiple perspectives. These perspectives should not be limited to, but should include, gender perspectives, natural environmental concerns, social justice and equity issues, animal treatment and humane issues, and, of concern to this paper, the voices and perspectives of those peoples who have been excluded from the mainstream knowledge generation in science.

Hines (2003) suggests that there are also basic instructional flaws in science education that exacerbate the complexity of the issues leading to the underrepresentation of minority groups in the fields of science. One of these flaws is the lack of instructional material containing multicultural content. Eide & Heikkinen (1998) argue that teachers lack the manuals and resources that offer insights into multicultural science. The problem is compounded since many teachers already feel a lack of confidence in the science content, and many elementary and secondary teachers rely on the science texts to teach science

(Yager, 1989). If the teaching materials and text that the teachers rely on lack multicultural perspectives or activities, then only traditional Western science education will be presented to *all* the students.

Introducing science and science education based on ways of knowing other than Western science can only be done while disrupting the dominance and privilege of EuroAmerican views of science in Saskatchewan, Canadian and worldwide educational systems. Science's subjective, changing and partial nature of knowledge construction must be exposed and examined with students so they can begin to understand how Western science is embedded in the beliefs and ideologies that hold privileged positions of power within our societies and the stories we tell about how the natural and social worlds are constituted and operate. Western science has shown itself to be useful knowledge. But it is not the only possible way of knowing the natural world. Nor is it the 'right' way of knowing. If First Nations knowledge is introduced into the typical science classroom without addressing the privileged position of Western science then First Nations knowledge will not seem as 'legitimate' in relation to the commonly known and dominant 'real' science. Teachers and students will tend to see First Nations science knowledge as 'nice stories'. A teacher who wishes to strengthen cultural relations between First Nations and non-First Nations peoples, but does not help her students to see that knowledge is social and political may unwittingly be reinforcing stereotypes.

The inclusion First Nations perspectives in science education does not assume a relativist positions. Including First Nations knowledge does not mean that educators argue that all explanations are equally useful in all cases. All explanations work well within the paradigm and situations where they have been developed and understood. Learning and respecting First Nations knowledge does, however, provide a way of introducing and exploring power relations in how we come to define, and may in the future define, what is science and science education. Teaching science this way ensures that knowledge and perspectives that have been generated from the very landscape of Saskatchewan by the many generations who have lived in Canada long before it was colonized becomes part of the knowledge of all those who presently live in that landscape.

A First Nations Science

Science is about knowing, and knowing rests upon taken-for-granted cultural assumptions about the external world (Kyle, 2001). What happens when the 'knowing' of two cultures are at odds with each other? What happens when the assumptions upon which the cultures have been historically based are opposed? Usually the 'knowledge' from the culture that is more powerful is viewed as 'correct' and the other 'knowledge' is dismissed, and/or marginalized. I argue this is the case of Western and First Nations ways of knowing the external world. For, in science education, Western science is constructed as mainstream and

normalized, whereas First Nations science is almost always excluded. However, do preservice science students realize the normalization of Western science? What do Saskatchewan preservice students believe should be taught under the title of science education? These questions form the foundation of this study. Yet Barton & Osborne (2001) would challenge us to take these questions further and ask what do we do with difference in the science classroom? It is hoped that the insights gained through this research moves science education in Saskatchewan one step closer to confronting these difficult questions.

To understand the different science paradigms Cajete (2000) describes the historical assumptions of Western science and what he calls Native science. Western science he argues rests on the assumption that in nature there are certain patterns that always remain the same. As logic would dictate, laws and 'truths' about this nature can therefore be 'found'. All that can be known is waiting 'out there' to be discovered by humans. He juxtaposes that view of nature with Indigenous views of nature that assumes that everything is in a constant process of change. There are certain things that after long-term observations take on regular patterns, but these too are subject to changes. In this perspective, the only thing that is constant is change. This leaves no room for the possibility of unchanging laws and truths. The only truth is change, and the need to balance oneself and one's society in a constantly living and changing world.

Native science for Cajete (2000) is a metaphor, as there is no word in native languages for 'science'. Native science describes coming to know what has evolved through human experience with the natural world. Native science is born of a lived and storied participation with the natural landscape. To gain a sense of Native science one must participate with the natural world. To understand the foundations of Native science one must become open to the roles of sensations, perception, imagination, emotion, symbols, and spirit as well as that of concept, logic, and rational empiricism (p. 2).

Kawagley (1995) writes that science for First Nations peoples is a quest for knowledge as well as a means for living a long a prosperous life. It is a way of assessing the physical phenomena of the present, comparing it to the past and also to what you believe the future holds. Past experiences provide lessons learned about your specific geographical area that prepares you for a future in that area.

The study reported on in this document was founded on the belief that all Saskatchewan students would benefit from the knowledge constructed by the many generations of peoples who have participated with this natural landscape for hundreds of years. First Nations peoples in Saskatchewan have a depth of knowledge and ways of knowing this province that are unrivaled by Western science as these understandings developed over generations to ensured

survival. This knowledge would not only be essential to any students living in Saskatchewan, but it is also part of the rich cultural heritage of Canada.

Much First Nations knowledge has been given though the medium of stories. The use of stories to teach about the world is extremely important in orally based traditions. Traditional stories provide cultural explanation of the how and why of things that First Nations peoples have learned as they have lived in the landscapes of Saskatchewan. Therefore stories are important in the teaching and learning of Native science. Stories encourage a deep intuitive understanding of the relationships people have with each other, the beings around them, and the places they live.

Cajete (2000) suggests that the stories of Native science that have been passed down through the oral traditions, have the basic components of scientific thought and application, but in a metaphorical sense. Central to this study is that Western science and Native science have very different philosophies towards the world and humans place and responsibility in that world. However, there is hope for cross-cultural work in science education. For both Western science and Native science have a common purpose, to understand and work with the natural world. Within both Western science and Native science there are many similar and divergent perspectives. It is here in these complex spaces where the possibility for commonalities can be found and where differences can be viewed as strengths rather than as weaknesses. It is to explore these spaces that this study investigated preservice science students' understandings of both Western and First Nations science.

First Nations Population in Saskatchewan

In Canada, the 1996 Census illustrates that First Nations peoples are underrepresented in academic areas in science, as well as being underrepresented in high school attainment. This Census highlights that 48% of First Nations people between the ages of 25 to 44 had less than a complete grade twelve diploma. Only 14% of First Nations people between this age range have a technical or Vocational certificate or Diploma, and only 5.5% has a university degree. Further, 19% have less than a grade 9 education. Unfortunately, the educational attainment for the current generation of youth is worse, as the Census highlights that 78% of First Nations youth between the ages of 15 and 24 have less than a grade twelve diploma. This educational attainment severely limits workforce participation, as the unemployment rate for First Nations youth in Canada, based on this Census is 44%. Only 2% of First Nations has a technical or Vocational certificate or Diploma, and only 0.3% of First Nations youth have a university degree (Federation of Saskatchewan Indian Nations, 2002).

These demographics are especially important for the province of Saskatchewan as a report published by the Federation of Saskatchewan Indian Nations (1997)

highlights that Saskatchewan has the largest proportion of First Nations to non-First Nations peoples in Canada and this is expected to continue to increase. *The Saskatchewan and First Nations Peoples in the 21st Century: Social Economy and Political Changes and Challenges* report illustrates that in Saskatchewan First Nations people between 0 and 24 years old are expected to comprise 38% of that age group by the year 2011. The combination of this growing demographic and the educational attainment rates certainly highlight the need for educational changes that seek to promote greater engagement with First Nations youth in all areas of schooling. In 2000 Saskatchewan Education published an Action Plan based on the recommendations of a First Nations Education Provincial Advisory committee that called for increased actualization of First Nations content and perspectives in all subjects in Saskatchewan schools (Saskatchewan Education, 2000). However, as this Saskatchewan Education document maintains, commitment to First Nations education is not simply about giving equal time to First Nations content or perspectives in curriculum guidelines or in classroom practices, but being more reflective and critical in the way policy is implemented and being more conscious of how curricula are actualized. As (science) educators we need to continuously evaluate and critique our socially constructed initiatives and standards for how issues of legitimacy, authenticity and quality perpetuate the status quo and exclude First Nations knowledge and peoples.

Methodology

The methodology of this research was grounded theory. This methodology seeks to unravel the nature and meaning of an experience (in this case, an understanding) for a group of people in a particular setting. In grounded theory, understandings are generated during the research and analytic processes, where the researcher engages in thematic analysis by formatting themes, summaries and hypotheses as the data unfolds the story. The aim is to construct an integrated theory specific to the histories and narratives of the people participating in the research. The method of this research was an online survey questionnaire given, in class, to the preservice science students at each of the participating education facilities. The students' regular instructors administered the short survey using wireless technology. The researcher was present during the administration of the questionnaire to introduce the research and answer any questions. The surveys consisted of closed questions (that had a limited number of choices) and some open-ended questions (questions that allowed students to write comments). The analysis of the data involved statistical and thematic analysis (where themes and questions were excavated from the data).

The research was conducted by surveying 91 teacher candidates during the Winter 2005 semester. For the Winter 2005 semester, there were approximately 130 students enrolled in the elementary and secondary science courses at the Faculty of Education at the University of Regina, and 91 participated in the survey. Those who did not participate were students involved with the Faculty of

Science rather than the Faculty of Education that semester. Of the approximately 9 students enrolled at the Saskatchewan Urban Native Teacher Education Program in elementary science education, 6 participated in the survey. Further, of the approximately 11 students taking science education through the Department of Indian Education at the First Nations University of Canada, all eleven participated in the study. This research included the majority of teacher candidates taking science education at an institution in Regina for the Winter 2005 semester.

Findings and Analysis

Overview of participants

Of the students who participated in the questionnaire, 7% were from SUNTEP, 12% were from First Nations University and 81% were from the University of Regina. Thirteen percent of those who completed the survey indicated they were from First Nations or Métis ancestry, while 87% indicated they were not. The composition of students attending the each of the institutions who indicated they where First Nations or Métis were: 100% from SUNTEP; 55% from First Nations University; and 0% from the University of Regina.

What the participants believe science education to be

When the participating students thought of science education, almost half (46%) thought of concepts or words associated with Western science content. Nearly the same percentage (44%) made reference to laboratory experiments and/or demonstrations when they commented on what science education was. Just over a quarter, 30% spoke of concepts associated with dominant Western processes of teaching science when asked what they believe science education to be, such as lecturing and note taking.

All these references highlight the dominant discourse of Western science pedagogy. How these students have come to know and make sense of science education is reflective of contemporary Western science pedagogical content and processes, where science content takes precedence to science process, and inside laboratory experiences are understood as the quintessential science experience.

Only one person out of the 91 surveyed commented about including First Nations perspectives in science education, even though the survey was clearly labeled as exploring their understandings of First Nations science education. This was the only comment about including any cultural perspective in science education. This comment did not suggest a critique of the power positions of Western Science or the associated privileging of this knowledge and the marginalization of

First Nations knowledge, but rather just suggested including some First Nations content into the curricular. Clearly, all students, even those students who self identified as First Nations or Métis, have been indoctrinated into the discipline of Western Science to the point that they do not conceive of a space for a critique of the privileging of Western science or for First Nations cultural knowledge or process to be included in the teaching and learning of contemporary science education. This may speak to an unjustifiable gap in the teaching and learning of science education at teacher education institutions in Regina in comparison to contemporary postmodern science education thought. Or further, to the lack of practical research in engaging local preservice science students in postmodern science pedagogies.

What is successful science education?

Half (50%) of the students commented that successful science education would include hands-on science learning. The next highest comments were that science was to be fun (36%), student-centered (17%) and then relevant to the students (14%). Only 12% of those surveyed believed that successful science education would include incorporating 'other perspectives or issues' in science. Only one person (1%) commented that First Nations perspectives should be included.

In this era, science education in North America is predominantly marketed as student centered and hands-on to help promote understanding of, and engagement with predominantly Western scientific concepts. The assumption follows that if students are 'experiencing science' through hands-on approaches they will understand rather than memorize the science concepts being taught. The participating students did indeed recommended in their answers that more laboratory activities be conducted and demonstrations be undertaken as a way to promote understanding of scientific concepts. What they did not communicate was that laboratory demonstrations or activities might not all be student-centered, or 'fun'. Further, laboratory activities do not necessarily promote understanding, or even the 'correct' Western science. Students may still have to memorize concepts even after doing 'hand-on' activities. The enticement of fun may also be seen as a way to promote students into the area of science. The assumption is that if students are having fun, they may be engaged in science concepts that may usually perceived as dry and boring. In these responses the underlying goal was seen to be a more efficient way to promote 'science', and more specifically, Western science content. The participating students had taken up the educational goal of promoting what some might believe to be more effective means of content acquisition. The content that is to be acquired, as demonstrated in later responses, was that of Western science.

Even though 13% (12 people) stated they had First Nations ancestry, only one person out of 91 stated that successful science education would include First Nations science education, or First Nations perspectives/knowledge. Further,

14% advised that science needed to be relevant to their students. This begs the questions of who do these participating preservice students believe their future students to be? What do they assume will be relevant to their future students? First Nations cultural knowledge does not seem to be something that 90 of these 91 participating students think will be relevant to their future students. This highlights the discursive function of Western science and Western science education. It speaks to the need for people who are familiar with addressing white privilege in science education and discussing First Nations science education to be teaching science pedagogy in tertiary institutions in Regina, as this may not have occurred for these participating students.

Participating Science Teachers' Advice to their Teachers

These answers speak once again to the discursive construction of the Western science teacher. Here the students advise their previous teachers to use more hands-on, interactive approaches to teaching science (46%). Nearly half (46%) also suggest making science more fun and/or interesting for their students. The promotion of understanding for science concepts rather than memorization, and an increase in using labs or demonstrations both received 12%.

Just over a quarter (26%) of the comments wanted their teachers to make science relevant to students. However, it seems that it is more appropriate for science to be relevant for some students than others, as later data will highlight. For if making science relevant for the First Nations students means making the non-First Nations students uncomfortable, than this is not as desirable goal. Science, it seems by listening to the unfolding data stories, can only be made relevant to student within in certain frames and parameters.

In the question asking for advise for their previous science teachers, three of these preservice students said that First Nations perspectives should be included in science education. This was an increase from previous questions concerning their beliefs about science education. Throughout this answer however, assumptions were made that First Nations students struggle as they are not familiar with Western science (and they can not read well). Could there not be an argument that all students learning Western science are not familiar with these Western science concepts? Cannot the same argument be made for students from any racial background? The assumption here is that First Nations students have grown up in traditional practicing ways. This may or may not be the case. Many First Nations people in Saskatchewan are urban dwellers and identify as Catholic (Federation of Saskatchewan Indian Nations, 2002). Therefore, many First Nations peoples may not have access to traditional customs, and/or may not support these traditional beliefs ideologically. This question highlights the need to further investigate the assumptions participating students have about the First Nations and non-First Nations students they will be teaching. Further investigations need to explore how these assumptions impact preservice teachers' understandings and practices of teaching science.

There was also the assumption in the participating students answers that because the First Nations population is increasing in Saskatchewan that teachers need to learn about First Nations content in order to relate to these students. The justification here was that First Nations science was needed because the population is increasing, and it was assumed that only First Nations students would benefit from this knowledge. First Nations science was further perceived as a tool to connect teachers to First Nations students while also acting as a bridge to Western science for these students. The knowledge of First Nations science and First Nations science education was also assumed to fit within the boundaries of Western science. Ultimately, First Nations science was viewed as a tool to help integrate or assimilate First Nations students into the learning of Western science in a faster and more efficient way.

There was no critique of science or science education included in the advice given to teachers, but rather how to make the acquisition of Western science more effective. The discursive desire to produce scientifically literate students, within the definition of the dominant Western science agenda is reflected by these students. There was no critical reflection on the problematic colonized infrastructure inherent in Western science education. However, one participant did suggest that stereotypes about science need to be broken, and critical thinking needs to occur in science education. However, they spoke to this critical thinking in terms of gender equity so students do not think that only men can do science. There was no further critique of race, age, or science itself.

What the students think is most important in science education

The students commented that Western science content was most important (64%) followed by First Nations science content (46%). These results highlight the importance students place on content. This is consistent with the findings that nearly half of the students think of science content when they think of science education. This also follows the findings that successful science, and the advice they would give to teachers, focuses on understanding science concepts. The hands-on, interaction elements are to make the accumulation of content more efficient.

The methods of teaching were viewed as less important with 28% commenting that Western science teaching methods were third most important and First Nations science teaching methods were the forth and least important with 27%. The participating students identified First Nations science methods to include hand-on, student led methods. Therefore, it could be hypothesized that First Nations science methods are assumed by these students to be seen as important to teachers, because they are understood to be reflective of ‘good’ (Western) pedagogy.

In the science education programs that these students were taking in the semester that they engaged in the survey, hands-on pedagogy processes were emphasized. Constructivist processes are the central element in all science education courses in Regina, and yet, the emphasis the students place on content as nearly double in percentage to the process of teaching science may highlight the persuasive nature of teacher subjectivity. It could be argued that as elementary, high school and as university students, these participants were indoctrinated to the essential nature of 'knowing the correct' science content. Without the 'correct' science content knowledge, a student could not become a 'top' student. It could be assumed that the acquisition of correct science content was essential for these participating students to be students at these educational institutions. Process, how you came to learn that content, may have been secondary in their endeavours as students. Therefore, even if hands-on, student centered approaches are emphasized in the prerequisites science education methods courses at the students must take at educational institutions, these may have little impact on the long term construction of these teachers beliefs that content acquisition is most important to educational success. This raises questions about how we culturally and infrastructurally, identify, measure and reward educational success. What messages are presented and perpetuated to students and teachers through this current educational system?

What students think teachers believe is most important in science education

The understandings these participating students have about what practicing science teachers believe about science education illustrates the complexity of colonization.

The participating students commented that 82% of practicing teachers would believe Western science content was the most important thing in science education. Western science methods of teaching were second with 64%. First Nations science methods of teaching were ranked third at 55%. The participating students believed practicing science teachers would rank First Nations science content forth, at 51%. What assumptions do these future teachers have about their soon to be mentors and colleagues? It would seem that they believe that the least important aspect of science education for practicing science teachers would be that of First Nations science content. If Western science content is perceived as the most important, and First Nations science content is perceived as the least important, do these students appreciate they are suggesting that their colleagues perpetuate normative ways of knowing in science that are inherently racist? Further, why did they advocate that First Nations science content was the second most important aspect of science education when commenting on their own perspectives, but the least for Saskatchewan science teachers? It would be important to conduct an in-depth, follow up investigation to explore this inherent racism, a legacy of colonization, with future and practicing Saskatchewan science teachers.

These results highlight the hierarchical power dynamics that occur between Western science and First Nations science. This dualism leads to power hierarchies where one science is normalized and the other is marginalized. The marginalized science, First Nations science is seen as less credible, weaker, and dominated over in the same way as the colonial power has oppressed First Nations peoples. The assumptions the students made about how they ranked what was important in science education and what they perceived teachers believed about science education reflects the privileging of Western science and the oppression of First Nations knowledge.

When I think of First Nations Education I think of?

The participants responded to the question of what First Nations education includes by stating that it implies learning about First Nations cultures and beliefs, and focusing on nature. Both these responses were tied at 23%. The next responses, again tied at 19%, were a way of teaching First Nations content and First Nations history. Twelve percent of the students said that they did not know what First Nations education would be, while 7% commented that it would include some form of traditional teaching style. Five percent said specifically it would be the same as 'normal' education but with First Nations content.

Comments where made in response to this question that First Nations education is an 'easier' education, and therefore more suited for elementary classes. There were repeated statements that First Nations education, and First Nations science should not include technology, as First Nations cultures did not use technology. Blatantly naïve statements like these illustrate power hierarchies where some students believe First Nations knowledge is not as credible as Western knowledge.

Further, it is predominately assumed through out this survey that First Nations education and First Nations science does not apply to non-First Nations people. The dominant assumption was that First Nations science is for First Nations students. Many participants suggested First Nations education was important due to the increasing demographics of First Nations and Métis people and the need to connect to First Nations students to Western science. There was limited, if any, recognition that First Nations science should be promoted as an integral and important knowledge base in its own right, for all Saskatchewan students.

What was acknowledged in the survey responses was that Western education, including Western science, does exclude First Nations students and their knowledge bases. But what was not suggested was that First Nations students might feel uncomfortable learning about Western science, in the same way that these participating students believe non-First Nations student may feel uncomfortable learning about First Nations science. The participant responses

speak to the normalized discourse of Western science and Western pedagogy in science education.

First Nations science suggests?

First Nations science tends to be associated (35%) with nature-based science concepts. Plants, animals and weather conditions were all used as examples of First Nations science. Further ideas such as the interconnection of living things, conservations and the need for sustainability were all included in the largest percentage of comments as to what First Nations science was. These seemingly 'softer' sciences stereotype First Nations people as the 'first conservationists', the biologists, rather than as cultures who also employed knowledge that Western science now identifies as physics, chemistry etc. The participating students often commented that it is important to teach "physics and chemistry too" when teaching First Nations science. First Nations science was narrowly defined as aspects relating to biology by the participants. But not all biology, just biology as it relates to the ecosystem.

Even though a few students said that this ecological knowledge is important as it will help benefit the planet and broaden other ways of knowing, there was a great majority who commented that First Nations knowledge that involve a spiritual dimensions would make non-First Nations people uncomfortable. Therefore, it was suggested that due to any discomfort around imposed spirituality, a First Nations science that included the spiritual aspects should be avoided in science education. However, a neutral First Nations science content about the ecosystem was generally seen to be acceptable. It was this neutralized form of First Nations science content that the participating teachers assumed First Nations science to imply.

Students commented that First Nations people use the land on a daily basis. Comments like this serve to remind how disconnected some students are from the resources they use on a daily basis. Comments like this beg the question of where do the students think their water, food, shelter and transportation come from? Further, it was suggested that First Nations science should include how First Nations people helped the settlers survive on the Saskatchewan landscape. This suggested framework reduces First Nations science to a simplistic contribution approach that still places the emphasis on a colonized agenda of what can be known.

In relation to nature based ways of knowing, it will be interesting to explore to what degree the perception of the outdoor nature based stereotype is granted to First Nations peoples and First Nations education. If First Nations science is limited to nature-based biological science contexts, then this would severely inhibit how science teachers choose to engage with this knowledge base in chemistry or physics related fields. Therefore, the understandings and images these participating students have about First Nations science may influence how

they choose to negotiate Western science and First Nations science in their future science pedagogies. This begs the questions: what are the images that students taking education degrees in Regina have of First Nations peoples, their culture, their beliefs and hence, First Nations pedagogy? And how do these images inhibit, limit or collide with what Postcolonial educators are trying to communication in anti-oppressive practices at the university level?

The third highest comment was for First Nations science to be taught as a 'historical element' within science education. This relates to another assumption that emerged that First Nations people are 'historical' not contemporary peoples. The historical element also suggests that First Nations science knowledge lives in the past and has not 'evolved', as Western science has. In a later question, one student comments that "Western science is 100 years ahead of First Nations science". Interestingly, Western science is not taught in a historical frame but rather in contemporary and future frames. In contemporary pedagogy literature, knowledge of the historical evolution of science is not viewed as being as important as knowledge of contemporary concepts. Indeed, the historical aspects of Western science are usually viewed as add-ons to the 'core' of the contemporary science content. These student responses shed light on how important the student might see First Nations science in the bigger scheme of science education. The hierarchies of the power dynamics between the white privilege of Western science compared to the marginalized, colonized knowledge of First Nations knowledge is clear in what is normalized as legitimate and credible 'truth' to be taught in science education.

In the question of what is First Nations science, 10% of students commented that First Nations science involved teaching First Nations perspectives. This 10% did not comment on how First Nations science should be treated in relation to Western science, however, 8% made the specific comment that First Nations science was showing how First Nations concepts aligned with Western science. These 8% clearly stated that First Nations science must know its place within Western science.

Only 8% of students directly commented that they were not familiar with First Nations science.

A First Nations science lesson would include?

The most frequent response (32%) to what a First Nations science lesson would include centered on the idea of nature. The participants hold the assumption that that plants, animals and the land, and their interconnections to humans, are "First Nations science". Twenty-three percent said that they are not sure what a First Nations science lesson would include. Ten percent said that it would include the history of First Nations people. Students commented on highlighting to First Nations students how First Nations people 'have evolved since joining Western societies'. The power dynamics of colonization were not discussed along side

these comments. Nine percent of the participating students commented that First Nations methods would be hands-on and student centered.

The idea that legends or stories would be used was also suggested by 9% of the students. In commenting on the use of stories, a student said, “traditional stories should be followed up with science facts and content”. The power dynamics behind the use of the term legends was not discussed in any of the students’ comments around stories or legends. Along side the use of stories or legends in the teaching of First Nations science, there needs to be an investigation into how the participating students hear the word ‘stories’ or ‘legends’. In Western cultures ‘stories’ are most often associated with children. If we contrast this, science knowledge, as highlighted in theses data stories, was most often associated with lectures, note taking and recommended processes such as hands on, student centered lab activities. The acquisition of Western science knowledge was not recommended through the use of stories or legends. Therefore, the power dynamics between how preservice students perceive the credibility of the different cultural modes of knowledge communication needs to be deconstructed in order for them to recognize and negotiate the effects of colonization on all facets of the teaching and learning of science.

Only one person commented that contemporary First Nations issues, perspectives, or presenters be included in First Nations science lessons. One student said that First Nations science includes students talking about their feelings. This was said by a First Nations person who also commented in other questions about using Medicine Wheel to bring balance to teaching.

A few students spoke of including both First Nations science and Western science in their classrooms and maintained that people ‘should teach both perspectives but there should be no value judgment placed upon either view’. The last comments shows how the student may not recognize that society already places value judgments on both Western science and First Nations science, and therefore these ways of knowing are not intrinsically ‘neutral’ in society. The participating students did not communicate a recognition of these value judgments as placed by society, or educational systems. It may be expected that as people growing up in colonized societies such as Canada, the students may have been exposed to, and normalized into infrastructural and social racism, and so may therefore not recognize these judgment values, or further, many not problematize them. The normalizing of the colonial agenda may not be avoided in Western societies, but can be identified, named and resisted. Therefore, these students need to understand there is no place of neutrality in science education. Neutrality the myth of those situated within the economic privilege of hegemony.

Comments about the benefits of learning about First Nations science in teacher education programs

Only 4% of the students commented that the benefit would be to recognize, acknowledge or respect First Nations knowledge. These four participants were First Nations students. The majority of students (37%) believed that offering their students another perspective of science was the main benefit, as "everyone can benefit from a broader perspective." However, when students were asked an earlier question of what successful science education would include, only 12% commented that it would involve a broadening of their students' perspectives. Therefore, even though the participating students perceived main benefit to including First Nations science was to offer students a wider understanding of science, they ultimately indicated this as a low priority in the overall scheme in what was important in the teaching and learning of science. What the students associate with science education is science content (46%) and science labs (44%). What successful science looks like was their students having fun (36%). If having 'fun' represents success in science education, then the inclusion of information that "will make students feel uncomfortable" will not be viewed as a desirable. Teaching Western science content through hand-on student centered approaches was constructed as the desirable goal for these soon to be teachers.

Seventeen percent of the students surveyed commented that First Nations science needs to be included in science education because the population of First Nations people is growing in Saskatchewan. Twenty-three percent said that the inclusion of First Nations science would be of benefit for First Nations students. The participating students suggested that by teaching First Nations science they could connect science to their students in more relevant ways, thereby allowing their students to learn more efficiently Western science. One student said, "If there is such a thing, it would help relate science to First Nations people and they might become more interested in it and therefore learn more and learn it more quickly." There was an acknowledgement that First Nations people are marginalized within the area of science education. With this assumption circulating about First Nations students, these preservice teachers realize they are going out into the teaching field not knowing how to 'connect' with First Nations students in science education.

Twenty percent of the students commented that increasing their own knowledge of First Nations science content thereby promoting a connection with First Nations students, would be the benefit of First Nations science education. There are many problematic assumptions here. One such assumption being that there was no mention that Western students could be interested in First Nations science. Problematic too was the belief that all First Nations students would be more 'in tune' with Western science if it was taught through a First Nations perspective. Or further, the belief that a First Nations science is only acceptable or worthy if it does actually correspond or endorse Western science paradigms.

There were many comments in response to this question that pointed to an assumption that First Nations students do not learn science as fast as non-First Nations peoples. This may reflect stereotypes that First Nations students are less familiar with Western science than non-First Nations students. Statistics reflect that a large percentage of First Nations peoples live Western influenced lifestyles (Federation of Saskatchewan Indian Nations, 1997) and could be exposed to Western science in the ways as their non-First Nations counterparts. Again, the insights gained from this study warrant a larger, more in-depth investigation to be undertaken to explore the images and beliefs preservice teachers have about the students they believe they will be teaching and how these thoughts may impact their teaching practices. Further, research should be extended to include what can be implemented at educational institutions to disrupt the influences of colonized thought.

Only 4% of the participating students said First Nations science would benefit all students.

I thought it was interesting that a student made the comment that concepts associated with First Nations science was not included in the one native studies course s/he took, but did not comment on how First Nations science was not included in the 3 years of science and science education courses undertaken. This speaks to the normalization of Western science and the marginalization of First Nations science within science and science education.

Finally, there were comments from the identified First Nations students that First Nations science would show First Nations people in a positive light because First Nations people have something to offer the discipline of science. Again, this highlights hierarchies of power and the legacy of colonization, for First Nations knowledge is legitimate within it own right and should not have to access Western science approval before it is deemed appropriate knowledge.

What do you believe to be the benefits of including First Nations science in your future classroom?

The most frequently cited benefit (41%) to including First Nations science in their classroom was to bring in 'another' perceptive into their teaching and learning of science. This was consistent with the most stated benefit for including First Nations science in teacher education programs (37%). Only 6% said anything about the important of acknowledging First Nations knowledge. The second most frequent comment was to help First Nations students succeed in science. There was no critique of Western science or how this knowledge base compares with First Nations science. First Nations science is just a tool that can be used to help First Nations students succeed in Western science and to show that there are other ways of explaining Western science. The students' comments in this question supported earlier assumptions that bringing in other perspectives were

fine, as long as those perspective fell within the parameters of Western science and were not ideological different. The participating students commented that if First Nations science was ideologically different than Western science then the parents, students, community, and I would argue, most of all, these preservice students themselves, would feel very uncomfortable.

Twelve percent commented that First Nations students would be more successful in science education if First Nations science were included in science classrooms. While 10% of the students said that with the First Nations populations increasing, teachers need to connect with First Nations students. They further commented that teaching First Nations science to First Nations students would be a way of making this connection.

Eight percent said that the benefit would be to increase learning about the natural environment. Another 8% said that including First Nations science would help students accept 'non-mainstream' science and people. However, I would argue that without an exploration and deconstruction of power dynamics and privilege the inclusion of 'non-mainstream' perspectives may not promote acceptance but rather may actually encourage further marginalization of these 'other' cultures.

What do you believe would be the drawbacks of learning about First Nations science in your teacher education program?

Only 39% said there would be no, or few drawbacks to including First Nations science in teacher education programs. The drawbacks that were most commonly mentioned were discomfort of non-First Nations students, parents and the community with the inclusion of First Nations science knowledge. Interestingly, there was the assumption is that First Nations students and parents would be supportive of the inclusion of First Nations science and non-First Nations students and parents would not be. Further, there was no mention of the comfort or discomfort of First Nations students, or non-First Nations students, with the indoctrination of Western science ideology in science education classrooms.

Extremes were cited as tied for third in the list of drawbacks. The students 'feared' that Western science might be completely forgotten if First Nations science were to be included. Many students commented on the need for a balance, but they did not say equal representation. Many students did not see why First Nations cultures were any different from other "immigrant" cultures. Others commented that the focus on First Nations knowledge would be too narrow.

Interestingly, 5% of the participating students said that First Nations science should not be taught as it might confuse their students. If science was to be avoided because it should not to confuse students, then the contemporary form

Western science would be completely avoided at all grade levels due to the inevitability of this fear.

Specific comments were made that there was "not be enough time to learn everything from the 'textbook' and First Nations science" implied, yet again, of the students assumptions about the hierarchy of valid knowledge.

In this question asking about drawbacks to teaching First Nations science, some students became quite assertive about their perspectives, stating, "I'm a strong believer in the scientific method and the different curricular topics. Western science was hundreds of years ahead of First Nations science and technology so I find it difficult to see the advantages of the First Nations science content." This example of privileging Western science and oppressing First Nations knowledge clearly highlights colonization perspectives that can be found throughout the data. Beliefs that Western science is "hard science" and "the truth" and First Nations science has "not much content", "is not accurate" and "is not as advanced" were situated beside comments that stereotyped First Nations science as "nature based", "more primitive science", while concepts "like physics, chemistry, technology etc are more important for student to learn to prepare them for the future."

Further, ideas such as "it is difficult to forge ahead and teach First Nations science in a society that is not quiet ready to accept the idea" show that some students are not willing to teach concepts that at the outset may seem controversial. As science teachers, there will be many topics within Western science that may be 'difficult to teach' or may 'offend' students and parents within the school community. Topics such as genetics for example would scarcely be avoided in Saskatchewan due to the discomfort of the community. Rather, the teacher would approach it with a 'scientific frame'. The participants seem to grapple with the ideological differences between Western science and First Nations science and could not find a space to resolve the two ideologies in the teaching and learning of science. In their comments they either dismissed First Nations science, or spoke of reducing it to a neutralized form that could be comfortably taught within the established paradigms of Western science.

The students discussed what they thought would be problematic in teaching First Nations science within the paradigms of Western science, in their responses to this question. One student stated that "learning another culture" in a short period of time would be difficult. Five percent spoke of the challenge of misrepresenting First Nations information if they were to include content in their science classes. These quotes captured a key assumptions of the participants, that being First Nations science could be captured, defined, and unitary presented as 'content' in the way Western science is currently, and problematically, being depicted. The majority of students communicated the assumption that First Nations science could some how be reduced down to agreed-upon concepts and taught without connection to the local places where that knowledge was gained. This again

speaks to the normalization of Western science, where everything is assumed to be 'naturally' like Western science concepts, process and structures. The idea that First Nations science is unitary and known may have instigated the request of 2% who just asked for more 'resources'. Further, the students do not communicate appreciating the complexity of the issues by their assumptions that simply adding this allusive homogenous content, First Nations science, could be considered 'taught'. The complexity of anti-oppressive education and post-colonial pedagogies necessitate that students, teachers and teacher educators, resist the alluring idea that simply adding First Nations content could ever address any inequity issues. These theories call for the deconstruction and questioning of deeply held beliefs, both individually and socially, that perpetuate the colonized agenda in how we have come to know science and science education, and how we negotiate the teaching and learning of science.

Specifically within this study, some of the questions the students' responses raise are: what is assumed about First Nations science? Do the students assume that First Nations science is like Western science, only with an 'earthy' twist? How does this assumption constrain First Nations science? How can this assumption be deconstructed and negotiated with preservice students?

What do you believe to be the drawbacks of including First Nations science in your future classroom?

When asked about their own classrooms, rather than an educational institution, the percentage of students, who believe that including First Nations science in their classrooms would make non-First Nations people uncomfortable, doubled. This was the most frequently given drawback. This answer may be more reflective of these future teachers' fears about negotiating conflicting perspectives in their classroom. Not one of these students commented that even though some people might feel uncomfortable, they would still teach First Nations science, as it was necessary to teach. They did not speak to their own discomfort with dealing with perceived conflict both within and outside of the classroom. These students did not comment on the political implications and positioning of the content of Western science and may perceive it as neutral or values free. Conversely, the students viewed First Nations science as biased and 'religion based'. As one student said, "There may be conflicts with parents who do not understand the beliefs and parents may feel that is it a religion being pushed on their child." These students may not understand that Western science is based upon a societal foundation of thought that is predominantly Christian in origin. This origin has influenced how we have come to understand scientific data and form hypothesis. Therefore, Western religions, specifically Christian worldviews, ethics and moral, have influenced Western science. An example of this is the hierarchical understanding of humans as compared to other 'animals'.

One student was concerned that when First Nations science was included in science education, "It could take away from the logical explanation of the

biological and chemical parts of science" therefore implying the idea that the inclusion of First Nations science would imply loss of logical explanations and/or Western science content. This was echoed by another student's fear that First Nations science was just a "dumbed down versions of science", and that those students pursing university degrees would be penalized by this content inclusion. Again, the privileging or normalizing of Western science is extremely evident in the comments of these preservice science students.

Summary

The underlying assumption of these participating students was that First Nations science is worthy of being infused into Western science if it assists in the promotion of the meaning of Western science for First Nations students. It was commonly assumed that First Nations science education should be taught in educational institutions as preservice teachers should know 'it' so they can connect with this growing majority of First Nations students who are thought to be marginalized by science. It was assumed that by acquiring this 'knowledge' (assumed to be acquirable, almost prepackaged and universal) these preservice students could highlight the relevance of Western science to these First Nations youths and thus, accelerate understanding of Western science. Stating this goal succinctly, a participant said, "First Nations science is needed to promote more First Nations scientists".

First Nations science was not generally understood as being beneficial to all students, but rather, it was assumed that non-First Nations students, parents and the wider community would resist its inclusion. Conversely, it was assumed that First Nations communities would embrace First Nations science.

Within these responses, there were no critiques of the hierarchy of Western science or how colonization has impacted the teaching and learning of science. The responses the participants offered are not reflective of contemporary thought in postmodern science pedagogy, nor are the goals they hold for science education. There seems to be a theory-practice gap here that may be reflective of larger infrastructural issues with what is being legitimatize, prioritized, researched and practiced in the name of science education in institutions in Regina, and arguably, elsewhere. The understandings the preservice students hold are reminiscent of the power hierarchies and colonializing agenda embedded in Western societies, of which tertiary institutions are part of if they do not deliberately and conscious make the choice to resist this status quo.

First Nations content and process are underrepresented in both science education research and practice. Such exclusion presents a serious social problem. Education is part of the invisible thread that creates, maintains, and binds individual and social thoughts, understandings, actions, and infrastructures shaping how a society makes sense of its world. The understandings gained through formal educational systems underlie power relations and value

judgments supporting certain ways of knowing that have, over time, become viewed as "natural". If one makes sense of one's world partly from the vantage point of the dominant Western images, storylines, metaphors, and concepts taught in secondary education, then we must ask: In what ways can we re-envision science education to disrupt Western privilege and create pedagogical initiatives allowing the realization of First Nations content and process? It is the ongoing struggle of bridging different epistemologies, decolonizing scientific knowledge and process, breaking oppressive power relations, and creating spaces for new ways of teaching that this research seeks to address.

The solution to this situation is not as easy. It is not as 'simple' as including 'First Nations science' content in teacher education. For even if there was agreement on what a First Nations science content and process would look like in Saskatchewan, many of the participants comments highlight that they would not necessarily include this perspective even if it was 'taught' to them. Postcolonial pedagogic theories and practices need to be explored with students in relation to what is understood as 'science education'. Students need to explore their everyday assumptions about what it means to be Western, or First Nations and deconstruction the power differentials embedded in social constructions about knowledge, truth and science. This will not be an easy task, but we who teach teachers science have the obligation to embrace this task or the inherent racism displayed in the comments of these well meaning preservice students will continue to the determent of their own students, and our Saskatchewan culture.

Dissemination of Information

To date the presentations of this research have been made to:

- The World Indigenous Peoples Conference on Education, Monday 28th November to Thursday 1st December 2005, Hamilton, New Zealand.
- The Centre for Research on Education in Context, School of Education, University of New England, Armidale, New South Wales, Australia. December 2005.
- The Department of Education and Professional Studies, Griffith University, Southport, Queensland, Australia. December 2005.
- SIDRU Seminars at the Faculty of Education, University of Regina, Saskatchewan. March 22nd, 2006.
- Invited Presentation to the Policy and Planning Branch, Saskatchewan Learning, Regina, Saskatchewan. May 1st, 2006.
- Race/Culture Divide in Education, Law and the Helping Professions. The Fifth Annual Canadian Critical Race Conference, University of Regina, Regina, Saskatchewan. May 4-6, 2006.

References

Abell, S. K., & Smith, D. C. (1994). What is science? Preservice elementary teachers' conceptions of the nature of science. *International Journal of Science Education, 16*, 475-487.

Aguirre, J. M., Haggerty, S. M., & Linder, C. J. (1990). Student-teachers' conceptions of science, teaching and learning. *International Journal of Science Education, 12*, 381-390.

Aikenhead, G. (1997). Towards a First Nations cross-cultural science and technology curriculum. *Science Education*, 81, 217-238.

Atwater, M.M. (1996). Social Constructivism: Infusion into the multicultural science education research agenda. *Journal of Research in Science Teaching*, 33(8), 821-837.

Barton, A. C. (1997). Teaching science with homeless children: Pedagogy, representation, and identity. Paper presented at the AERA annual meeting, Chicago, IL, March 1997.

Barton, A.C. & M. Osborne (2001). *Teaching science in diverse settings.* New York: Peter Lang.

Brickhouse, N. (1994). Bringing in the outsider: Reshaping the sciences of the future. *Journal of Curriculum Studies*, 26(4), 401-428.

Cajete, G. (2000). *Native Science: natural laws of interdependence.* Santa Fe, New Mexico: Clear Light Publishers.

Eide, K.J. & Heikkinen, M. W. (1998). The inclusion of multicultural material in middle years science teachers' resource materials. *Science Education*, 82(2), 181-195.

Ellsworth, E. (2005). *Places of Learning: Media, architectures, pedagogy*. New York: Routledge.

Federation of Saskatchewan Indian Nations, (1997). *Saskatchewan and Aboriginal Peoples in the 21st Century: Social, Economic and Political Changes and Challenges*. Regina: PrintWest Communications Ltd.

Federation of Saskatchewan Indian Nations, (2002). *A Research Report on The Schooling, Workforce and Income Status of First Nations Persons in Saskatchewan*. Regina: Education and Training Secretariat.

Gill, D. & Levidow, L. (1989). Science curriculum innovation and Holland Park School. In D. Gill & L. Levidow (Eds.), *Anti-Racist Science Teaching* (pp. 147-174). London: Free Association Books.

Helms, J. (1998). Science and/in the community: Context and goals in practical work. *International Journal of Science Education*, 20(6), 643-653.

Hines, S. M. (2003). *Multicultural Science Education: Theory, Practice and Promise*. New York: Peter Lang.

Hodson, D. (1999). Going beyond pluralism: Science education for socio-political action. *Science Education*, 83, 775-796.

Kawagley, A. O. (1995). *A Yupiaq worldview: A Pathway to Ecology and Spirit*. Illinois: Waveland Press Inc.

Kyle, W. (2001). Towards a political philosophy for science education. In Calabrese Barton & M. Osborne (Eds.), *Teaching science in diverse settings* (pp. xi-xix). New York: Peter Lang.

Laplante, B. (1997). Teachers' beliefs and instructional strategies in science: Pushing analysis further. *Science Education, 81*, 277-294.

Lederman, N. G. (1992). Students' and teachers' conceptions of the nature of science: A review of the research. *Journal of Research in Science Teaching, 29*, 331-359.

Rodriguez, A. (1997). The dangerous discourse of invisibility. *Journal of Research in Science Teaching*, 34(1), 19-39.

Rodriguez, A. (1998). Strategies for counterresistance: Towards sociotransformative constructivism and learning to teach science for diversity and for understanding. *Journal of Research in Science Teaching*, 35(6), 589-608.

Sammel, A. (2003). *Environmental Education and the Ontario Science Curriculum: In where? About what? For whom?* In D. Hodson (Ed) OISE Papers in STSE Education, Volume 4.Toronto: University of Toronto Press with the Imperial Oil Centre for Studies in Science, Mathematics and Technology Education.

Saskatchewan Education, (2000). *Aboriginal Education Provincial Advisory Committee: Action Plan 2000-2005*. Regina.

Southerland, S. A., Gess-Newsome, J., & Johnston, A. (2003). Portraying science in the classroom: The manifestation of scientists' beliefs in classroom practice. *Journal of Research in Science Teaching, 40*, 669-691.

Weaver, J. A. (2001). (Post) Modern Science (Education): Propositions and Alternative Paths. In J. A. Weaver, M. Morris, &. P. Appelbaum (Eds.), (Post) Modern Science (Education): Propositions and Alternative Paths (pp. 1-22). New York: Peter Lang.

Yager, R. E. (1989). What science should contribute to cultural literacy. *Clearing House*, 62(7), 297-302.

Yerrick, R. K., Pedersen, J. E., & Arnason, J. (1998). "We're just spectators": A case study of science teaching, epistemology, and classroom management. *Science Education*, 82, 619-648.